Doctoral School of
Economics

THESIS SYNOPSIS

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Analysis of consumers' welfare on the European gas market

-

investigations based on gas market modelling

Ph.D. Dissertation

Supervisor:

Éva Berde, CSc.

Budapest, 2016.

Department of Microeconomics

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I. BACKGROUND

Natural gas markets are in focus nowadays due to different events and market trends. The most important are the Russian-Ukrainian conflict, the pressure on the Russian suppliers due to increase of global gas supply and the continuous regulatory intentions to facilitate the evolution of the more competitive and efficient natural gas wholesale markets.

In 2015 about 70 percent of European gas consumption was covered by import and this import dependency is expected to increase in the following years due to the continuous decrease of European inland production. Since the European gas import is mostly delivered by Russia, which is furthermore the only supplier in some of the member states, the conditions of long-term gas contracts between European countries and Russia and the Russian strategic behaviour are very important.

One possible way to quantitatively analyse natural gas markets is market modelling which synthetizes industrial organization models with a detailed database representing the real market circumstances.

This dissertation summarizes some of my analysis work which was carried out using gas market modelling. All analysed topics are in connection with market distortions due to Russian long-term contracts and the strategic behaviour of Russian supplier which have significant impact on the wholesale gas prices and consumers' welfare. During the analysis we endeavoured to examine practical problems and to find results which can support policy decisions.

The structure of my dissertation is the following. First the most important characteristics of European gas markets will be introduced mainly aiming to confirm the relevancy and actuality of the analysed problems. Then after a short summary of gas market models, the European Gas Market Model – the modelling tool used for the analysis is introduced. The main part of the dissertation contains three detailed analysis which investigate the most important factors of the consumers' welfare on the European gas markets.

II. MAIN CHARACTERISTICS OF THE EUROPEAN GAS MARKETS

However a slight convergence can be observed, there are still significant differences among the wholesale gas prices of different regions in Europe. In the Balkan region for example gas

prices are higher by 30 percent than the Western European spot prices (DG ENERGY (2015)).

Higher prices arise typically in those countries where there is a weak competition on the wholesale market and among suppliers. Only a few suppliers compete for the European markets: pipeline gas is delivered by Russian, Algeria and Norway while LNG is mainly delivered by Qatar, Algeria, Nigeria and the Middle East. According to the Monitoring Report of ACER 75 percent of the gas supply derives from one supplier (mostly Russia) in 10 member states. This dominant supplier has a significant market share and market power in more European countries. This implies that the conditions of Russian long-term contracts have an outstanding importance. Market distortions derive from these contracts and the possible regulatory solutions to eliminate them are analysed in the first analysis of my dissertation.

Week interconnection between certain European countries can also prevent from the development of effective competition. In the second analysis, the most important missing infrastructure in the European gas system will be identified assuming different market structures and demand scenarios.

In the recent past Asian gas prices have declined due the demand decrease and increase of global gas supply. The main reasons of the demand decrease are the cheap coal, the spread of renewable energy sources, the restart of nuclear power plants in Japan, and the low oil prices. These developments have increased the relative attractiveness of Europe for the LNG importer countries. The entry of new suppliers (such as USA) to the European gas markets have to be taken into consideration by the Russian exporter Gasprom. The third analysis included in the dissertation examines the possible entry strategies of US LNG to the European markets and the possible strategic response of Russia.

III. RESEARCH METHOD: GAS MARKET MODELLING

All analysis included in my dissertation was carried out by the European Gas Market Model developed by the Regional Centre of Energy Policy Research. In the followings the main characteristics of this model will be summarized compared to other models used in academic

literature.[1] It must be noted that all simulation runs were run and all calculations based on modelling results was carried out by the author.

The literature spanning equilibrium models for European natural gas markets is extensive. Prominent modeling tools are, for example, GASTALE (Boots et al, (2004), Egging and Gabriel (2006)), NATGAS (Mulder and Zwart (2006), Zwart (2009)), TIGER (Lochner and Bothe (2007), Lochner (2011), Dieckhöner et al(2013)), GASMOD (Holz et al (2008)), World Gas Model (Egging et al (2010)), Global Gas Model (Holz et al (2013), Richter and Holz (2015)). Smeers (2008) provides an in depth analysis of the models prior to 2008.

