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Representing GASPEC with the World Gas Model[1]

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Abstract

This paper presents results of simulating a more collusive behavior of a group of natural gas producing and exporting countries, sometimes called GASPEC. We use the World Gas Model, a dynamic, strategic representation of world gas production, trade, and consumption between 2005 and 2030. In particular, we simulate a closer cooperation of the GASPEC countries when exporting pipeline gas and liquefied natural gas; we also run a more drastic scenario where GASPEC countries deliberately withhold production. The results shows that compared to a Base Case, a gas cartel would reduce total supplied quantities and induce price increases in gas importing countries up to 22%. There is evidence that the natural gas markets in Europe and North America would be affected more than other parts of the world. Lastly, the vulnerability of gas importers worldwide on gas exporting countries supplies is further illustrated by the results of a sensitivity case in which price levels are up to 87% higher in Europe and North America, but non-GEC countries increase production by a mere 10%.

Keywords: natural gas, trade, cartel, collusion, World Gas Model

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1 Introduction

The scenario of a cartel of natural gas producers, sometimes called a “GASPEC”, is an important issue in international natural gas trade and has occupied a central role in the Energy Modeling Forum (EMF) 23 study (EMF, 2007). The three countries with the biggest natural gas reserves account for more than 50%: Russia: 25%, Iran: 16%, and Qatar: 14%, (BP, 2008). Dwindling gas reserves in worldwide markets contribute to worries over future gas supplies and prices, and, although the world’s reserves-to-production ratio is about 60 years, it is much lower for North America (10 years) and Europe (24 years). Over the years, many countries have become largely dependent on importing gas and due to depletion of reserves more countries will rely on imports to cover significant parts of their gas consumption. Security of supply has become a concern of import-dependent countries, encompassing both infrastructural risks as well as political and economic dependencies (Stern, 2007).

Proving the existence of cartel behavior in real markets is difficult. Salant (1976) and Pindyck (1978) were among the first to address the market power of OPEC in the global oil market. Al-Qahtani et al. (2008) provide an extensive literature overview of the research related to the role of OPEC in the global oil market. To the best of our knowledge there is no model available to-date to adequately characterize the effects of cartel behavior in the world gas market. So far, the treatment of a potential gas cartel has been mainly qualitative, with some quantitative support from models that were not originally designed for such analysis. For example, Perner and Seliger (2003) introduce cartel behavior “by hand” in an otherwise competitive model of international gas trade. They show lower pipeline expansion by the cartel members, and higher investments by the fringe; LNG expansion proceeds slower in the Cartel Case, too. Since Perner and Seeliger (2003) assume Russia not to be part of the cartel, comparisons should be drawn with care. The difficulties of implementing cartel behavior in models of international gas trade was also the reason why, despite some discussion, no “Cartel Case” was explicitly included in the EMF 23 scenario design (see EMF, 2007).

Another important issue for future natural gas trading is the development of capacities, both upstream (i.e., in natural gas production, pipelines, and LNG liquefaction capacities), and downstream (i.e., regasification terminals, storage, and distribution pipeline systems). Major investments in infrastructure will be necessary in the coming decades to transport additional volumes of natural gas over increasingly longer distances, needing several trillions of dollars (See e.g., Cayrade, 2004, Finon and Locatelli, 2008, and IEA, 2003). However, so far research has not explicitly considered the impact that different market structures could have on the types of infrastructure, capacity expansions and the capital needs.

In this paper, two important topics in the longer-term future of the natural gas industry are explored: the potential forming of a closer collusion between some exporting countries, and investments in infrastructure. The World Gas Model (WGM), a dynamic strategic representation of world gas production, trade, and consumption between 2005 and 2030 is used for the analysis. WGM is an extension of the European Gas Model described in Egging et al. (2008). The main contribution of this paper is: i) to illustrate how and where market driven infrastructure expansions will occur over the next decades; and ii) how more collusion in the global natural gas market could affect capacity expansions, trade-flows, consumption, production and price-levels in the period up to 2030.

The organization of this paper is as follows: in Section 2 there is a brief discussion of the likelihood of a cartel by a group of exporting countries; Section 3 illustrates some technical modeling aspects and the main features and extensions of the World Gas Model, including mixed complementarity problem (MCP) and cartel modeling, as well as an introduction to the endogenized investment decisions. Section 4 describes the data and the cases analyzed: a Base Case and a Cartel Case, for the period 2005-2030. In addition, a scenario is run where the production capacities of certain exporting countries is constrained exogenously. Section 5 provides a discussion of results and their interpretation. Lastly, section 6 provides conclusions and possible future research directions.

2 From GECF to GASPEC?

The development of the "Gas Exporting Countries Forum" (GECF) has spurred concerns about the potential forming of a cartel of the world natural gas markets. The GECF was formally set up in 2001. Since then, it has developed into a formal organization with broadening membership.[2] Several GECF countries are also OPEC members.

Is there a real danger of the GECF becoming a cartel, with a prominent role such as OPEC in the petroleum industry? The literature is divided on this issue, and so are industry experts and politicians. On the one hand, it is argued that the danger of a cartel is high. Observers point to the fact that OPEC, created in September 1960, also was slow in becoming a serious organization, but became so in the wake of the world oil market turmoil in 1973. Recent moves of individual countries show a tendency towards collusion in gas as well. Thus, Darbouche (2007) indicates closer Russian-Algerian gas cooperation, based on an extensive Memorandum of Understanding. According to Darbouche (2007), the GECF suffers from weak institutional and organizational structure, but these conditions could change with Russia's recent involvement. Ehrman (2006) shares this view, when describing various possible structures that a gas cartel could evolve to. She addresses how ties among the GECF countries have gradually strengthened and become more formal over the past few years, as well as some actions taken by the member countries to enhance information exchange and natural gas market analysis.

