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Natural Gas Transits and Market Power – The Case of Turkey

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Abstract

Turkey is a key country in order to realize the Southern Gas Corridor (SGC) due to its geographical location. However, as the main transit country within the SGC, Turkey could potentially exert market power with gas transits. Whether Turkey exerts market power or not, is crucial for an economic assessment of the SGC. Hence, the article investigates this issue quantitatively using a global partial equilibrium gas market model. An oligopolistic and a competitive supply structure in Europe in 2030 are considered in the model. If the European gas market in 2030 is characterized by an oligopolistic supply, Turkey is able to exert market power resulting in higher prices compared to competitive transits, in particular in South Eastern Europe. In a competitive market structure, however, the importance of the SGC and thus the potential of Turkish transit market power is limited.

Keywords: Natural Gas, Southern Gas Corridor, Transit Market Power, Mixed Complementarity Problem

JEL classification: L13, L95

1. Introduction

The Southern Gas Corridor (SGC) consists of planned pipeline projects that connect the natural gas producers in the Caspian region and the Middle East (Azerbaijan, Turkmenistan, Iran, Iraq and Israel) with the natural gas markets of the European Union (EU). The EU promotes the SGC for 2 reasons: (1) it would like to diversify its natural gas supplies and (2) it aims to closing its growing supply gap that arises due to decreasing indigenous production. Turkey has a key role in realizing the SGC, since Turkey's geographical

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location is between the producing countries and the EU. This crucial role of Turkey is widely discussed in the literature[1]. Compared to Ukraine, which is a single-source transit country for Russian gas only, Turkey has the potential to become a multi-source transit country fed by several suppliers from the Caspian region and the Middle East or Russia. The goal of the Turkish government, however, is not only to aim for a pure transit role for Turkey, but rather to use its multi-source advantage for actively trading in the natural gas markets, as is outlined in Skalamera (2016):

> “Turkey, however, bargained hard against a straightforward transit role, intending instead to take over the role of a hub, which means that it would buy gas arriving at its borders, consume what it needs, and sell on the balance at profit.”

However, this perception is far away from the economic definition of an energy hub.[2] In economic terms, the Turkish perception means that Turkey wishes to use its geographical location to exercise market power in the European natural gas market (transit market power). If the natural gas producers have market power themselves, Turkey’s plans would give rise to double marginalization (Tirole, 1988). This perspective is missing within the current discussion about the SGC although it could potentially eliminate the economic benefits of the entire project.

Hence, the research objective of this paper is to investigate possible implications of Turkey’s strategic behavior for the EU natural gas markets and for the economic feasibility of the SGC project. Therefore, the global natural gas market model COLUMBUS (Hecking and Panke, 2012) is extended and applied. Transit countries like Turkey are modeled as profit-optimizing exporters that trade actively in the gas markets.[3]

The structure of the paper is as follows: In Section 2, a review of literature that is is relevant for the analysis is given. A stylized theoretical model to discuss the problem of Turkish transits is developed in Section 3. Subsequently, in Section 4, the global natural gas market model COLUMBUS and its inputs are described. Furthermore, Section 4 provides a discussion about the model calibration. Based on the calibration, Section 5 focuses on the model results and discusses the implications of Turkish transit market power for the EU. Finally, Section 6 concludes.

[1] See for instance Berk et al. (2017), Tagliapietra (2014a), Tagliapietra (2014b), Winrow (2013), Wigen (2012) or Lise et al. (2008)

[2] Heather (2015), for instance, identifies five important requirements for an energy hub: a high level of (1) liquidity, (2) volatility and (3) anonymity as well as (4) market transparency and (5) traded volumes. Furthermore, a physical hub is a location where several pipelines coming from and going to different directions converge and enable physical trade and competition (IEA, 2016). The Turkish perception of becoming a hub rarely fulfills those requirements. For a deeper discussion of this topic see also Berk et al. (2017).

[3] In reality, besides buying gas volumes upstream and reselling them downstream, a transit country could exert market power by inducing high transit fees or imposing taxes for gas transits on its territory. Those measures would result in a mark-up increasing the price of gas deliveries through the transit country and hence have a similar effect for the final customers as a policy of the transit country to explicitly buy and resell gas.

2. Literature Review

There are different streams of literature which this work is related to. A first important stream is literature that relies on simulation models based on non-cooperative game theory to analyze natural gas markets. As the COLUMBUS model that is applied and extended within this work, these simulation models are programmed as mixed complementarity problems (MCP). MCPs allow the simulation of market behaviour and thus to consider different forms of competition on different stages of the value chain. An early study is provided by Boots et al. (2004) in which gas producers are represented as oligopolists in a static model called GASTALE. The model considers downstream traders that act either oligopolistically or competitively. The study shows that successive oligopolies in gas markets lead to higher prices. Later on, a dynamic version of GASTALE is developed by Lise and Hobbs (2009) that consider the SGC producers Azerbaijan, Iran and Iraq as potential suppliers for Europe. A further early work is Gabriel et al. (2005a). It also considers the natural gas supply chain as a mixed complementarity problem in which the traders marketing gas of the producers had market power. Several existence and uniqueness results are provided as well as illustrative numerical results. Gabriel et al. (2005b) considers more in-depth numerical simulation of a version of this model for the North American natural gas market. In a later contribution by Holz et al. (2008), a static model named GASMOD is applied to analyze the European gas markets with regard to their market structure. Using data of 2003 they analyze different combinations of competition in upstream and downstream markets and come to the conclusion that Cournot competition in both markets (double marginalization) is the most accurate representation to model the European gas market. In later research, Holz (2009) extends the static GASMOD model into a dynamic version. Smeers (2008) criticizes the aforementioned publications by stating that market observations do not justify the assumption of double marginalization in upstream and downstream markets. Based on his criticism, Smeers discusses alternative modeling options.

A second stream of literature that is of relevance for the analysis is literature about natural gas transits. Yegorov and Wirl (2010) analyze games that appear in the context of gas transits. They distinguish between games with a transit country as a net gas exporter and with a transit country as a gas importer. They conclude that the game structure arising from a transit problem is not absolute but depends on geography and international law. Furthermore, von Hirschhausen et al. (2005) analyze Ukrainian market power for Russian gas exports to Central Europe. They analyze the effects of an alternative Russian export route to Central Europe, the Yamal pipeline via Belarus and how cooperation between Ukraine and Russia could have made the investment into the Yamal pipeline unnecessary. Dieckhöner (2012) analyzes Ukrainian transits from a security of supply perspective discussing potential diversification options for Europe like the Nabucco pipeline. Later, Chyong and Hobbs (2014) introduce a strategic European natural gas market model to analyze a gas transit country. They apply their model to investigate the case of the South Stream gas pipeline. The question of Ukrainian transit market power is hereby important for the profitability of the South Stream pipeline. Transit market power is represented by a conjectured transit demand curve approach. However, the conjectural variations of the transit country are chosen as a calibration parameter and vary between 0 and 1. This approach is common in natural gas market modeling but also often criticized, e.g. by Perry (1982), Dockner (1992) and Smeers (2008). Within the literature about transit problems, there are further cooperative game theory approaches: Hubert and Ikonnikova (2004), Hubert and Suleymanova (2008), and Hubert and Ikonnikova (2011), for instance, analyze market power of transit countries within the Eurasian supply chain. Furthermore, they examine strategic investments into alternative infrastructure projects to bypass the transit countries and reduce their market power. However, the above-mentioned works focus all on Ukraine, a single source transit country fed by Russian gas only. In the study at hand, the potential multi-source transit country Turkey that would not be dependent on a single dominant exporter is in the focus of investigation.