The EGMM differs from these models in several aspects. The most important advantage it has, particularly in this instance, is a detailed representation of long-term take-or-pay contracts that allows Russian long-term contracts and European gas prices to interact under different scenarios. This also allows for the examination of the effects of virtual reverse flows. While most models are based on the strategic behavior of the Cournot-game framework with competition amongst market participants, the EGMM assumes that all market participants are price takers. Working with perfectly competitive equilibrium has drawbacks, but our assumption is that most upstream market power is exercised within the context of long-term contracts and the market operates more like the competitive benchmark in the short run. The price-taking assumption allows for more detailed geographic and temporal dimensions. While modeling literature often merges smaller neighboring markets especially in South Eastern Europe, we only aggregate demand at the country level. Demand functions in the model are assumed to be price responsive which allows for detailed social welfare analysis. Whereas the cited models typically include only 1-3 seasons per year, the EGMM timeframe is broken into monthly periods. This monthly division is particularly important for market disruption scenarios, which tend to be short-lived, and it also allows for the effect of seasonal storage activities to be observed.

IV. MAIN RESULTS

In the followings the main results of the three analysis presented in the dissertation will be summarized.

[1] Detailed model description can be found in (Kiss et al. (2015))

IV.1. Short-term effects of the Ukrainian crisis on the security of gas supply in Central-Eastern Europe and Hungary[2]

In Chapter 6 of the dissertation the vulnerability and the short term resilience of the European gas market to supply side shocks are modelled. We analyse the effect of some short-term regulatory interventions on the wholesale gas price and consumers' welfare of the most vulnerable Central and Eastern European gas markets in the case of a security of supply crisis.

Two security of supply scenarios are modelled:

- A short-term security of supply situation is modelled through a one month disruption of Russian gas supplies through Ukraine in January.
- A longer-term crisis is modelled through a six-month disruption on the same route.

Three short term regulatory measures were analysed that aim to increase the resilience of gas markets to supply disruptions in the short run through the better use of existing infrastructure:

- allowing spot trade on all interconnection points;
- allowing virtual trade against the physical flow;
- allowing bidirectional flows on all EU-EU borders.

In the followings the main effect of this three regulatory measures will be summarized. All parts of the analysis were carried out by using European Gas Market Model introduced before.

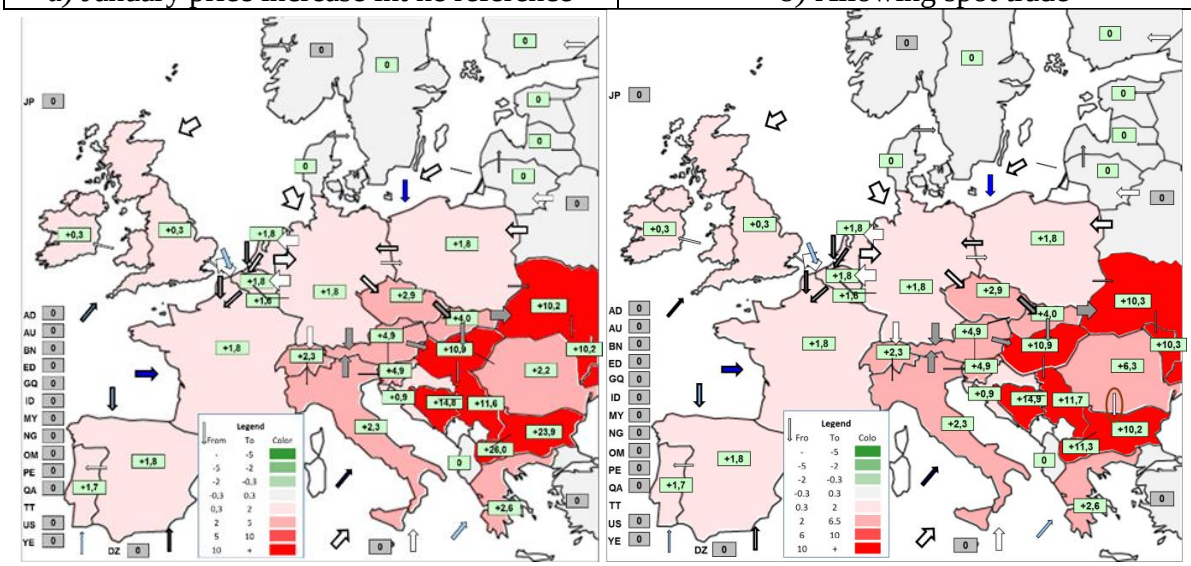
Allowing spot trade on the interconnection points

In this section we analyse the effect of allowing short-term (spot) trade on the gas interconnector from Romania to Bulgaria. The capacity of this interconnector is currently booked by Gasprom and it is not possible to use these capacities even if they are not fully used by long-term Russian gas deliveries. Modelling results are summarized in Figure 1 and Table 1.