On the other hand, one might argue that parallels between GECF and OPEC are artificially made up, and that the gas markets are less subject to market power than the world oil markets. It is argued that the long-term contracts in the gas business would make short-term oligopolistic behavior unrealistic. Also, the interests of the GEFC-members, ranging from Iran to Norway (as observer) might be too diverse to pursue joint action (Hallouche, 2006). Finon and Locatelli (2008) analyze several possible forms of collusion, focusing on Russia. They conclude that in the short-term the chance of a successful cartel with just a few members is low since the barriers to entry are rather low for Gazprom's main competitors in the European market. In particular, the North Sea production is a competitive force that may counter-balance the Russian position in the next 20 years. Last but not least, it can be argued that the oil price indexation of many traditional gas contracts already emulates cartel (OPEC) behavior. See also Wagbara (2007) on different interpretations of the GECF.

3 Modeling Aspects

3.1 An Equilibrium Model of Natural Gas Markets: the World Gas Model

The World Gas Model (WGM) is a multi-period, mixed complementarity model for the global natural gas market, allowing for capacity investments in the liquefied natural gas (LNG), pipeline and storage sectors. The model contains more than 80 countries and regionsand covers about 98% of world wide gas production and consumption. It is an equilibrium model that includes game-theoretic elements by allowing for Nash-Cournot type market power of individual producers (via their dedicated traders arms) as well as for collusion among groups of natural gas suppliers.

For each market (country) covered, three seasons are modeled (low, peak, high) with the market participants including producers and their marketing and trading arms (traders), pipeline operators[3] and storage operators, LNG liquefiers, regasifiers, tankers (implicitly), marketers (implicitly), and consumers in three sectors (residential/commercial, industrial, and power generation) via their aggregate inverse demand functions. These players, except for LNG tankers, marketers and consumers, are modeled via (convex) optimization problems whose necessary and sufficient Karush-Kuhn-Tucker (KKT) optimality conditions when combined with market-clearing conditions comprise a market equilibrium formulation (Gabriel et al., 2005ab; Egging and Gabriel, 2006; Egging et al., 2008). The optimization problems of the

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[2] In 2008, the GECF comprised Algeria, Bolivia, Brunei, Egypt, Equatorial Guinea (observer), Indonesia, Islamic Republic of Iran, Libya, Malaysia, Nigeria, Norway (observer), Qatar, Russian Federation, Trinidad & Tobago, United Arab Emirates and Venezuela (www.gecforum.com.qa, July 4, 2008)).

[3] For technical reasons, the functions have been split into two transportation players: one for operations and one for investment decisions.

players are typically profit maximization objectives subject to operational/engineering constraints, with all players except for the traders and the regasifiers being price-takers in the production, transportation, and storage markets. By contrast, the traders and regasifiers are allowed to behave strategically in multiple countries and can withhold gas to downstream customers to maximize their profits.

The producer sells gas directly to its dedicated pipeline trading arm (trader) as well as to the LNG liquefier. The trader then sells to the storage operator and the marketer, the latter being the interface with the three consumption sectors (residential/commercial, industrial, power generation). Each trader can be active in different countries, namely all those countries that he can reach by pipeline. The liquefier sells to a regasifier at an LNG import terminal. The regasifier in turn sells to the storage operator and the marketer. The storage operator, finally, sells to the marketer taking advantage of seasonal arbitrage by buying gas in the low demand season and selling it to the marketer in the high and peak seasons.

Modeling traders as separate participants increases model transparency by clearly splitting production and pipeline sales/export aspects and it is also consistent with legal requirements forcing unbundling of production and trade operations. Examples of traders in this sense in today's natural gas marketplace include Gazexport for Gazprom (Russia) and GasTerra for NAM (Nederlandse Aardolie Maatschappij).

3.2 Mixed Complementarity Problems and Investments

To compute market equilibria often the mixed complementarity problem (MCP) formulation is used (Facchinei and Pang, 2003). Each of the players (e.g., producers) is represented by a profit maximization problem subject to engineering or operational constraints. If players act non-cooperatively à la Nash-Cournot, then they need to take into account the actions of their competitors in this profit maximization. Taking together all the Karush-Kuhn-Tucker (KKT) optimality conditions for the players, combined with appropriate market-clearing conditions, then gives rise to an MCP.

Typically, MCPs for computing market equilibria do not include investments as decision variables. There are at least two reasons for this. First, investments are usually discrete choices corresponding for example to build/not build decisions or integer levels of the investment. If the integrality restrictions are taken into account at the same time as the MCP, the resulting problem is difficult to solve and in some cases there may not be a solution. Several examples that do combine these two aspects of market equilibria include the work of García-Bertrand et al. (2005, 2006) and Gabriel et al. (2006) in which electric power markets are modeled with the ability to keep/reject certain generators based on market conditions.

A second reason that investments are not always combined with MCPs is that there is a sequential aspect that must be considered. Typically, the investment decisions are made first, for example corresponding to long-term planning. Then, the market is considered with a fixed set of investments or network. This usually leads to a two-level problem which can be computationally more challenging than an MCP. In practice, researchers often either fixed the level of investments exogenously or take a continuous relaxation of the integer restrictions but mostly in the context of solving an optimization problem and not an MCP. In this paper we have adopted the latter relaxation approach since combining investments with MCPs is already a challenging strategy. Lise et al. (2008) adopt a similar approach but with less detail for the market players. The following illustrates how the investment decisions have been implemented in the MCP framework. Consider an economic agent in a simplified multi-period setting. The agent has perfect foresight and must decide on his sales $SALES_y$ and capacity expansions Δ_y in each year *y*. The selling price π_y is exogenous to the agent, and his costs are given by a convex function: $c_y(SALES_y)$. The initial capacity is $\overline{CAP}$; the costs for capacity expansion are b_y per unit; and there is an upper bound on the maximum expansion in each year $\overline{\Delta}_y$. Finally, γ_y is the discount factor for future cash flows. The mathematical formulation for this simplified problem is as follows: (symbols in parentheses are dual prices.)

$$\max_{SALES_y, \Delta_{lm}^L} \sum_{y \in Y} \gamma_y \left\{ \pi_y SALES_y - c_y(SALES_y) - b_y \Delta_y \right\} \tag{0.1}$$

$$s.t. \quad SALES \le \overline{CAP} + \sum_{y'<y} \Delta_{y'} \quad \forall y \quad (\alpha_y) \tag{0.2}$$

$$\Delta_y \le \overline{\Delta}_y \quad \forall y \quad (\rho_y) \tag{0.3}$$

3.3 Representation of Market Power in WGM

In the present configuration of the World Gas Model, the market power lies with the pipeline trading arm of the producer (trader) and with the last element of the LNG value chain, the regasifier. This differs from the version of the World/European Gas Model in Egging et al. (2008) where only the traders exerted market power due to the focus on the European pipeline market. Both types of players, traders and regasifiers, are chosen for modeling reasons because they are the agents that face the final demand function emanating from the market (marketer). Facing the final demand allows them to manipulate it (that is, to take it into account in their profit optimization program) in case they have market power. In modeling terms, there is a one-stage market game which can be expressed as a mixed complementarity problem (MCP). Figure 1 shows the possible routing of natural gas flows in the market game, via the pipeline trader or the LNG chain.