The third stream of literature which is important to address the research objective of this paper, are geopolitical and economic publications about Turkey's energy relations. Cagaptay (2013) discusses geopolitical factors associated with different potential gas suppliers for Turkey. Skalamera (2016) finds that there are many obstacles for Turkey to become a gas hub. Furthermore, Berk and Schulte (2017) show that Turkey's potential to become an important transit country for the European natural gas market is strongly restricted. Moreover, they quantify different drivers that could increase Turkish transit volumes and therefore its importance as a transit country.

The value added to the literature of this analysis is two-fold. Firstly, it considers the specific case of Turkey and quantitatively examines its potential to exercise transit market power in the EU gas market. Secondly, a double marginalization approach (successive oligopolies) is used to describe a multi-source transit country like Turkey. In contrast to Chyong and Hobbs (2014), the conjectural variation of a transit country takes on either the value of the Cournot conjecture or the competitive conjecture. Thus, the critique of arbitrary conjectural variations is not relevant for this analysis.

3. Stylized Theoretical Model

Tirole (1988) describes double marginalization in the most basic setting, the succession of two monopolies in a vertical integrated value chain. In this section, an extended version of this textbook model is introduced to describe a market structure with a multi-source transit country potentially giving rise to double marginalization and suppliers that are not dependent on the transit country. Therefore, a setup with 4 players, 3 producers and the multi-source transit country, is considered in order to obtain insights into the functioning of transit market power. It is assumed, that the transit country and the producers are not vertically integrated. Producer 1 can sell volumes q_1 directly to the final market representing a value chain without double marginalization. Producer 2 (respectively producer 3) is dependent on the transit country and thus can only sell volumes q_2 (respectively q_3) to the transit country that then resells the volumes $q_T = q_2 + q_3$ to the final market. Figure 1 illustrates the stylized model. The assumption that all the volumes entering the transit country are resold corresponds to the assumption that no domestic market of the transit country needs to be served (in the absence of indigenous production of the transit country).

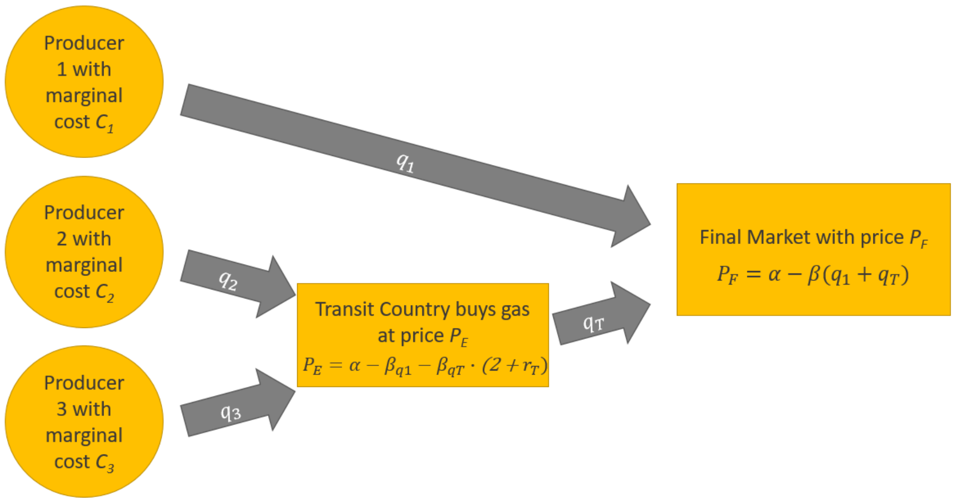

Figure 1: Illustration of the stylized model

The final market has a price P_F and a total supply $Q = q_1 + q_T$. The demand function of the final market is assumed to be linear with an intercept α and a slope β:

$$P_F(Q) = \alpha - \beta Q$$

The profit-maximization problem of producer 1 with her marginal cost C_1 is given by:

$$max(\Pi_{P1}) \text{ with } \Pi_{P1} = (P_F(Q) - C_1) \cdot q_1 \text{ subject to } q_1 \geq 0 \tag{1}$$

The corresponding first-order conditions with a conjectural variation $r_1 = \frac{\partial q_T}{\partial q_1}$, which takes on the value of 0 for Cournot behavior and -1 for competitive behavior of the producer, are:

$$C_1 - P_F + \beta \cdot (1 + r_1) \cdot q_1 \geq 0 \perp q_1 \geq 0 \tag{2}$$

Producer 2 (respectively producer 3) produces gas at marginal cost C_2 (respectively C_3)and sells it to the transit country at the price P_E. The problems of the producers 2 and 3 are given by:

$$max(\Pi_{Pi}) \text{ with } \Pi_{Pi} = (P_E(q_i) - C_i) \cdot q_i \text{ subject to } q_i \geq 0 \text{ for } i = 2, 3 \tag{3}$$

The corresponding first-order conditions are:

$$C_i - P_E - \frac{\partial P_E}{\partial q_i} \cdot q_i \geq 0 \perp q_i \geq 0 \text{ for } i = 2, 3 \tag{4}$$

The demand function $P_E(q_T)$ is found by considering the transit country's profit maximizing problem and its first-order conditions with the conjectural variation $r_T = \frac{\partial q_1}{\partial q_T}$. The transit country's profit is determined by the difference between the price of the final market $P_F(Q)$ and the price for which the transit country can buy volumes from the upstream producer P_E:

$$max(\Pi_{TR}) \text{ with } \Pi_{TR} = (P_F(Q) - P_E) \cdot q_T \text{ subject to } q_T \geq 0 \tag{5}$$

The first-order conditions are given by:

$$P_E - \alpha + \beta q_1 + \beta q_T + \beta \cdot (1 + r_T) \cdot q_T \geq 0 \perp q_T \geq 0 \tag{6}$$

If r_T has the value -1, transits are modeled as competitive, whereas the value of 0 corresponds to a situation in which the transit country exerts market power (Cournot conjecture). If $q_T > 0$ is fulfilled, the equation (6) can be rewritten as:

$$P_E = \alpha - \beta q_1 - \beta q_T \cdot (2 + r_T) \tag{7}$$

With $q_T = q_2 + q_3$, this can be plugged into equation (4). With $r_2 = \frac{\partial q_3}{\partial q_2}$ and $r_3 = \frac{\partial q_2}{\partial q_3}$, this yields:

$$C_i - P_E + \beta \cdot (1 + r_i) \cdot (2 + r_T) \cdot q_i \geq 0 \perp q_i \geq 0 \text{ for } i = 2, 3 \tag{8}$$

Equations (2) and (8) define the mixed complementarity problem for the stylized model. The important insight is that the transit demand function can be included in the first-order conditions of producer 2 and producer 3. Turkey's transit demand function is implemented in the global gas market model COLUMBUS accordingly as described in detail in the appendix.

4. Methodology: The Global Gas Market Model COLUMBUS

4.1. Model Description

In order to analyze the double marginalization induced by a multi-source transit country within a more complex market, the global natural gas market model COLUMBUS is extended and applied. COLUMBUS is introduced in Hecking and Panke (2012) and applied in Growitsch et al. (2014), Hecking et al. (2016), Berk and Schulte (2017) as well as in Berk et al. (2017). It is an intertemporal partial equilibrium model. Formulated as an MCP, it is able to account for strategic behavior of the upstream sector. Therefore, producers and exporters are modeled as vertical integrated gas companies. In the model, these major national gas companies are associated with their countries, e.g. Gazprom with Russia or Sonatrach with Algeria. In this sense, supply countries are modeled as the strategic actors in the model. Inputs are assumptions about production capacities, demand and existing gas infrastructure, e.g. capacities of pipelines, liquefaction terminals, regasification terminals and gas storages. COLUMBUS is a dynamic model which means that demand for investment into gas production and infrastructure are determined endogenously based on exogenously given economic factors such as investment costs and discount rates.