[2] This chapter is based on Selei-Tóth (2015a)

Figure 1 Price increase due to a one month disruption of Russian deliveries through Ukraine in case of allowing spot flows compared to the reference case (€/MWh)

a) January price increase int he reference	*b)* Allowing spot trade



Note: green boxes show the price increase (in €/MWh) due to a short-term security of supply crisis compared to the normal (without crisis situation). Colouring is in line with the seriousness of price increase: darker colour means higher price increase.

Source: Selei-Tóth (2015a) – output of gas market model

In line with our expectations due to allowing spot trade on the interconnector between the significantly cheaper Romania and the more expensive Bulgaria, the price growth in Romania due to a short-term crisis increases by 5.8 €/MWh, while price increase in Bulgaria and Macedonia drops by 16.4 €/MWh.

Table 1 Price and consumer welfare change due to allowing spot trade compared to the reference case in the case of short and long-term security of supply crisis[a]

	Wholesale gas prices (€/MWh)				Consumer's welfare (million €)			
	January		Six months		January		Six months	
	Absolute price	Change	Average price	Change	Absolute value	Change	Absolute value	Change
Austria	28.6	0.0	27.3	0.0	340.6	0.0	1696.2	0.0
Bosnia-Hercegovina	42.3 (37)	0.1	49.5 (46.7)	0.0	3.0 (3.7)	0.0	11.8 (13.5)	0.0
Bulgaria	34.0	–16.4	38.6	–20.8	122.7	60.4	454.1	288.7
Greece	26.8	0.0	25.5	0.0	111.1	0.0	599.4	0.0
Croatia	27.9	0.0	29.8	0.0	86.5	0.0	444.3	0.0
Hungary	37.5 (32.1)	0.1	45.4 (42.0)	0.0	309.4 (374.0)	–1.0	988.1 (11 44.7)	0.0
Italy	26.9	0.0	26.9	0.0	3178.2	0.0	14 344.7	0.0
Macedonia	37.0	–16.4	41.4 (41.1)	–20.8	3.2	1.7	16.0 (16.3)	10.6
Moldova	38.5 (36.6)	0.1	48.3 (47.7)	0.0	26.1 (28.0)	–0.1	87.8 (90.0)	0.0
Poland	26.6	0.0	25.9	0.0	658.8	0.0	3 320.2	0.0
Romania	31.1	5.8	35.6	7.1	316.9	–64.5	1 422.2	–389.5
Serbia	40.3 (35.0)	0.1	47.6 (44.7)	0.0	63.1 (77.0)	–0.2	263.1 (300.0)	0.0
Slovenia	29.9	0.0	28.3	0.0	29.8	0.0	146.4	0.0
Slovakia	27.7	0.0	26.7	0.0	271.5	0.0	1 172.1	0.0
Ukraine	34.6 (32.8)	0.1	44.5 (43.9)	0.0	2 191.5 (2 337.5)	–7.0	6 413.7 (6 564.9)	0.0
Regional average/total	30.3 (29.5)	0.1	33.0 (32.7)	0.2	7 712.4 (7 939.5)	–10.7	31 380.0 (31 755.0)	–90.2
EU-average/total	25.5 (25.4)	0.0	25.1 (25.0)	0.1	19 435.6 (19 500.1)	–5.1	90 455.4 (90 638.1)	–100.8

[a] The values in the brackets show the same values assuming that Hungarian strategic storage stocks are released. The analysis of these results are not detailed here.