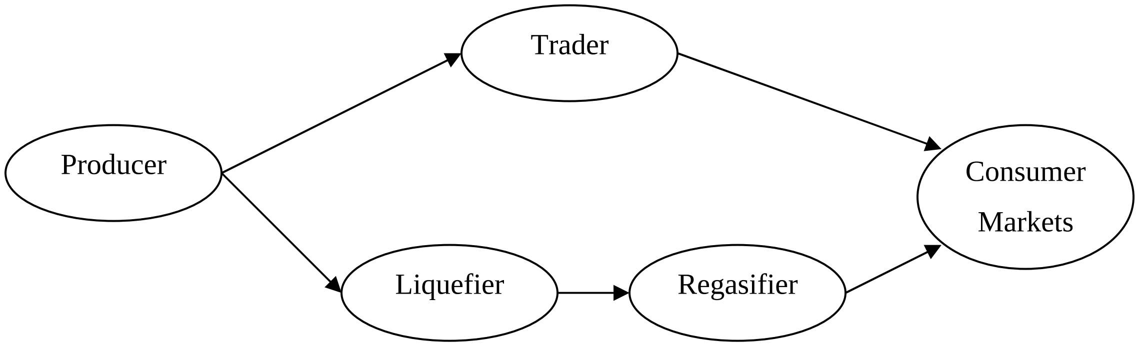

Figure 1 Natural gas export chains

The standard definition of a cartel is that several producers jointly maximize their profits, that is, they maximize a single profit function given their individual cost functions. Given the current structure of our model, and the fact that a full-fledged cartel is unlikely to emerge soon, we model a close cooperation (or: collusion) between the members of the GECF, deploying the following approach:

- the pipeline exports are jointly optimized by all cartel members by exporting via one single cartel trader for all cartel member producers (as opposed to one dedicated trader for each producer);
- the LNG exports to each importing country, too, are jointly optimized by all cartel members by selling LNG via one single market power exerting regasifier in each importing country;
- all other LNG exporters will export to a different regasifier, that is assumed to exert no market power.

It should be noted that this is only an approximation of a standard cartel with one single monopolistic supplier as cartel supplies are split into pipeline and LNG supplies.[4]

4 Data and Case Description

4.1 Base Case - data and calibration

The period considered for the case runs is 2005 to 2030, in five-year steps. 2035 and 2040 have also been included in the model data to allow for a sufficient payback of the investments in the last years, but no results are reported after 2030. The model has been calibrated to projections of the future energy markets, namely PRIMES forecasts for Europe (European Commission, 2008) and POLES forecasts for the rest of the world (European Commission, 2006) [5]. These sources are used to determine the (exogenous) production capacities and the reference consumption quantities and prices of the demand function.

[4] The stability of the cartel is not modeled

[5] While the PRIMES and POLES forecasts have the advantage of being officially approved forecasts, we have not been able to verify some of the underlying assumptions. In particular, it seems that their forecasts of natural gas production are optimistic, and not necessarily constrained by reserve availability. All scenarios require large capacity expansions in liquefaction, re-gasification and pipelines.

POLES projections reflect a worldwide increase in natural gas production and consumption of 70% in 2030 relative to 2005.

Since the POLES projections are on a regional level rather than on country level, an assessment has been made to determine benchmark production and consumption levels for countries and regions included in the model. The model has been carefully calibrated to match observed production and consumption volumes in 2005 (BP 2007, IEA 2006) and to reflect a world wide average wholesale market price close to \$180 per 1000 cm^3 [6], allowing for regional differences (BP, 2007). For future years an effort has been made to reflect the PRIMES and POLES projections within about 5% deviation on a regional basis as well as the major consumption and production countries. The calibrated worldwide Base Case consumption (production)[7] in 2005 is 2368 (2435), and 3757 (3905) bcm in 2030, and a wholesale price of \$375. An average yearly price increase of 3%, in accordance with POLES projections is used.

For infrastructure capacities (pipelines, LNG liquefaction and regasification terminals, storage), project and company information from various sources (e.g., Oil and Gas Journal, GSE database at www.gte.be, EIA[8]) has been employed. This information was used to include existing additional capacities since 2005 and also considered when assessing the maximum allowable capacity expansions per period for the Base Case.

4.2 Cartel Case – main assumptions

The mechanism to represent a cartel in WGM was explained in Section 3.3. The cartel will be referred to by "GEC" (Gas Exporting Countries). The countries included in the cartel are the current full members, observer Equatorial Guinea, and the Central Asian countries with large export potential. To implement the cartel every regasifier in the model data set had to be split up into two parts. One part, with full market power, to import from GEC countries; and a second perfectly competitive part, to receive LNG shipments from countries not included in GEC. Therefore an assessment had to be made to divide the base year regasification capacities and the allowed capacity expansions in future years. For the first and second year (2005 and 2010) contractual obligations were explicitly considered when dividing up existing re-gasification capacities. For future years the allowed capacity expansions were set equal to 80% of the base values for the total regional regasification to represent 'GEC'- regasifiers, and 30% of the total regional regasification to represent the other regasifiers. A rationale for these values is that the GEC members currently have a market share of about 80% of LNG exports; but 30% (instead of 20%) allows non-GEC members to invest more and supply more LNG to countries from which GEC would withhold LNG supplies.