In its standard version, COLUMBUS is only able to consider strategic behavior of the vertical integrated suppliers defined "as a trading unit associated with one or more production regions" (Hecking and Panke, 2012). Transit countries, as in the focus of this study, are not associated with their own production region but can buy gas at their border from the neighboring countries. Therefore, the model is extended by introducing transit countries such as Turkey as profit-optimizing exporters. Technical details of the model extensions as well as a detailed technical description of the existing standard version of the COLUMBUS model can be found in the appendix.

4.2. Input Data and Assumptions

4.2.1. Market Characteristics

In line with political and regulatory targets of the EU[4] (ACER, 2015b), further integration of the natural gas markets until 2030 is assumed. The EU market is aggregated into two clusters of countries: (1) a Northern & Western European (NWE) market and (2) a South Eastern European (SEE) market. The respective countries of each cluster are shown in Figure 2. The SEE market consists of the Balkan peninsula and Italy. Italy will be connected to the SGC by the TAP pipeline that is planned to become operational

[4]Within this study the EU includes the United Kingdom, Switzerland, Norway and all states of former Yugoslavia.

in 2018. The NWE market is composed of the remaining EU countries. The countries of each cluster are assumed to form an integrated market. Integration means that only one entry tariff (respectively exit tariff) has to be paid in order to ship gas into (respectively out of) the integrated market area.[5] A prerequisite for such a market design are investments in pipeline connections between the countries of the market area to reduce the risk of structural congestion.[6] An integrated market implies that there is only one gas price within each market area.

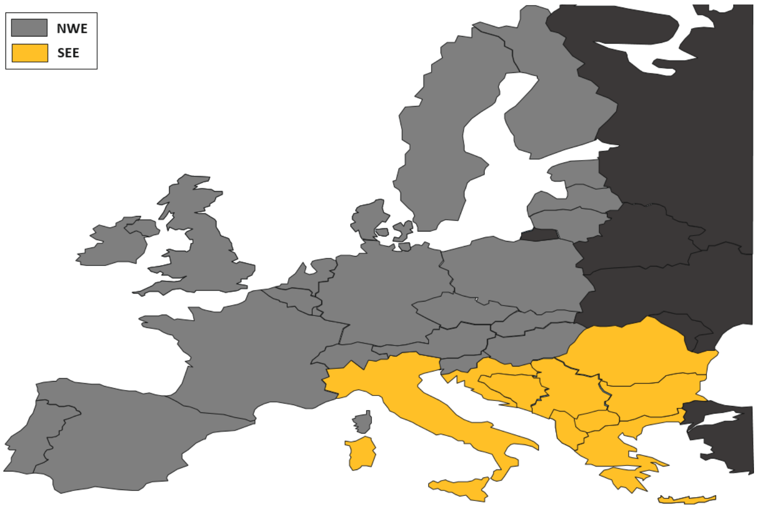

Figure 2: Definition of the two clusters NWE & SEE

While the NWE market is already today characterized by a high degree of market integration in terms of sufficient infrastructure, competitive hub pricing and a high number of supply sources, the SEE market currently lacks connecting infrastructure and is dominated by Russian gas supply and oil-indexed long-term contracts (ACER, 2015a). However, there are various infrastructure projects supported by the European Commission (for instance the so called CESEC initiative[7]) that are supposed to increase the interconnectivity of today's national markets in SEE. Furthermore, the agreement between the European Commissions Directorate-General for Competition and Gazprom regarding commitments on destination clauses and pricing issues in Central and Eastern Europe[8] will also result in a stronger market integration. Hence, the assumption of an integrated market in SEE in 2030 is in line with EU's long-term energy strategy. The

[5]Uniform entry/exit tariffs are assumed that are calculated as a capacity weighted average of the 2014 tariffs from the ACER market report 2014 (ACER, 2015a). Basing the analysis on 2014 tariffs implies that the costs of further investments into the natural gas infrastructure would be regained at the exit points to the customers. For an interesting discussion of how to derive entry/exit fees in an integrated European market see Hecking (2015).

[6]Persistent congestion within a market area would lead to high redispatch costs that would have to be distributed to the gas customers within the market area.

[7]`https://ec.europa.eu/energy/en/topics/infrastructure/central-and-south-eastern-europe-gas-connectivity`

[8]`http://europa.eu/rapid/press-release_IP-17-555_en.htm`

modeling of two segments of the EU gas market allows a differentiation of effects of imports via the SGC on the NWE and SEE markets.

4.2.2. Demand

The model is based on linear demand functions as in Lise et al. (2008). Inputs for each demand region are a reference demand, reference price and point elasticity of demand. The general level of the demand is an input to the model as the reference demand. However, given the fact that the model is an equilibrium model, the equilibrium demand is an output of the model and can deviate marginally from the input demand path. The input reference demand used for this analysis is mainly based on reports of the International Energy Agency (IEA). The fundamental data source for the historical data is the Natural Gas Information 2016 (NGI) (IEA, 2016). Future demand development is based on the projections of the Medium Term Gas Market Report 2015 (MTGMR) (IEA, 2015a) and the World Energy Outlook 2015 (WEO) (IEA, 2015b). Concerning the WEO 2015, the assumptions are founded on the New Policies Scenario. Hence, a nearly constant demand development in the EU is considered in this analysis. The point elasticities of demand are chosen in line with Growitsch et al. (2014) and Egging et al. (2010). Thus, for instance, for Europe a price elasticity of -0.25 is assumed. The European reference price is based on the Title Transfer Facility (TTF) price for 2014.

4.2.3. Production

The EU is characterized by a strong import dependency. Therefore, the indigenous production is modeled exogenously. That means the respective EU reference demand is reduced by indigenous production. However, all external natural gas suppliers relevant for the EU such as Norway, Russia, suppliers from North Africa, but also potential suppliers from the SGC as Azerbaijan, Turkmenistan, Iran, Iraq and Israel as well as global players that are able to supply LNG to the EU, are modeled endogenously. The input data about production capacities and costs is based on a comprehensive literature research of current and historic upstream projects. Data has been obtained from Seeliger (2006), Aguilera et al. (2009), Hecking et al. (2016), publications of the Oxford Institute for Energy Studies, current press notifications about new field discoveries / developments, and by exchange with industry experts. The COLUMBUS model distinguishes operational and capital costs for the production.

4.2.4. Infrastructure

The COLUMBUS model encompasses the major elements of the global gas infrastructure including pipelines and LNG terminals. Some projects that have reached the financial investment decision (FID) status are exogenously given to the model (e.g. LNG terminals in the USA and Australia). The data for the existing pipeline infrastructure in Europe is based on the capacity map and the Ten Year Network Development Plan (TYNDP) of the European Network of Transmission System Operators for Gas (ENTSOG, 2015). In Turkey, the existing pipeline connections from Russia (Blue Stream), Georgia (Southern Gas Pipeline) and Iran (Tabriz-Ankara Pipeline) are modeled. In addition, the first stage of the Trans Anatolian Pipeline (TANAP) that runs from the Eastern to the Western Turkish border and the Trans Adriatic Pipeline (TAP) that runs from Turkey via Greece and Albania to Italy are considered in the model with commissioning in 2018 and 2020. Information regarding LNG liquefaction and regasification capacities has been gathered from publications of Gas Infrastructure Europe (GIE) (GIE, 2015) and from the LNG Industry Report 2015 which is published by the International Group of Liquefied Natural Gas Importers (GIIGNL) (GIIGNL, 2016). Facts about gas storage originate from reports of Gas Storage Europe (GIE, 2015) and the Natural Gas Information 2016 (IEA, 2016).

COLUMBUS has the ability to endogenously invest in new pipeline and LNG infrastructure. This means for example that the model can decide whether it is economically viable to invest in pipeline connections as Nord Stream 2, Turkish Stream or the SGC as well as into new LNG liquefaction or regasification terminals or other projects. For the purpose of a realistic understanding of the investment costs, a comprehensive literature analysis of historic pipeline and LNG projects has been conducted as well as an evaluation of costs for currently discussed projects.