Source: Selei-Tóth (2015a) – own calculations based on gas market model

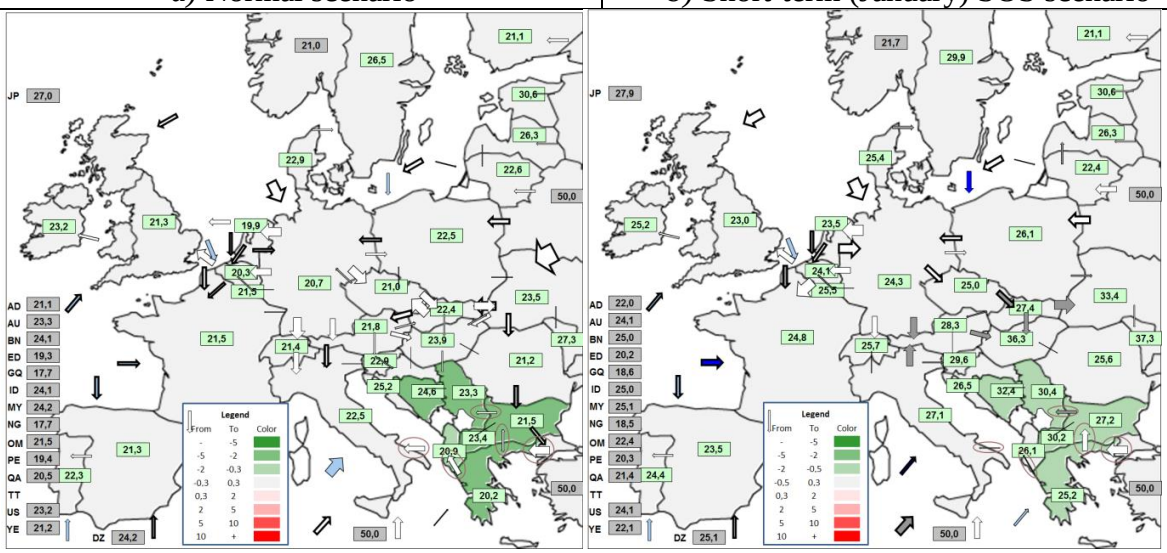
Table 1 shows that allowing spot trade has only a local effect: it improves the situation of the Bulgarian and Macedonian consumers, while worsen the situation of Romanian consumers. As the gas demand in Romania is triple than the sum of gas demand in Bulgaria and Macedonia, the overall consumers' welfare decreases. However this decrease is overbalanced by the welfare change of other market participants, mainly the Romanian producers.

The effect of allowing virtual reverse flows

In the followings we analyse the effects of allowing virtual reverse flows (backhaul) on a certain delivery route. To examine this question we assume that Trans-Adriatic Pipeline (TAP, which delivers Azeri gas from Turkey through Greece and Albania to Italy) and two connecting interconnectors (Greek-Bulgarian and Bulgarian-Serbian) come online. The results are summarized in Figure 2 and Table 2.

Figure 2 The effect of allowing virtual reverse flows on the Trans-Adriatic Pipeline in case of normal and short-term SOS scenarios

a) Normal scenario	*b)* Short-term (January) SOS scenario



Note: Green boxes show the wholesale gas prices allowing virtual reverse flow on TAP in €/MWh: a) yearly average, b) January prices. Colouring shows the price decrease due to virtual reverse flow. Circled arrows show the assumed new infrastructure

Source: Selei-Tóth (2015a) – output of gas market model

Table 2 Effect of allowing virtual reverse flows on the wholesale gas prices and consumers' welfare

	Wholesale gas prices (€/MWh)			Consumer's welfare (million €)		
	in normal scenario	in short-term SOS scenario	in long-term SOS scenario	in normal scenario	in short-term SOS scenario	in long-term SOS scenario
Austria	0.1	–0.2	0.2	–5.6	1.8	–9.5
Bosnia-Hercegovina	–2.1	–1.5	0.0	3.4	0.2	0.0
Bulgaria	–2.4	–0.6	–0.7	90.6	2.9	13.9
Greece	–2.2	–0.6	–0.8	78.0	2.2	14.1
Croatia	0.0	0.0	0.0	–0.8	0.0	–0.7
Hungary	–0.1	0.0	–0.1	6.1	0.5	6.4
Italy	0.2	0.2	0.2	–86.5	–18.0	–86.1
Macedonia	–2.2	–0.6	–0.8	3.5	0.1	0.6
Moldova	0.0	0.0	–0.5	0.5	0.0	2.1
Poland	0.0	–0.1	0.1	–4.9	2.0	–9.9
Romania	0.0	–0.1	–1.1	3.0	1.5	65.0
Serbia	–2.1	–1.5	0.0	66.2	4.5	0.0
Slovenia	0.1	–0.2	0.2	–0.4	0.2	–0.8
Slovakia	0.0	–0.2	0.1	–0.9	1.4	–4.6
Ukraine	0.0	0.0	–0.5	28.2	3.4	140.2
Regional average/total	–0.2	0.0	–0.1	180.2	2.7	130.6
EU-average/total	0.0	–0.1	0.0	–12.6	36.2	–91.9

Source: Selei-Tóth (2015a) – own calculations based on gas market model

It can be seen that in case of normal scenario in Bulgaria, Macedonia, Serbia and Bosnia Hercegovina prices decrease by more than 2 €/MWh due to allowing virtual reverse flows. However in Italy a slight price increase arises, as less Azeri gas reach Italian market.

Concerning consumer welfare it is worth noting that the previous countries can realize most of the consumer welfare growth already in the normal scenario, in the SOS scenarios this effect is less important.