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[6] All reported prices are in \$2005/1000 m^3.

[7] We account for losses in liquefaction, regasification, storage and pipelines. Consumption in WGM is corrected for 'own consumption' in the energy sector, based on IEA statistics.

[8] We thank the Energy Information Agency for sharing data regarding seasonality of consumption, and likely pipeline capacity expansions.

5 Results and Discussion

5.1 Results Overview

A first look at some variables at a global level shows the significant impact of the cartel on the world natural gas market. As can be expected, the cartel reduces the total world production of natural gas (Figure 2) and increases the average price level (Figure 3) compared to the Base Case until 2030. All figures show the results for both cases (Base Case BC, and Cartel Case CC) for each five-year-period; the cartel members are designated by “GEC”. The average price difference between the Cartel and Base Cases is rather modest, which is a consequence of specifying the Cartel Case where there is a Cournot fringe of non-cartel suppliers in addition to the cartel members. Hence, the average price in the Cartel Case is not as high as it would be in a “pure” cartel market.

Figure 2 shows the relative importance of the cartel members in the world natural gas market: they have a share in total production of about 50% in the starting year 2005, and this share increases to about 60% in 2030. Depending on the case, the GEC share in total production is somewhat lower in the Cartel Case due to the withholding strategy of the cartel members. As economic theory predicts, the cartel members can increase the prices and hence their profits by withholding quantities from the market.

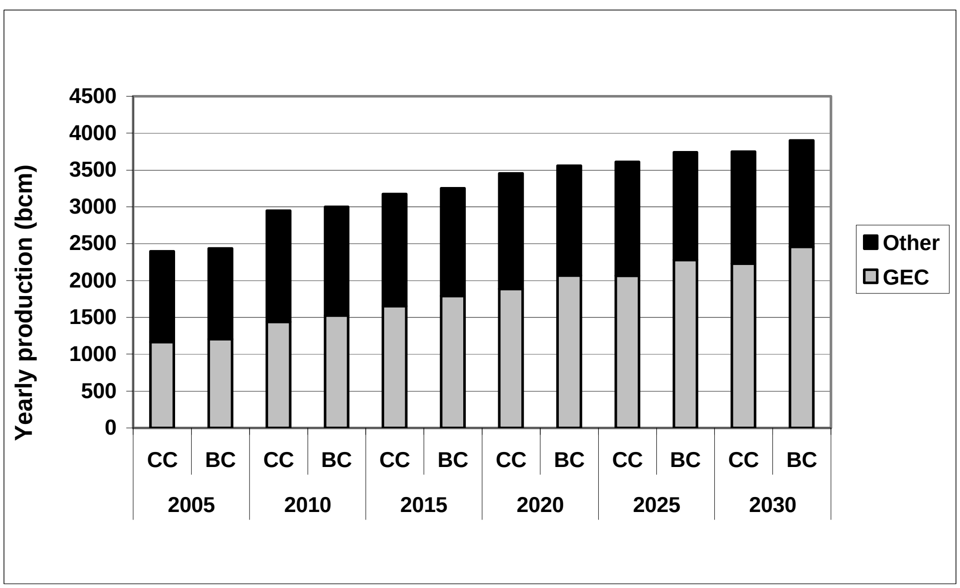

Figure 2: Yearly production by GEC and non-GEC (bcm)

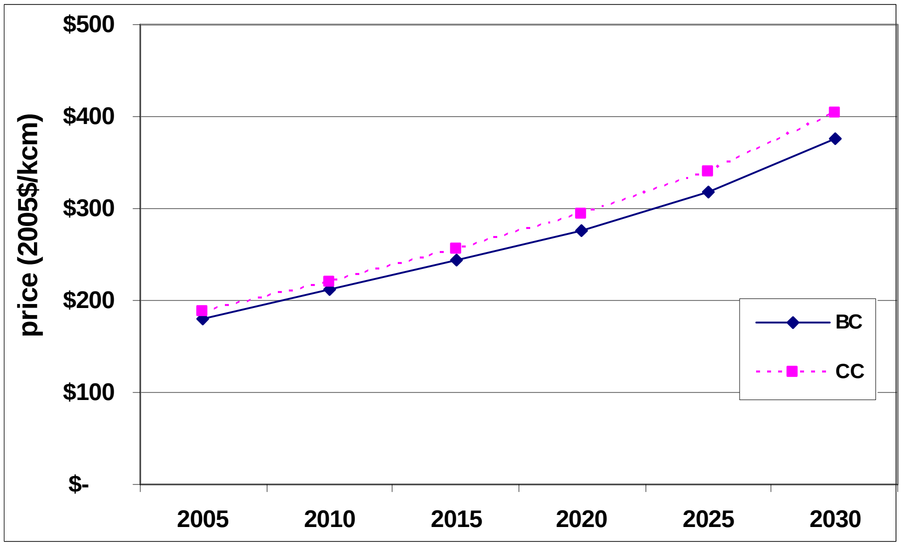

Figure 3: Volume-weighted world average gas price

As can be expected, given the importance of LNG exporters among the cartel members, the cartel impact is particularly manifest in the LNG market. Section 5.2.1 will show that the impact on the pipeline market is mostly felt in Europe.

Figure 4 shows the liquefaction quantities for the cartel and the non-cartel liquefiers. The cartel members produce considerably lower quantities in the Cartel Case than in the Base Case. Because the withholding strategy is also adopted in the investment behavior (see Section 5.3) the non-GEC liquefiers can increase their market share over time and more than in the Base Case.