Besides investment costs, short-run marginal transport costs are relevant for the market equilibrium. As already mentioned in Section 4.2.1, for the two considered European market areas, uniform capacity weighted entry/exit tariffs based on the ACER market report 2014 (ACER, 2015a) are used. The Ukrainian entry/exit tariffs are from Interfax (2015).[9] Transport costs for the SGC, for the South Caspian Pipeline (SCP), for the TANAP and for the TAP are based on a detailed analysis by Pirani (2016). A distance-based approach is applied to derive transport costs, entry/exit fees and transit fees for other non-European world regions for which no detailed cost data is available.

The analysis is based on a pure economic rationale. This means that if not explicitly stated no political constraints are considered. Such constraints could be for example limited pipeline investment options between countries hostile to each other, or limited production capacities in countries that are politically unstable. Furthermore, the model does not consider discrete investment choices. Therefore, the simulation may also identify small capacity demands for investment into infrastructure that would not take place in

[9]The assumed Ukrainian tariffs from 2015 imply that the Ukrainian route is the most expensive Russian export option to Europe. So despite not modeling the Ukrainian market power with respect to transit volumes endogenously, the Ukrainian market power is reflected in the exogenous tariff assumption.

reality.

4.3. Model Calibration

The COLUMBUS model is calibrated with the data described in Section 4.2. The calibration is based on data from 2014. Thereby, two different kinds of strategic behavior of the upstream sector are considered: an oligopolistic upstream market and a competitive upstream market.

The calibration results are shown in Figure 3 and Figure 4. Figure 3 illustrates the 2014 EU natural gas supply by source. The first bar depicts historical data from Eurogas (2015). The second bar illustrates the COLUMBUS simulation results if the upstream sector behaves oligopolistically, and the third bar is the result for competitive behavior. It becomes clear, that for 2014, the oligopolistic case matches history better than the results with the competitive assumption. In the competitive case, about 12% more gas would have reached the EU gas markets compared to the oligopolistic case. According to the model results, especially Russia withheld gas volumes in 2014.

Figure 4 shows the historical average European import natural gas price of 2014.[10] Furthermore, it depicts the price results of the COLUMBUS simulation, differentiated for the NWE and the SEE market and for an oligopolistic as well as a competitive upstream behavior. Again, it can be seen that the simulation of oligopolistic suppliers fits the reality best.[11]

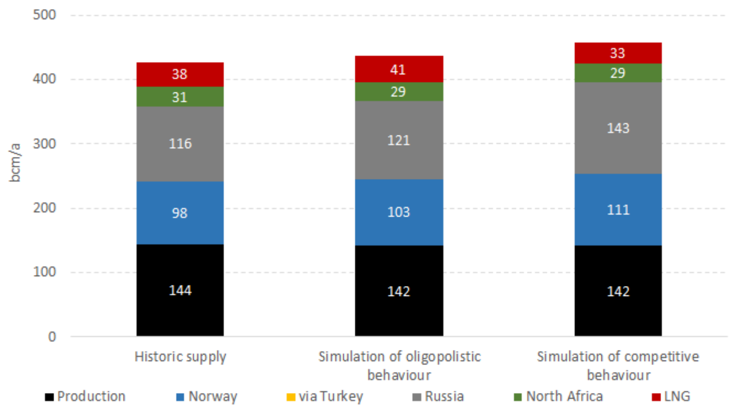

Figure 3: Comparison of historical imports and model results in 2014

[10] Average import border price with a component of spot price, including UK as reported by World Bank. Applied exchange rate: 1.32 EUR/USD

[11] Because an integrated gas market is assumed, demand (especially in SWE) is slightly higher and modeled gas prices are lower than historically observed prices.

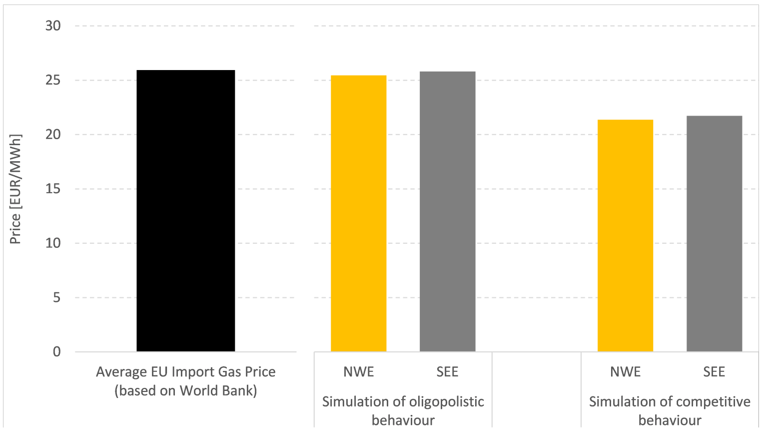

Figure 4: Comparison of historical prices and model results in 2014

However, the future development of the natural gas markets is uncertain. Today, it is hard to predict if the upstream producers will behave oligopolistically or competitively in 2030. Therefore, both potential developments are considered in the following analysis. Since it is known from the literature that the role of the SGC in a competitive gas market environment is limited (Berk and Schulte, 2017), however, the main and first focus is on the oligopolistic setup for which the calibration of the model to the year 2014 was shown in this section.

5. Results

5.1. Impact of Turkish Transit Market Power in an oligopolistic European gas market

In order to analyze the effects of Turkish transit market power for an EU market that is characterized by oligopolistic acting suppliers, two different scenarios are investigated: (1) a scenario with competitive Turkish transits and (2) a scenario with Turkish transit market power. Initially, a scenario with competitive Turkish transits is considered.[12] That means, Turkey transits gas from the SGC producers[13] without an additional profit margin. Figure 5 illustrates the simulated EU supply mix in 2014 (left) and 2030 (right). It can be seen that the relative share of the domestic European production (EU plus Norway) nearly halves from 56% in 2014 (245 bcm) to 32 % in 2030 (163 bcm). Due to Russia's oligopolistic behavior, also the Russian market share declines. The absolute Russian imports decline from 121 bcm in 2014 to 105 bcm in 2030. The LNG market, which is assumed to be competitive, partly fills the resulting supply gap. Another

[12] In terms of the theoretical model described in Section 3 this means Turkey has a conjectural variation of -1.

[13] SGC producers are potential suppliers from the Caspian region as Azerbaijan and Turkmenistan or from the Middle East as Iran, Iraq and Israel, that are also assumed to act strategically. Hence, they potentially withhold quantities to generate higher prices.

part is filled by imports from the SGC via Turkey. On this route 45 bcm reach the EU market in 2030. Assuming that 10 bcm/a of SGC capacity is already financed in the TAP project and will be realized, this means that an additional pipeline capacity investment into the SGC of 36 bcm would be economically viable according to the model results. Obviously, Turkey and the SGC producers could benefit from an oligopolistic EU market situation with high prices in 2030. Hence, the share of EU's gas consumption that arrives via the SGC could be about 9% with Azerbaijan (6% of final EU demand) as the main supplier.