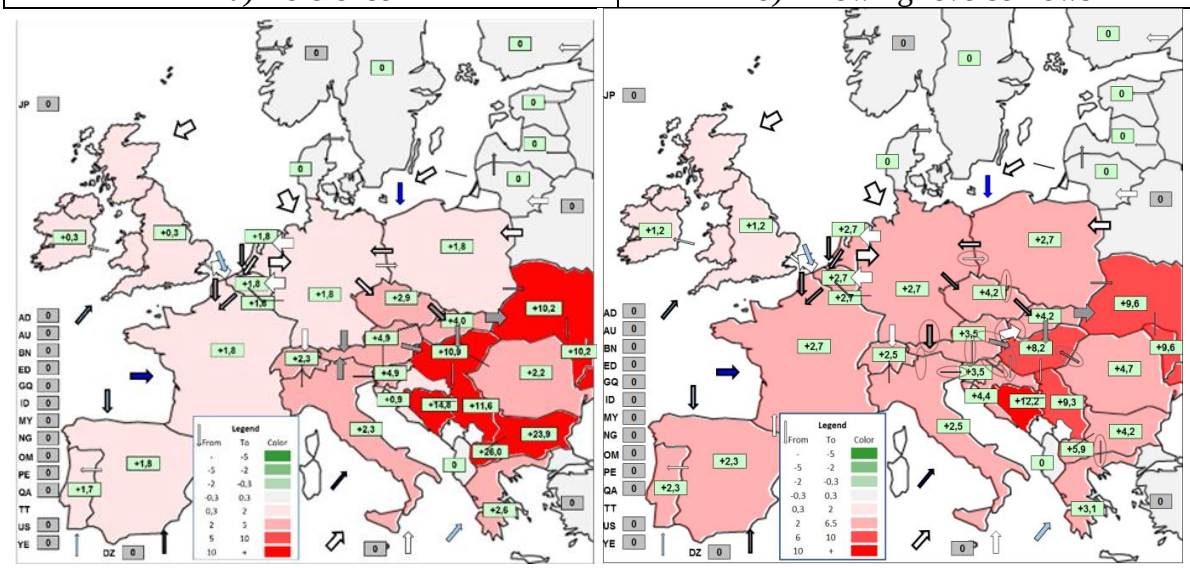
The effect of allowing reverse flow on existing pipelines on the regional security of supply

In the followings we analyse the situation when regulation obligates to allowing reverse flow on all existing pipelines of EU-EU borders up to total capacity.

Figure 3 shows the market integration effect of allowing reverse flows: while in the analyzed region the price growth due to a security of supply crisis decreases, price growth in Western European countries slightly increase.

Figure 3 Price increase due to a January SOS crises in the reference scenario and allowing reverse flows (€/MWh)

a) Reference	*b)* Allowing reverse flows



Note: green boxes show the price increase (in €/MWh) due to a short-term security of supply crisis compared to the normal (without crisis situation). Colouring is in line with the seriousness of price increase: darker colour means higher price increase.

Source: Selei-Tóth (2015a) – output of gas market model

Table 3 summarizes the effect on wholesale gas prices and consumers' welfare.

Table 3 Change of wholesale prices and consumers' welfare due to allowing reverse flows in case of short- and long-term SOS scenarios

	Wholesale gas prices (€/MWh)				Consumer's welfare (million €)			
	January		Six months		January		Six months	
	Absolute price	Change	Absolute price	Change	Absolute value	Change	Absolute value	Change
Austria	27.1 (27.0)	–1.5	25.9	–1.4	357.1	16.6	1 771.0	74.8
Bosnia-Hercegovina	39.6 (36.1)	–2.6	46.0 (45.1)	–3.6	3.4 (3.8)	0.3	14.0 (14.5)	2.2
Bulgaria	28.6	–21.6	28.8	–30.6	146.4	84.1	639.7	474.3
Greece	27.3	0.5	27.2	1.7	109.4	–1.7	568.9	–30.6
Croatia	30.5 (27.0)	2.7	37.0 (36.1)	7.2	79.4 (88.8)	–7.1	346.6 (358.4)	–97.7
Hungary	34.7 (31.2)	–2.6	41.3 (40.3)	–4.1	341.7 (3 85.4)	31.2	1 178.0 (1 222.4)	189.8
Italy	26.9	0.0	26.6	–0.3	3 178.2	0.0	14 499.7	155.0
Macedonia	31.8 (31.7)	–21.6	31.7	–30.6	3.9	2.3	23.0	17.6
Moldova	37.5 (36.4)	–0.9	47.1 (46.1)	–1.2	27.1 (28.3)	0.9	92.8 (96.9)	5.0
Poland	26.9	0.4	25.7	–0.2	650.6	–8.2	3 336.7	16.6
Romania	27.8 (24.8)	2.5	33.8 (33.0)	5.3	353.1 (387.6)	–28.2	1514.3 (15 56.8)	–297.5
Serbia	37.6 (34.1)	–2.6	44.0 (43.1)	–3.6	70.0 (79.5)	6.7	309.9 (321.9)	46.8
Slovenia	28.4 (28.2)	–1.5	27.2	–1.1	31.3	1.5	151.8	5.4
Slovakia	27.5	–0.2	26.2	0.0	273.0	1.5	1 173.5	1.5
Ukraine	33.6 (32.5)	–0.9	43.3 (42.3)	–1.2	2 269.6 (2 359.3)	71.1	6 749.8 (7 023.0)	336.0
Regional average/total	29.2 (28.5)	–1.0	32.2 (31.9)	–0.6	7 894.1 (80 88.0)	170.9	32 369.5 (32 758.1)	899.3
EU-average/total	25.9 (25.7)	0.5	25.2	0.2	19 180.5 (19 317.4)	–60.3	90 202.7 (90 301.5)	–353.6