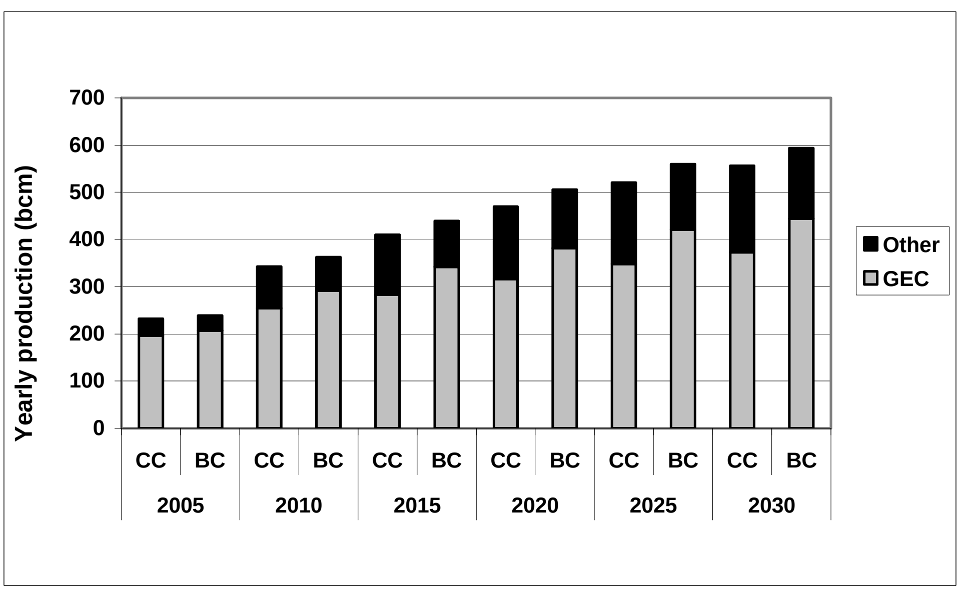

Figure 4: Yearly liquefaction by GEC and non-GEC liquefiers, in bcm

The cartel members have an incentive to collude because their joint profit optimization yields higher joint profit levels than the sum of individual oligopolistic profits. Figure 5 shows that the model results reflect this behavior. The cartel members (GEC) obtain higher profits in the Cartel Case (CC) than in the Base Case (BC) in all model periods. The difference between the Cartel and Base Case is increasing over time because the withholding strategy in investments is felt more and more strongly with tighter and tighter capacities.

Interestingly, also non-cartel members obtain much higher yearly profits in the Cartel Case than in the Base Case. This is due to a positive price and a positive quantity effect. First, the overall higher price level induced by the cartel withholding strategy also applies to the sales of the non-cartel suppliers. Second, the non-cartel members can partly fill in the gap with natural gas supplies where the cartel members supply less than in the Base Case. This allows the non-cartel members to increase their quantities compared to the Base Case. Price and quantity effects combined lead to higher profits of the non-cartel members in the Cartel Case.

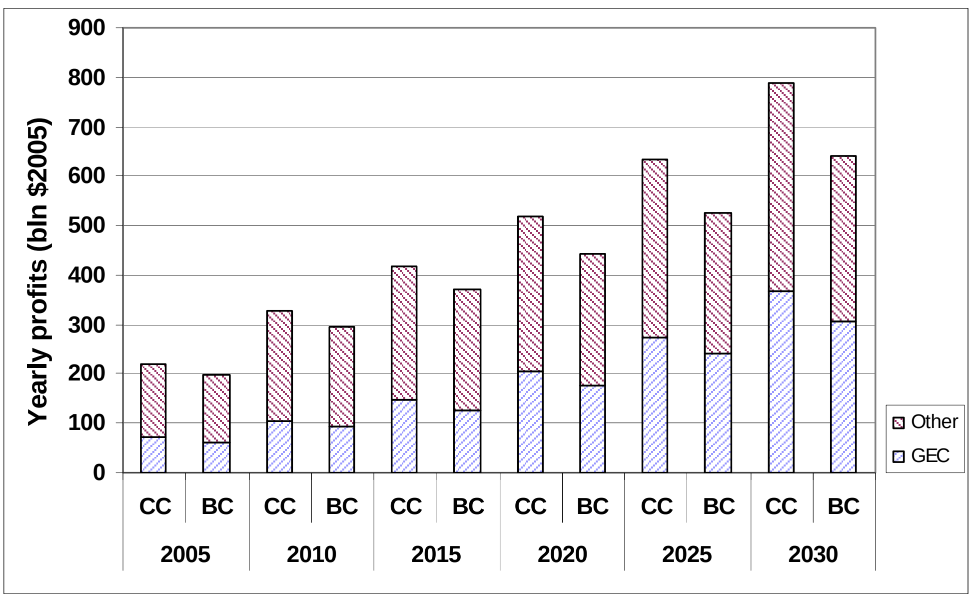

Figure 5: Indicative yearly profits upstream (bln$2005)

Figure 6 shows the consumer surplus in the world natural gas market. An increasing demand for natural gas is assumed (increase of reference quantities and prices in the demand functions for each period) which triggers an increasing consumer surplus over time. As can be expected, the higher price regime in the Cartel Case leads to a lower consumer surplus than in the Base Case. Again, the difference between the Base and Cartel Cases is the strongest at the end of the time horizon when the investment withholding is felt more keenly.

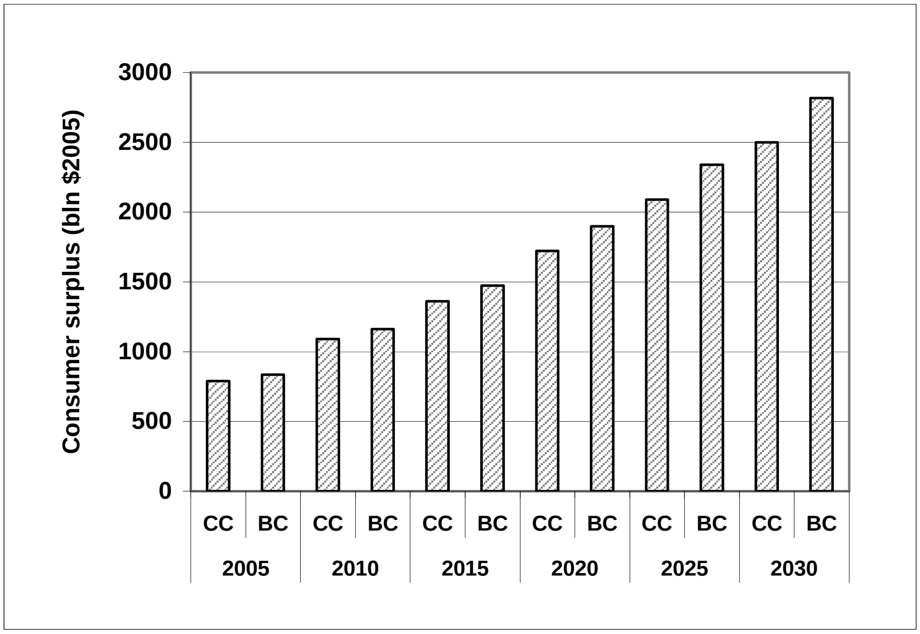

Figure 6: Indicative global yearly consumer surplus in both cases, in billion US $