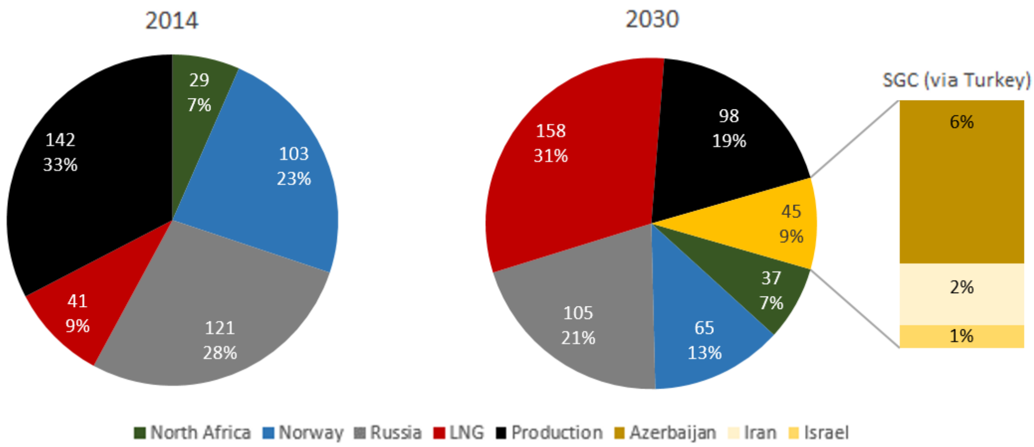

Figure 5: EU supply mix per source with competitive Turkish transits in 2014 (left) and 2030 (right), absolute values in bcm and share of source within total demand

Besides the scenario with competitive transits, a scenario in which Turkey acts as a Cournot player, buying gas from the neighboring SGC producers and reselling it to the EU with a profit margin, is considered (a behavior called Turkish transit market power in the following).[14] The SGC producers are assumed to have pipeline access to the EU market via Turkey only. Because the SGC producers are modeled as Cournot players as well, this implies successive oligopolies with double marginalization as described in Section 3.[15] Pipeline investment on Russian territory by non-Russian actors are thereby excluded. The assumption that SGC producers are not able to deliver gas via Russia to the EU is relaxed in Section 5.2.

Figure 6 contrasts the 2030 EU supply mix with competitive Turkish transits (left bar) to the situation in which Turkey exerts market power (right bar). As already pointed out, if Turkey would act competitively,

[14]In terms of the theoretical model described in Section 3 this means Turkey has a conjectural variation of 0.

[15]Russian transits through Turkey are still assumed to be competitive. Russian volumes are not bought by the Turkish Cournot player but can be sold to the European markets through Turkey directly by the Russian exporter that pays competitive transit fees. Turkey is not in the position to force Russia into a double marginalization structure as long as Russia has alternative channels to supply the European markets. Russia's direct investment options to Europe are not restricted and Russia rather prefers such direct routes to the EU as Nord Stream 2 due to lower costs compared to the Turkish transit option.

its re-exports to the EU would be about 45 bcm in 2030. However, due to the fact that Turkey is the only option for the SGC producers to export gas via pipeline into the EU in this scenario, Turkey is in the position to exert market power. If Turkey decides to use this option, Turkish re-exports would be much lower at 13 bcm/a or additionally to the TAP capacity 3 bcm/a in 2030. For the EU this would mean higher gas prices and thus a slightly lower demand (-10 bcm/a). However, most of the gas that would originally be imported via Turkey could be replaced by higher LNG imports (+10 bcm/a) as well as higher direct imports from Russia (+7 bcm/a).

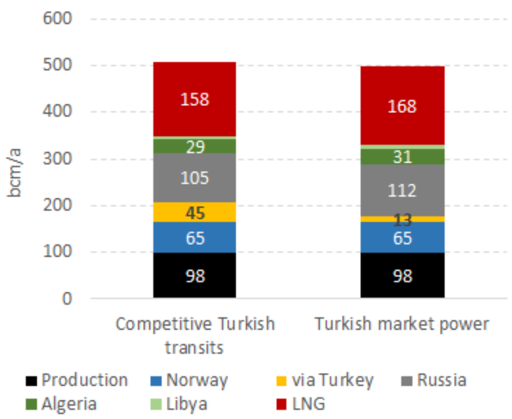

Figure 6: EU supply mix per source in dependence of Turkish behavior in 2030

The effect of Turkish transit market power on the EU gas market prices in 2030 is shown in Figure 7.[16] The figure again compares a situation with (left bar) and without (right bar) the exertion of Turkish transit market power. Additionally, due to the differentiation of the EU markets into a NWE and a SEE market, regional prices in Europe can be analyzed. In the competitive scenario, prices are lower in SEE than in NWE in 2030. This is opposed to today's situation in which prices in South Eastern Europe are the highest on the continent. As already illustrated in Figure 9 in Section 4.3, the model results also show higher prices in SEE in 2014. This can be explained with the fewer number of actors that offer gas in the SEE market compared to NWE. If the SGC producers enter the market as new suppliers via Turkey, competition increases and leads to lower prices. However, if Turkey would exert market power, the positive effect of further market entries diminishes resulting again in higher prices in SEE. It can be observed that by the exertion of Turkish transit market power prices in NWE would be 4.3% higher, while prices in SEE would be 6.9% higher than in a situation with a competitively behaving Turkey. This points out that in an oligopolistic European gas

[16]Prices are in real terms based on EUR 2014.

market structure the strategic behavior of Turkey would have a significant economic impact, in particular on the SEE market.

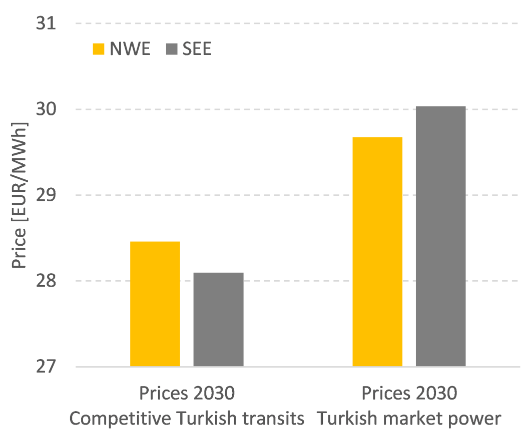

Figure 7: Natural gas prices in dependence of Turkish behavior in 2030

The implication of Turkish transit market power on the profits of Turkey, Russia and the SGC producers is shown in Figure 8. Additionally, the figure points out the impact on the EU consumer surplus. It shows the differences in profits and consumer surplus between a competitively acting Turkey and when Turkey exerts transit market power. In the competitive case, the Turkish profits are by definition 0. Thus, if Turkey exerts market power, it earns profits of 1.8 billion EUR in 2030. Due to less SGC gas within the EU gas markets, more Russian gas is exported to the EU in the transit market power case which leads to higher Russian profits of 2.5 billion EUR. However, profits of the SGC producers are 13.1 billion EUR lower in 2030. The EU suffers a loss of consumer surplus by 8.2 billion EUR.

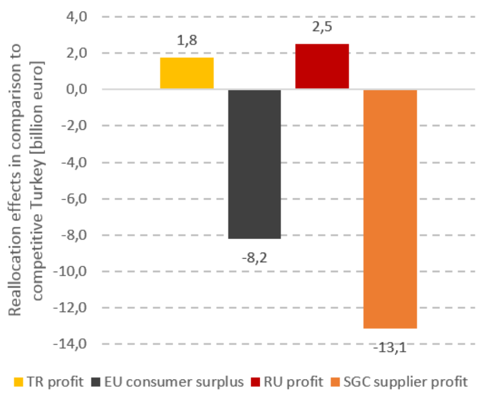

Figure 8: Development of profits and consumer surplus if Turkey exerts market power in 2030

The results discussed so far have focused on transits of the SGC producers via Turkey to the EU. However, it is also important to look at the domestic Turkish gas market. Within this study it is assumed that Turkey would not exert market power in its domestic market. This is in line with a policy of the Turkish government to aim on low domestic gas prices that support economic growth. Thus, the domestic market can be directly supplied by all connected exporters. In the scenario with competitive Turkish transits, Turkey's modeled gas demand grows to 63 bcm in 2030 from 49 bcm in 2014. If Turkey exerts transit market power, its domestic demand amounts to 65 bcm in 2030 according to the model results. In the market power case, the SGC producers have an incentive to ship gas to the Turkish domestic market instead of using the expensive transit option to the EU. Hence, the competition in the Turkish domestic market increases leading to 5% lower gas prices and hence to 1.1 billion EUR additional Turkish consumer surplus compared to the case with competitive Turkish transits. Thus, Turkey benefits twice by exertion of transit market power: (1) by profits from transits and (2) by a higher consumer surplus in its domestic market.