[a] The values in the brackets show the same values assuming that Hungarian strategic storage stocks are released. The analysis of these results are not detailed here.

Source: Selei-Tóth (2015a) – own calculations based on gas market model

It can be seen that Bulgaria and Macedonia realize the highest benefits due to the interconnection with Greece. Significant benefits also arise in Hungary, Serbia and Bosnia-Hercegovina due to Hungary's interconnection with Romania and Croatia. However prices increase in Greece, Romania and Croatia, the overall effect on the regional consumer welfare is positive.

Looking at the utilization of these reverse flow capacities it can be seen that the most important ones are the German-Austrian, Romanian-Hungarian, Croatian-Hungarian and Greek-Bulgarian interconnectors.

During the analysis we overall found that the first two regulatory measures (allowing spot trade and virtual reverse flows) have rather local effect on the markets, but bidirectional physical flows increase the security of supply of the whole region - mostly because of better

connecting Central and Eastern Europe to the Western gas markets. Modelling the three measures together we found that Hungarian consumers realize significant part of the monetized benefits that we measure; hence Hungary has a profound interest in supporting the European gas market integration. In the analysis we also found that the Hungarian strategic storage is a useful tool to mitigate the damages of a potential crisis not only within the Hungarian borders but also on a regional basis.

IV.2. A top-down approach to identify the most important natural gas cross-border infrastructure projects[3]

This chapter identifies the most important missing natural gas interconnections under varying market circumstances based on gas market modelling. Apart from analyzing the current market structure we also carry out the examination in an innovative way: we change the delivery points of Russian gas supply contracts to the borders of the EU, excluding Ukraine which is in line with the will of Russia.

As whole version of this paper is written in English (Selei-Tóth (2015b)) and attached to my documentation, here I only summarize the main conclusions:

1. Beyond the expansion of existing infrastructures (Austria to Hungary in 2015; Germany to Austria in 2020), the identified infrastructures to be implemented (with predefined routes for long term contracts) are the full reverse flow on the Romanian-Hungarian, the Romanian-Moldavian 1,5 bcm/yr pipeline, the 5 bcm/yr interconnector between Greece and Bulgaria, and the Bulgarian – Serbian 3 bcm /yr interconnector and by 2020 also the Bulgarian-Romanian interconnector.
2. Modelling runs for 2015 show that with current destination restrictions in long term contracts additional interconnections between markets will create losses on European level. In the 2020 scenario, however, mainly due to the phasing out of long term contracts, the social welfare impact of new infrastructure becomes significantly higher and positive in the EU28. The policy implication is that by 2020 there will be substantially less incentive for market participants to delay the identified projects.
3. Beyond assumptions in the present structure and route of Russian long term contracts in the 2020 setup, key natural gas infrastructure was also identified more innovatively: Russian gas was delivered exclusively to EU borders outside of Ukraine at the same

[3] This chapter is based on the working paper Selei-Tóth (2015b) which was submitted to The Energy Journal and currently is under review.

price (23 €/MWh) for all buyers, leaving market forces to handle the internal distribution of the gas between countries. For this scenario the pre-requisite is that two strings of the Turkish Steam are built (30 bcm/yr), the Turkey- Greece interconnector is extended, and reverse flow on Trans-Balkan is allowed between Turkey and Bulgaria. In this scenario on top of the defined key projects of point 1 the Polish-Slovakian interconnector assumes a significant role in delivering Russian gas from Yamal to CSEE.