5.2 Regional Developments: Demand Side

In the following paragraphs the demand side of the natural gas market for Europe, Japan and North America, three regions with very different characteristics, are analyzed.[9]

5.2.1 Europe

The European natural gas market can be characterized as a mature pipeline market with increasing reliance on LNG. Some countries are significant producers (Norway, United Kingdom, and the Netherlands), but most countries greatly rely on gas imports to cover domestic gas demand. Natural gas demand is projected to continue to grow on the European continent until 2030, but decline afterwards. In some countries demand reductions are anticipated earlier, which could affect the willingness of market players to invest in capacity. Table 2 shows for the years 2010, 2020 and 2030, for both cases, the total yearly consumption level of Europe (as well as Japan and North America), and the origins of the gas supplies to cover the demand: production (in Europe), LNG imports (and the share of GEC therein), and the pipeline imports (and the amount bought from GEC members.)

Table 1 shows the wholesale prices in the three regions for the three reported years. The relative price increase in Europe is the most severe of the regions analyzed, although the Base Case prices (due to

[9] See the appendix for an overview of which countries are included in these regions.

accessibility and proximity of the pipeline suppliers) are much lower, and the Cartel Case prices are still lower, than in Japan and North America.

The numbers for supplies and price changes show that the impact of a gas cartel could be severe; in later years even more. The decreasing own production in combination with the increasing demand, makes the import dependency higher, and the supply position of GEC stronger. LNG imports can only partially compensate for the volumes withheld by GEC.

5.2.2 Japan

Japan has been the largest LNG importer in the world and will probably remain so for a number of years. Among the three regions analyzed, it is affected least by a cartel. The high prices in the Japanese market make it very attractive for exporters. In later years LNG imports decline, however only when a pipeline from Sakhalin has been put in place.

5.2.3 North America

Production rates in North America are expected to start declining after 2010. Canada will for awhile continue to export to the U.S., and a pipeline from Alaska could lessen the immediate pressure on the market. To meet the projected consumption levels, a large number of LNG import terminals would have to be put in place in rather short term.

In 2010 North America as a whole is still close to self-sufficient. The almost one-fourth lower LNG imports from GEC members in the Cartel Case versus the Base Case are partially compensated by non-GEC suppliers, and the price impact is negligible. However in later years the impact becomes more severe, with price increases of 7% to 14%.

Table 1 Wholesale prices in three regions ($2005/1000 m^3)

year	Europe			Japan			North America		
	CC	BC	Δ	CC	BC	Δ	CC	BC	Δ
2010	280	243	15%	339	334	1%	331	324	2%
2020	379	312	22%	428	422	1%	465	433	7%
2030	521	437	19%	551	524	5%	606	533	14%

Table 2 Consumption and breakdown of gas supplies (bcm)

		Europe			Japan			North America		
		CC	BC	Δ	CC	BC	Δ	CC	BC	Δ
2010	Consumption	518	554	-6%	97	100	-4%	759	770	-1%
	Production	286	275	4%	3	3	0%	715	713	0%
	LNG Imports	71	71	0%	91	95	-4%	53	65	-19%
	GEC	63	64	-3%	61	68	-10%	50	65	-23%
	Pipeline Imports	166	212	-22%						
	GEC	160	208	-23%						
2020	Consumption	582	635	-8%	103	106	-3%	772	809	-5%
	Production	257	226	14%	3	3	0%	612	604	1%
	LNG Imports	67	47	44%	81	84	-4%	165	210	-21%
	GEC	55	41	33%	44	54	-18%	135	175	-23%
	NetPipeInflows	262	367	-29%	16	16	0%			
	GEC	235	346	-32%	16	16	0%			
2030	Consumption	616	667	-8%	104	113	-8%	741	801	-7%
	Production	225	203	11%	3	3	1%	512	496	3%
	Regasification	71	27	160%	64	73	-12%	231	304	-24%
	GEC	55	22	148%	48	63	-23%	164	239	-31%
	NetPipeInflows	320	437	-27%	35	35	0%			
	GEC	272	393	-31%	35	35	0%			

5.3 Regional Developments: Supply Side

The collusion in the Cartel Case leads to a notable reduction in total output compared to the Base Case. In this section, the focus is on selected suppliers both from the GEC (Algeria, Qatar, Russia) and others (Norway, Netherlands, Australia). This section also gives some insight into whether there is a shift in trade flows due to collusive behavior. In addition to a general reduction of trade flows from GEC countries, a shift of flow from cartel to non-cartel members can be expected as the latter may replace quantities withheld by the GEC. This is particularly true in Europe, which is affected by the cartel in both the pipeline and the LNG markets. Europe has the advantage, however, of some important domestic producers (e.g., Norway, Netherlands) that can fill in considerable supplies, albeit within their reserve and production capacity limits.

5.3.1 Gas Exporting Countries Forum: Qatar, Algeria, Russia

Figure 7 shows the total sales of three selected GECF producers (Qatar, Algeria, and Russia) in the Base and Cartel Cases, split into pipeline and LNG sales. For all three producers, and similar to the global picture, the difference in output between CC and BC becomes larger over time, due to the reduced investment in previous periods.

For Algeria, the share of LNG sales in the Cartel Case decreases over time (from 37% in 2005 to 22% in 2030) and relative to the Base Case (29% in 2030). This can be explained by the following two points. First, Algerian LNG supply is relatively more expensive than its pipeline. Secondly, there are lower cost LNG suppliers in the cartel that will preferably export more in order to minimize the total cartel supply costs.