Figure 9 shows the origin of the gas exports of Turkey to the EU in 2030. It compares the transits for both considered scenarios (with and without the exertion of Turkish transit market power). If Turkey behaves competitively, about two thirds or 30 bcm of Turkish transits to the EU is Azerbaijani gas from the Shah Deniz field in the Caspian Sea. Since no Iranian sanctions are considered (pure economic rationale), an additional 11 bcm of Iranian gas would reach the EU market via Turkey in 2030. This Figure seems to be quite small compared to the fact that Iran has the world's largest natural gas reserves (BP, 2016). Nevertheless, according to the model results Iran supplies other markets than the EU such as Pakistan, India or the global LNG market.[17] Furthermore, about 4 bcm of expensive Israeli off-shore gas from the Mediterranean Sea would reach the EU. Turkmenistan and Iraq would not transit gas via Turkey to the EU. They would only supply the Turkish domestic market. Furthermore, Turkmenistan would prefer to supply gas to Asian customers. Even with competitive transits, they would not ship gas to Europe, due to comparably low price signals and the far distance. If Turkey, on the contrary, exerts market power nearly all of the 13 bcm gas transits that would reach the EU would be from Azerbaijan. The reason lies in the missing alternative demand sinks and thus the strong Azerbaijani dependence on Turkey compared to Iran that can ship gas to the above mentioned alternative markets. Gas from Israel, however, would be too expensive and not exploited. Again, Turkmenistan and Iraq would deliver the Turkish domestic market only. Besides that, Turkmenistan would focus on non-European markets. Against this background, it is relevant to consider a sensitivity analysis in which Azerbaijan can ship gas through Russian territory to the EU.

[17] For a more detailed discussion about Iranian exports see Berk and Schulte (2017).

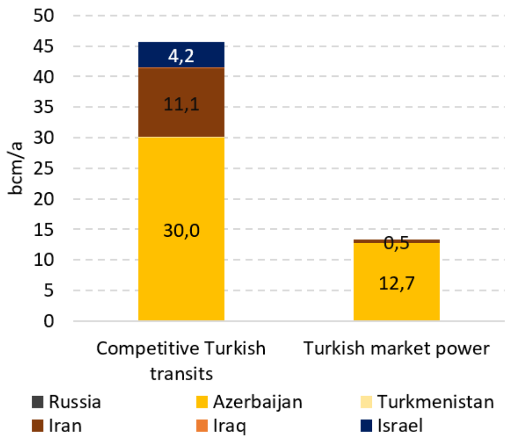

Figure 9: Turkish gas transits into the EU per source in dependence of Turkish behavior in 2030

5.2. Caspian Gas via Russia

So far it was assumed that Azerbaijan would be able to deliver gas via Turkey only to reach the EU market. Besides the EU, Azerbaijan could solely sell its gas to Georgia or Turkey. However, the Turkish and Georgian demand for Azerbaijani gas is relative small and accounted for only 8 bcm in 2015 (Pirani, 2016). Looking into the past, Azerbaijan delivered up to 2 bcm of gas to Russia in 2012 (Pirani, 2016). Since then supplies have declined to zero in 2015. As of 2016, Azerbaijan is even importing about 2 bcm/a from Russia[18]. The main reason is the increasing domestic demand and the underdeveloped production of the Shah Deniz field. When the Shah Deniz stage 2 will come online in 2018 this situation may change. Then Azerbaijan would be able again to export gas also to Russia or even via Russia into the EU.

Thus, in a first sensitivity, it is assumed that Azerbaijan and also Turkmenistan are able to deliver gas competitively via Russia into the EU while Turkey is exerting transit market power. As a consequence, both countries would not deliver any gas via Turkey and total Turkish transits to the EU would only be at 6.7 bcm in 2030. As shown in Figure 10, these 6.7 bcm of natural gas that would reach the EU are Iranian gas. Due to reduced competition in the first-stage oligopoly (SGC producers competing about the transits through Turkey) compared to a situation in which Azerbaijan and Turkmenistan are part of this oligopoly, the remaining SGC producers can exercise more market power when selling gas to Turkey. Hence, it becomes more profitable for Iran to export gas via Turkey to the EU. The EU, however, benefits from Azerbaijani and Turkmen gas supplies via Russia. While EU prices would be 1.5% (0.9%) lower in SEE (NWE) compared to the scenario "Turkish market power" without outside options of Azerbaijan and Turkmenistan, EU's

[18] `http://www.azernews.az/oil_and_gas/96768.html`

consumer surplus would be 0.1 billion EUR higher. As can be seen in Figure 10, due to lower natural gas transits, Turkey's profit would be 0.5 billion EUR if Azerbaijan and Turkmenistan can circumvent Turkey instead of previously 1.8 billion EUR. But because of lower European gas prices and stronger competition with Azerbaijan and Turkmenistan in its key markets, Russia would also lose 0.7 billion EUR revenues as well as 0.2 billion EUR of profits by allowing transits on its territory compared to the case in which Turkey exercises market power and no SGC producer can ship through Russia. Thus, a situation in which Russia would allow Azerbaijan and Turkmenistan to use its infrastructure to bring additional gas amounts into the EU seems to be not likely.

Another possible scenario would be that Russia buys gas from Azerbaijan and Turkmenistan and resells it to the EU instead of allowing competitive transits - similar to Turkey's assumed behavior. However, it is questionable if double marginalization would be the appropriate approach to describe this setting, since Russia has a huge indigenous gas production with comparably low production costs. Hence, Azerbaijan and Turkmenistan are not in a good position to exert market power against the Russian exporter.[19] Therefore, the scenario in which Russia buys gas from Azerbaijan and Turkmenistan is modeled as a cartel situation in which the three countries offer their gas amounts jointly as one player[20]. Together, these countries are in a strong position to act strategically. Thus, compared to the scenario in which all SGC producers have to sell gas to an oligopolistic Turkey in order to deliver gas to European markets, gas prices are higher in both modeled EU market areas (SEE and NWE) by about 2.8%. This leads to an EU welfare loss of 1.8 billion EUR compared to the Turkish market power scenario with all SGC producers selling to Turkey. Nonetheless, as illustrated in Figure 10, even if Russia and the Caspian producers Azerbaijan and Turkmenistan would form a cartel, still 5.7 bcm of mainly Iranian natural gas would reach the EU markets via Turkey. Turkey could earn 0.4 billion EUR of profits.

Concluding, if Azerbaijan und Turkmenistan can ship gas through Russia (either competitively or by cooperation forming a cartel with Russia), the volumes that Turkey could resell to Europe would be below the already financed TAP capacity of 10 bcm. Nevertheless, Turkey could still earn profits of 0.4-0.5 billion EUR from the transits.[21]

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[19] Turkey, on the other hand, does not have many options to buy gas from different producers.

[20] For modeling a cartel the same modeling approach as in Egging et al. (2009) is chosen.

[21] In reality, it is possible that the Caspian countries and Russia could find a form of cooperation between competitive transits and the cartel. In principle, a transit problem can also be seen as a bargaining problem in which the cartel and competitive transits would be extreme outcomes. However, both considered scenarios with respect to the relations between the Caspian countries and Russia have similar implications for the SGC, i.e. if Azerbaijan and Turkmenistan ship through Russia, the volumes coming through the SGC are diminished.