4. Only the structural change in Russian delivery points at EU borders (without any PCI project built) would bring benefits to the region of a similar magnitude as building all of the infrastructures identified for 2020 integration, however the position of the market participants shifts substantially. LTC holders would benefit considerably by eliminating contract routes, but the total welfare change for most of the CSEE regions (except for Bulgaria) would be negative.
5. Modelling LTC delivery point changed to EU borders together with the PCI projects of point 1 plus Polish-Slovakian interconnector positive welfare change results triple: besides LTC contract holders, also consumers and TSOs would become beneficiaries of the structural change. Thus the Russian President might inadvertently encourage a more competitive and efficient European gas market by freeing up delivery points in the existing contracts.
6. Finally, the demand scenario analysis that quantifies gas consumption savings due to energy efficiency and RES development shows that average European-wide wholesale gas prices would decrease an average of of 2.3 €/MWh. These measures also solidify the utilization of the identified key pipeline infrastructure.

IV.3. Modelling of market strategies in connection with the entry of US LNG to the European market

Although a few years ago US LNG deliveries into Europe seemed to be a utopia in the latest months it has started to materialize as the first contracts were signed with a delivery in 2018. The showing up of US gas in the European markets is due to two main factors. First, the non-conventional gas production revolution in the US pushed down the prices on the US market and increased the global gas supply, and the decrease of Asian gas prices (due to the previously mentioned reasons) has also increased the relative attractiveness of the European prices.

The arrival of US deliveries into Europe is expected to strengthen Europe's position against Russia. Therefore Russia will probably make strategic response keep its current market position.

This chapter of my thesis analysis the optimal entry strategy of US and the possible strategic responses of Russia in a simple game theoretic framework.

IV.4. Possible strategies of Russia

In my thesis it is shown that Russia has a favourable position to be able to protect its current market share in the European market. Its production cost structure makes it to be able to give significant price discounts. Based on Henderson et. al. (2014) we assume that Russian gas can be sold at a price of 4.5 $/MMBtu in Western Europe.

We analyse three possible strategies of Russia:

- **Focus on market share (SPOT):** selling low-priced spot gas on the European market
- **Achieving higher prices in Europe (ACQ):** Russia can try to preserve its price-setting role by reducing TOP quantities and limit spot sales
- **Price discount of contracted deliveries (PRICE):** Russia tries to increase its sales by give price discounts in the case of long-term contracts differentiating between markets

In our sequential market game first the US traders decide whether they enter into European market or not. If they decide to enter, they can choose from three different prices:

- They are selling at a minimum price of 7.4 $/MMBtu on average in Europe. This case is in line with our modelling reference scenario.
- They are selling at a minimum price of 6.5 $/MMBtu on average. Based on market information this is "good enough" price for the American traders.
- They are selling at a minimum price of 5 $/MMBtu on average, which is estimated to be enough to cover the marginal cost of US gas's delivery into Europe.

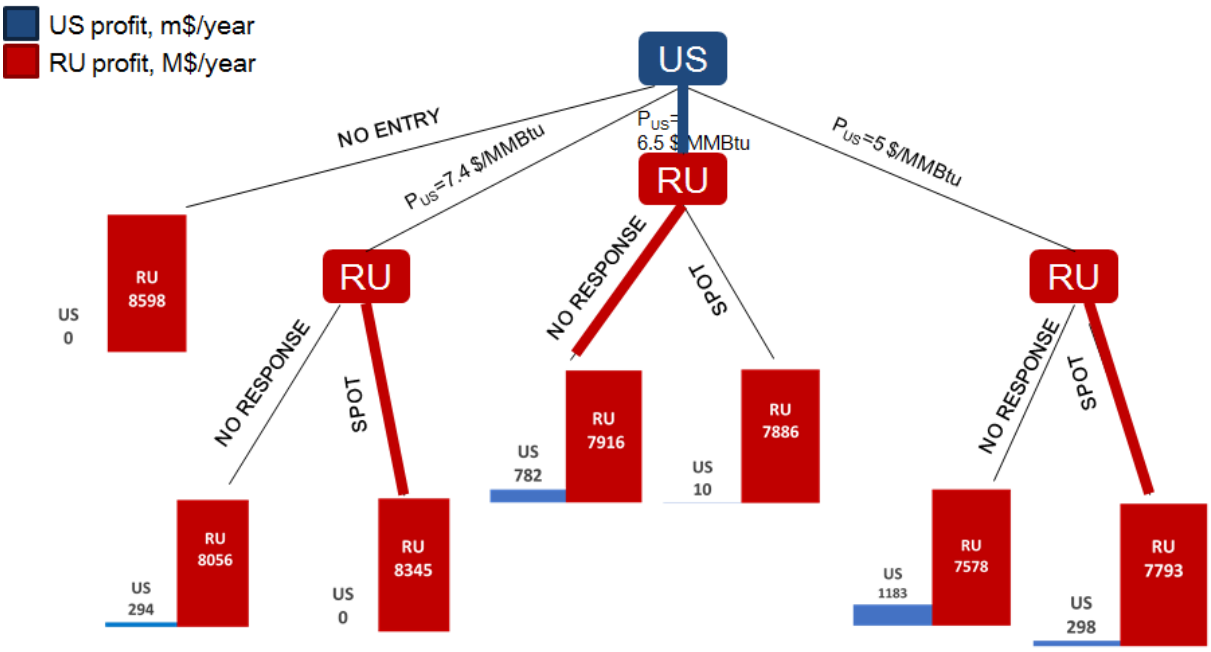
All of these prices are the minimum prices at which Americans are willing to sell on average; however the actual selling prices are depends on the equilibrium market prices of LNG importer countries.