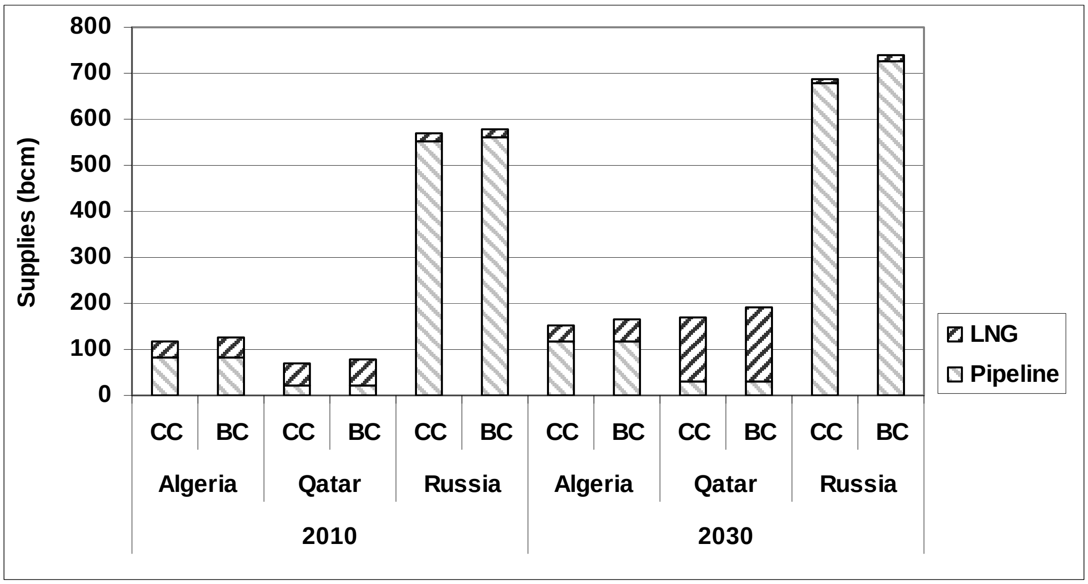

Figure 7: Algerian, Qatari and Russian Supplies through pipeline and LNG (in bcm per year)

Qatar, which is one of the most important cartel members with a very large liquefaction capacity in all model periods increases its LNG exports by a factor of approximately five in both cases between 2005 and 2030. Hence, the impacts of the Cartel Case on the Qatari output are especially strong. In 2030, when the difference to the Base Case is the largest, Qatar's output is 24 bcm (12.5%) lower. Although Qatar is a large LNG supplier, it supplies some volumes to the domestic market and via pipeline to Oman and the United Arab Emirates, but the share of the pipeline exports decreases over time.

Russia is the largest of all suppliers to Europe and its participation in the GECF has evoked concern in Europe relative to supply security. The results show a limited effect of the Cartel Case, however, with Russia reducing its total exports by 53 only bcm (7%) relative to the Base Case. Interestingly, Russia does not fully use its liquefaction potential in the East (Sakhalin) and West (Baltic Sea, later Shtokman) and exports only 29 bcm at its peak (2020 and 2025, Base Case) via LNG. This is due to the relatively high costs of liquefaction operation and investment in Russia. Russian pipeline supplies, however, remain to a large extent available for the European market.

5.3.2 Compensation from Non-GECF Producers? Norway, Netherlands, and Australia

Europe is among the most affected consumption regions by the cartel because it imports both pipeline and LNG from GECF members. However, Europe can potentially compensate parts of the failing supplies by own production. Norway (not included in the definition of the European consuming region) and the Netherlands are particularly large producers in Europe with reserves of about 3 trillion cubic meters (tcm) and 1.25 tcm, respectively (BP, 2008).

As expected, Norwegian and Dutch output is notably larger in the Cartel Case than in the Base Case. Figure 8 shows that in 2030 Norwegian supplies would be 13 bcm higher or 12%, and 5 bcm (14%) for the Netherlands. Their exports, mainly by pipeline, replace failing cartel imports, especially from Russia and the Caspian region.

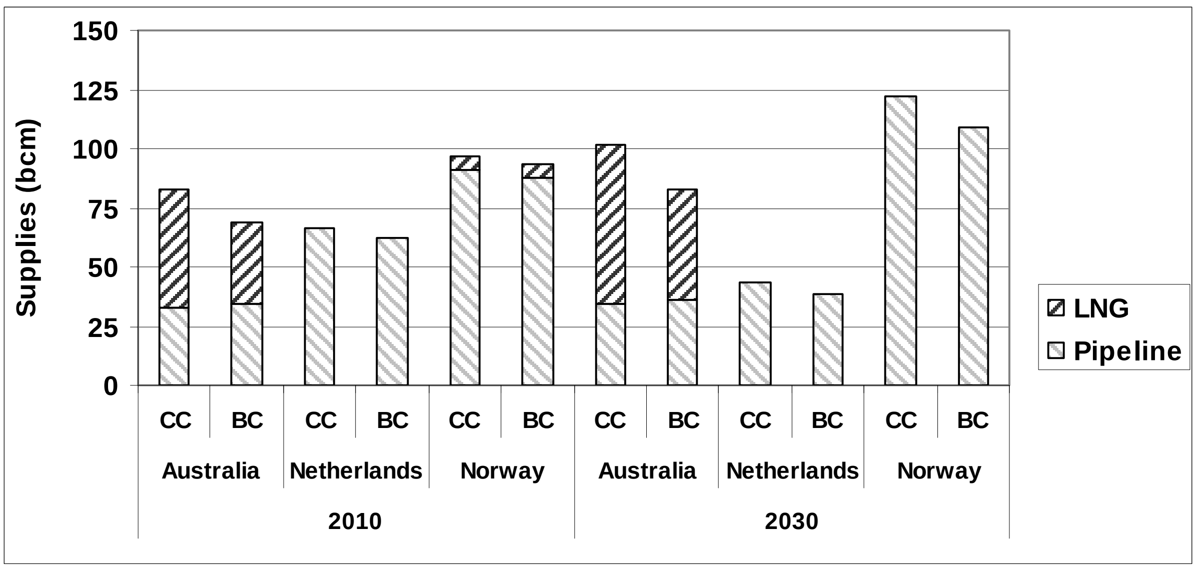

Figure 8: Norwegian, Dutch and Australian supplies through pipeline and LNG (in bcm/year)

The exports from Australia are important because it is the largest non-GECF LNG supplier, but its ability to replace failing cartel supplies may be hampered by the long distances to the consuming markets since distance-based transport costs for LNG are part of the modeling assumptions. However, for consumers in the Pacific basin, such as Japan and South Korea, Australia can be an important supplier. Figure 8 reports that Australia indeed fills in the missing supply gap in the Cartel Case with very significant volumes. It increases its LNG exports by 50% between 2005 and 2030 in the Cartel Case, to 68 bcm per year.