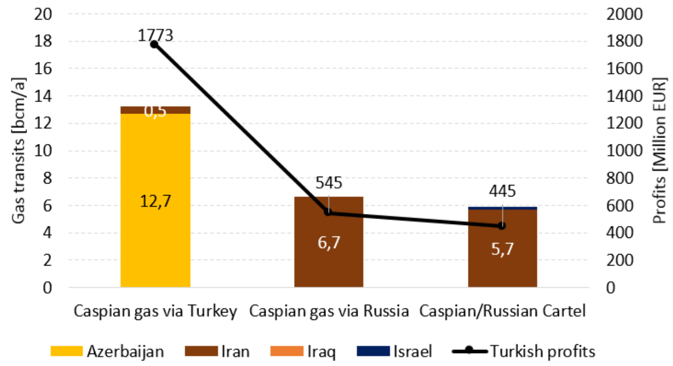

Figure 10: Turkish gas transits into the EU per source and Turkish profits in dependence of Caspian supply options in 2030

5.3. Impact of Turkish Transit Market Power in a competitive European gas market

In the next step, the effects of Turkish transit market power in a competitive EU market is investigated. However, as already shown by Berk and Schulte (2017)[22], the chance of Turkey to become an important transit country for the EU is quite limited under competitive market conditions. There is only a minor demand for expensive gas from the SGC in a competitive EU gas market setting with a nearly constant future demand development. Similar results are found in this study.

If Turkey behaves competitively and SGC producers have only to pay the current TANAP transit fees, 23 bcm of gas would pass through Turkey to the EU. Nearly 18 bcm would come from Azerbaijan and approximately 5 bcm form Iran. Gas from Israel would be too expensive to reach the EU markets. However, even in this situation Turkey would be able to exert transit market power. Hereby it would earn profits of 0.5 billion EUR. Nonetheless, if Turkey would exert market power in such a competitive environment, the potential of the SGC project to diversify the EU gas markets is negligibly small. Approximately 5 bcm from Azerbaijan would reach the EU gas markets. That means that even the capacity of the already financed first stage of the SGC would be oversized. That underlines the minor importance of the SGC under competitive market conditions.

6. Conclusion

The results of the paper illustrate that Turkey has the potential to exert market power in the EU natural gas markets if an oligopolistic market structure is assumed. If Turkey behaves competitively in this market environment, 45 bcm of Turkish transit volumes would arrive in Europe in 2030 according to the model

[22] A further study that investigates the role of the SGC under competitive market conditions is Hecking et al. (2016).

outcome. In such a situation, gas prices in the SEE region could be lower than in the NWE region, because the SGC producers would increase the competition, in particular in the SEE region. In the case of Turkish transit market power, however, the transits through Turkey would be reduced to 13 bcm in 2030, illustrating a big potential to withhold quantities from the markets. According to the model outcome, gas prices in the NWE region would be 4.3% higher in this setting in 2030 compared to a situation with competitive Turkish transits. However, SEE would be most significantly affected by 5.9% higher prices if Turkey exercises market power. The consumer surplus of the EU would be 3.2 billion EUR lower compared to the case in which Turkey behaves competitively. If Turkey would only withhold quantities to the European markets and not to its domestic market, lower gas prices in Turkey would be the consequence. Hence, Turkey could increase its consumer surplus (by 1.1 billion EUR) besides earning profits from transits (1.8 billion EUR) making it attractive for Turkey to use the market power option.

In a sensitivity analysis, Azerbaijan and Turkmenistan are allowed to transit gas via Russia to the EU. Due to additional competition in the European markets, Russia's profits are diminished by 0.2 billion EUR in this scenario compared to the case in which all SGC producers sell gas to an oligopolistically acting Turkey. Furthermore, a scenario is considered in which Turkmenistan, Azerbaijan and Russia form a cartel. In this scenario, a Turkey with transit market power can resell less than 6 bcm to the European markets. Nevertheless, the cartel leads to comparably high gas prices in Europe.

In a competitive future gas market setting, gas imports via Turkey and the SGC would be only of minor importance, even if Turkey behaves competitively. Hence, also the Turkish potential of pursuing transit market power is limited.

Our analysis illustrates that the economic raison d'être for the SGC is only given for an EU gas market that is characterized by oligopolistic natural gas suppliers. However, in this oligopolistic environment, Turkey could benefit from exerting market power and hereby eliminate the potential benefits of the SGC for the EU. As a policy implication, the EU could prefer direct connections between supply and demand avoiding new dependencies on transit countries.

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AppendixA. Model Description

The following model description is based on Hecking and Panke (2012). COLUMBUS is a spatial model consisting of vertices and edges. Vertices can be either sources (production facilities) or sinks (demand). Pipelines and LNG shipping routes are connected with edges. Table C.2 gives an overview of all sets, parameters and variables in the model.

AppendixA.1. Notation: Sets, Variables and Parameters

Table A.1: Sets, Dual Variables, Parameters

1. Sets	
$n, n1 \in N$	all model nodes
$c \in C$	cost levels (steps of piecewise linear supply function)
$t \in T$	months
$y \in Y$	years
$p \in P \in N$	producer / production regions
$e \in E \in N$	exporter / trader
$d \in D \in N$	final customer / demand regions
$r \in R \in N$	regasifiers
$l \in L \in N$	liquefiers
$s \in S \in N$	storage

2. Primal Variables	
$pr_{p,c,t}$	produced gas volumes
$fl_{e,n,n1,t}$	physical gas flows
$tr_{e,d,t}$	traded gas volumes
$st_{s,t}$	gas stock in storage
$si_{s,t}$	injected gas volumes in stroage
$sd_{s,t}$	depleted gas volumes from storage
$dr_{p,c,y}$	depleted resources
$ip_{p,c,y}$	annual investment into production capacity
$it_{n,n1,y}$	annual investment into pipeline transport capacity
$is_{s,y}$	annual investment into storage capacity
$ilng_{y}$	annual investment into LNG transport capacity
$ir_{r,y}$	annual investment into regasification capacity
$il_{l,y}$	annual investment into liquefaction capacity
$mdo_{e,d,t}$	minimal delivery obligation

3. Dual Variables	
$\lambda_{p,c,t}$	marginal costs of physical gas supply by exporter e to node n in time period t
$\sigma_{s,t}$	(intertemporal) marginal costs of storage injection
$\alpha_{p,c,y}$	marginal value of resources in node n at cost level c in year y
$\beta_{d,t}$	marginal costs / price in node n in time period t
$\mu_{p,c,t}$	marginal benefit of an additional unit of production capacity
$\phi_{n,n1,t}$	marginal benefit of an additional unit of pipeline capacity
$\epsilon_{s,t}$	marginal benefit of an additional unit of storage capacity
$\psi_{s,t}$	marginal benefit of an additional unit of storage injection capacity

Table A.1: Sets, Dual Variables, Parameters

$\theta_{s,t}$	marginal benefit of an additional unit of storage depletion capacity
ι_t	marginal benefit of an additional unit of LNG transport capacity
$\gamma_{r,t}$	marginal benefit of an additional unit of regasification capacity
$\zeta_{l,t}$	marginal benefit of an additional unit of liquefaction capacity
$\chi_{e,d,t}$	marginal costs of delivery obligation
4. Parameters	
$dem_{d,t}$	final customer's demand for natural gas
$cap_{n,t/n,n1,t/n,c,t}$	monthly infrastructure capacity
$res_{n,c,y}$	maximum resources
$trc_{n,n1,t}$	transport costs
$prc_{n,c,t}$	production costs
$opc_{n,t}$	operating costs
$inc_{n,y/n,n1,y/n,c,y}$	investment costs
$dist_{n,n1}$	distance between node n and node n1 in km
$LNGcap$	initial LNG capacity
$speed$	speed of LNG tankers in km/h
cf_s	conversion factor used for storage inj. and depl. capacity
elt	economic life time of an asset
$slope_{d,t}$	slope of the linear demand function in node d
cv_e	conjectural function of exporter e; market power level

COLUMBUS is based on profit optimization problems of the different players (exporters, producers, transmission system operators, liquefiers, regasifiers). Each profit optimization problem has corresponding first order conditions. Together with the market clearing conditions, the first order conditions define the model.