After observing the decision of American traders, Russia selects its best response from the abovementioned possible actions.

In the case of all outcomes the profits of American and Russian parties were calculated based on the market modelling results. Based on (Henderson et.al., 2014) we assumed that the marginal cost of Russia to deliver their gas to Western Europe is 4.5 $/MMBtu.

Assuming that the players maximize these profits we are looking for the sub-game perfect equilibrium. Payoffs (profits) of the market players and their optimal decisions are depicted in Figure 4.

Figure 4 Payoffs of the different market players and optimal decisions



Source: own figure based on own calculations

In the subgame perfect equilibrium the optimal strategy for the American traders is to enter the European market at a minimum price of 6.5 $/MMBtu. The best response from Russia is to selling low-priced spot gas on the European market when US LNG enters at low (5 $/MMBtu) or high (7.4 $/MMBtu) price, and not to response when US LNG enters at middle price.

Based on the modelling results and the solution of the game described before the following main conclusions can be drawn:

- Assuming that US LNG enters at 7.4 $/MMBtu price RU would react by selling more gas on spot market or auctions. By that some (Western) European countries would reduce their Russian LTC offtake to the minimum level, and buy RU spot gas instead of US LNG. RU would earn a bit more on the auctions than what it would loose on reduced LTC offtakes.

  These results are in line with the fact that Gazprom started first spot auctions just recently, in September 7-10, 2015, and plans to hold its next gas auction by the end of 2015.

- For Russia selling on the spot market is always a better strategy than to give price discount on LTCs or reducing ACQ levels.
- However Russia would not respond to US LNG entering to Europe at a US selling price of around 6.5 $/MMBtu. In this case income on spot sales would not compensate for losses on LTC offtakes.
- At the 5 $/MMBtu US price the offtake of Russian LTCs is anyway on the minimum level. This is why spot sales are increasing the RU profit.

It is worth noting that during the analysis we assumed that the main objective of Russia is the profit maximization. However other strategic objectives are also possible, for example deterring US from entry.

V. CONCLUSIONS

As the gas import dependency of Europe is expected to grow in the near future, the competition between the main importers, and strategic behaviour of Russia has a significant impact on the wholesale gas prices and consumers' welfare. Investment into missing infrastructure also has an outstanding importance. In this dissertation summarize three analysis which examine these questions using gas market modelling.

In Chapter 6 of the we analyse the effect of some short-term regulatory interventions on the wholesale gas price and consumers' welfare of the most vulnerable Central and Eastern European gas markets in the case of a security of supply crisis. While those interventions which concern only one interconnector have typically local positive effect, allowing bidirectional flows significantly improve the security of supply situation in CEE due to better interconnection with Western markets.

The aim of Chapter 7 of the dissertation was to identify those missing infrastructure elements which are necessary for the European gas market integration. We also calculated the welfare effects of these interconnectors and compared to the investment costs. We find that a small number of projects are sufficient to maximize the net gain in regional welfare, but different scenarios favour different project combinations.

Chapter 8 of the dissertation analyses the effect of supply increase in the global gas market: potential entry strategies of US LNG and the possible strategic response of Gazprom. The results show that if US LNG enters the European market at low or high prices the best response of Russia is to sell cheap gas on spot markets. This is in line with the spot gas

auctions held by Gazprom in 2015 September. There is however a middle level of US LNG price next to which it is not profitable for Gazprom to make strategic response.

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