AppendixA.2. KKT Conditions

AppendixA.2.1. Exporters

$$-\beta_{d,t} + (cv_e + 1) \cdot \text{slope}_{d,t} \cdot tr_{e,d,t} - \chi_{e,d,t} + \lambda_{e,d,t} \geq 0 \quad \perp \quad tr_{e,d,t} \geq 0 \qquad \forall e, d, t. \tag{A.1}$$

$$\begin{aligned} -\lambda_{e,n,n1,t} + \lambda_{e,n,t} + trc_{n,n1,t} + trc_{n,n1,t} + opc_{n,t} \\ + \phi_{n,n1,t} + \zeta_{l,t} + \gamma_{r,t} \\ + \iota_t \cdot 2 \cdot dist_{l,r} \geq 0 \quad \perp \quad fl_{e,n,n1,t} \geq 0 \qquad \forall e, n, n1, t. \end{aligned} \tag{A.2}$$

AppendixA.2.2. Producers

$$-\lambda_{e,p,t} + prc_{p,c,t} + \sum_{y \in Y_t} \alpha_{p,c,y} + \mu_{p,c,t} \geq 0 \quad \perp \quad pr_{p,c,t} \geq 0 \qquad \forall p, c, t \tag{A.3}$$

$$\alpha_{p,c,y+1} - \alpha_{p,c,y} \leq 0 \quad \perp \quad dr_{p,c,y} \geq 0 \qquad \forall p, c, y \tag{A.4}$$

$$in_{c,p,y} - \sum_{t \in T(y)} \mu_{p,c,y} \geq 0 \quad \perp \quad ip_{p,c,y} \geq 0 \qquad \forall p, c, y \tag{A.5}$$

AppendixA.2.3. Transmission System Operators

$$inc_{n,n1,y} - \sum_{t \in T_y} \phi_{n,n1,t} \geq 0 \quad \perp \quad it_{n,n1,y} \geq 0 \qquad \forall n, n1, y. \tag{A.6}$$

AppendixA.2.4. Liquefiers

$$inc_{l,y} - \sum_{t \in T_y} \zeta_{l,t} \geq 0 \quad \perp \quad il_{l,y} \geq 0 \qquad \forall l, y. \tag{A.7}$$

AppendixA.2.5. Regasifiers

$$inc_{r,y} - \sum_{t \in T_y} \gamma_{r,t} \geq 0 \quad \perp \quad ir_{r,y} \geq 0 \qquad \forall r, y. \tag{A.8}$$

AppendixA.2.6. LNG Shippers

$$inc_y - \sum_{t \in T_y} (\iota_t \cdot 8760/12 \cdot speed) \geq 0 \quad \perp \quad ilng_y \geq 0 \qquad \forall y. \tag{A.9}$$

AppendixA.2.7. Storage

$$-\beta_{d,t} + \sigma_{s,t} + \theta_{s,t} \geq 0 \quad \perp \quad sd_{s,t} \geq 0 \qquad \forall s, t \tag{A.10}$$

$$-\sigma_{s,t} + \beta_{s,t} + \rho_{s,t} \geq 0 \quad \perp \quad si_{s,t} \geq 0 \qquad \forall s, t \tag{A.11}$$

$$\epsilon_{s,t} = \Delta\sigma_{s,t} = \sigma_{s,t+1} - \sigma_{s,t} \leq 0 \quad \perp \quad st_{s,t} \leq 0 \qquad \forall s, t \tag{A.12}$$

$$in_{c,s} - \sum_{t \in T_y} [\epsilon_{s,t} + cf_{s,t} \cdot (\rho_s, t + \theta_{s,t})] \geq 0 \quad \perp \quad is_{s,y} \geq 0 \qquad \forall s, y \tag{A.13}$$

AppendixA.2.8. Market Clearing Conditions

The market clearing conditions are given by the following equations:

$$\sum_{c \in C} pr_{p,c,t} - tr_{e,d,t} + \sum_{n1 \in (n1,n) \in A} fl_{e,n1,n,t} - \sum_{n1 \in (n,n1) \in A} fl_{e,n,n1,t} = 0 \quad \perp \quad \lambda_{e,n,t} \quad \text{free} \qquad \forall e, n, t. \tag{A.14}$$

$$\sum_{e \in E} tr_{e,d,t} + mdo_{e,d,t} + sd_{s,t} + si_{s,t} - dem_{d,t} = 0 \quad \perp \quad \beta_{d,t} \quad \text{free} \qquad \forall d, t. \tag{A.15}$$

Equation (A.14) must be fulfilled for each exporter $e \in E$ that is active at the node $n \in N_e$. Additionally, the equation ensures equality of traded volumes and physical flows. Equation (A.15) defines the gas balance at demand nodes d in month t making sure that the final demand is met.

AppendixB. Model Extensions

Equation (A.1) defines the first-order conditions of the exporter's problem[23]. This problem is reformulated to optimize profits of exporters that sell volumes to a transit country with the transit country's conjectural variation cv_{tr} and the slope of the final demand region with the function $slope_{dem,t}$[24]:

[23] Growitsch et al. (2014) use a different convention of conjectural variations. This explains the difference between equation (11) in Growitsch et al. (2014) and equation (A.1).

[24] In the study at hand this is in particular the slope of the linear demand function of the EU market which is modeled in two regions. A more detailed description of the regions is given in Section 4.2. It is based on each country's linear demand function that are aggregated for the respective EU regions. The parameters of the EU demand functions determine the demand function for Turkish transit gas.

$$- \beta_{d,t} + (cv_e + 1) \cdot (2 + cv_{tr}) \cdot slope_{dem,t} \cdot tr_{e,d,t} - \chi_{e,d,t} + \lambda_{e,d,t} \geq 0 \perp tr_{e,d,t} \geq 0 \ \forall e, d, t \quad \text{(B.1)}$$

Equation (B.1) has the structure of equation (8). The transit country can be modeled as competitive (conjectural variation $cv_{tr} = -1$) or as a Cournot player (conjectural variation $cv_{tr} = 0$). The exporters that are supplying to a final market (including the transit country itself) have still first-order conditions of the form of equation (A.1).

Furthermore, the market clearing conditions given by equations (A.14) and (A.15) need to be extended. The volumes bought by the transit country $transit_t$ need to be included in those market clearing constraints for the nodes at the border of the transit country where it buys the transit volumes $n \in N_{TR}$:

$$\sum_{c \in C} pr_{p,c,t} + transit_t - tr_{e,d,t} + \sum_{n1 \in (n1,n) \in A} fl_{e,n1,n,t} - \sum_{n1 \in (n,n1) \in A} fl_{e,n,n1,t} = 0 \perp \lambda_{e,n,t} \text{ free } \forall e, n \in N_{TR}, t \quad \text{(B.2)}$$

The volumes bought by the transit country $transit_t$ are included in the second market clearing constraint as follows:

$$\sum_{e \in E} tr_{e,d,t} + sd_{s,t} - si_{s,t} - transit_t = 0 \perp \beta_{d,t} \text{ free } \forall d, t \quad \text{(B.3)}$$

AppendixC. Data and Sources

Table C.2: Data and Sources

Data	
Reference demand	Natural Gas Information 2016 (IEA, 2016), Medium-Term Gas Market Report 2015 (IEA, 2015b), World Energy Outlook 2015 (NPS) (IEA, 2015a)
Price elasticities	Growitsch et al. (2014) and Egging et al. (2010)
Reference price	Based on TTF 2014
Production costs	Hecking et al. (2016), Seeliger (2006) and Aguilera et al. (2009)
Existing pipeline infrastructure	Ten Year Network Development Plan (ENTSOG, 2015)
LNG facilities	Capacity Map GIE (2015), LNG Industry Report GIIGNL (2016)
Storage facilities	Gas Storage Map GIE (2015), Natural Gas Information 2016 (IEA, 2016)
Transportation costs	ACER Market Report 2014 ACER (2015b), Interfax (2015) and Pirani and Yafimava (2016)