5.4 Investments

WGM allows investigating the impact of cartel behavior not only in the short run, but also in the long run on investment decisions. The model includes endogenous investment decisions in transport infrastructure (pipeline, LNG liquefaction and regasification) and in storage. As briefly noted above (see section 5.1), the global trade flows indicate that there is a withholding strategy by the cartel members with respect to investments.

Figure 9 shows the yearly (lines) and the cumulative (bars) investments in pipeline capacity from cartel countries to all other countries. The set of pipelines between GECF countries and their non-cartel importers is the most affected by the cartel withholding, compared for example to pipelines between non-GEFC countries.

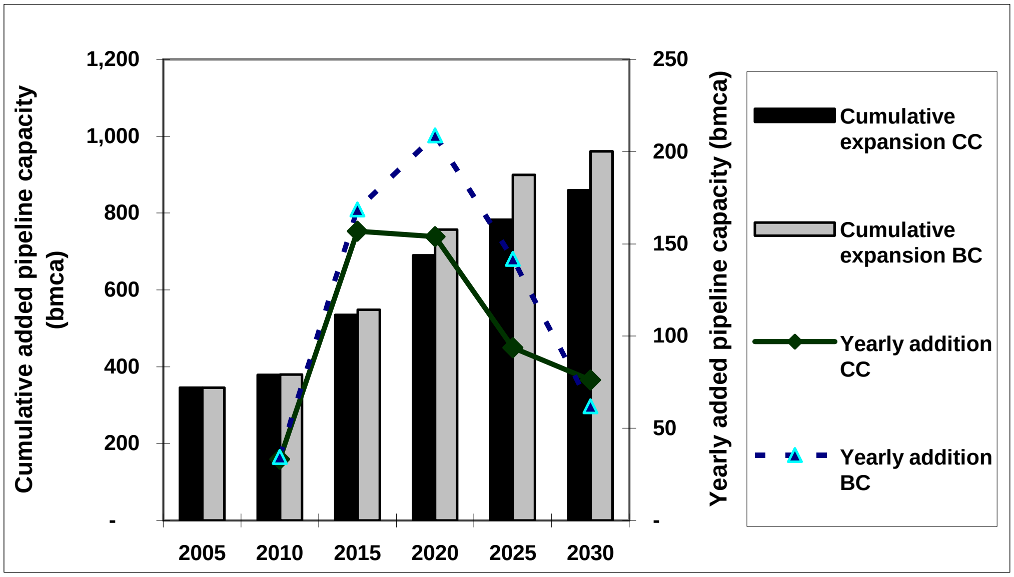

Figure 9: Pipeline capacity expansions from GEC to non-GEC countries (in bcm per year)

Figure 10 on liquefaction capacity expansion shows similar trends as the pipeline case in the cumulative sense. While in 2010 and 2015 the investment levels in the Base Case (BC) and the Cartel Case (CC) are very similar (due to the proximity of the time period, for which many projects are already known, if not confirmed), there is a large investment gap between BC and CC between 2015 and 2025. Together with the cumulative investments, this clearly shows the withholding strategy of transport capacity of the colluding cartel countries. In 2030 the investments in pipelines (Figure 9) in the CC are higher than in the BC, what may seem somewhat puzzling. However when put in the perspective of the cumulatively built-up capacity it is clarified by the large under-investment by cartel members in the previous periods.

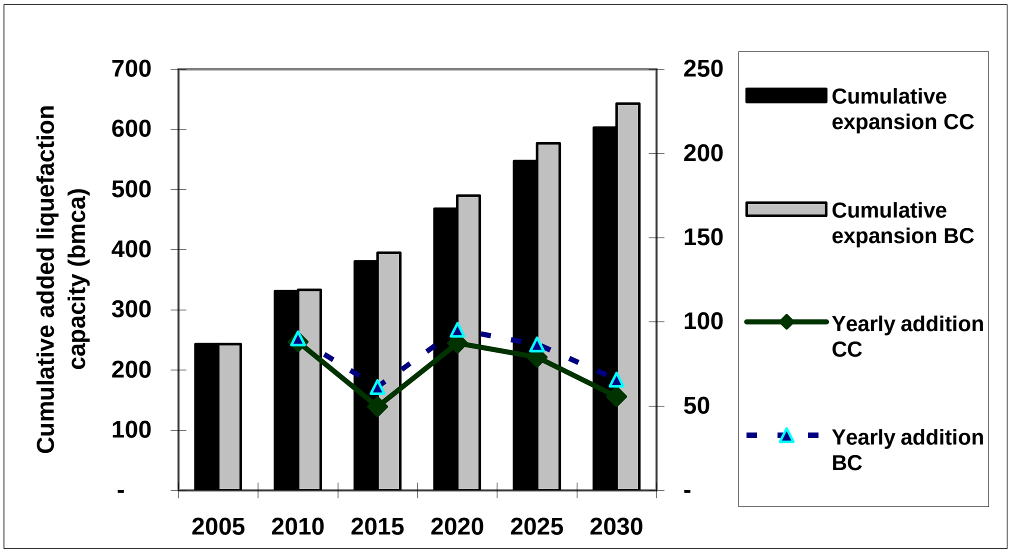

Figure 10: Liquefaction expansions (in bcm per year)

The model does not cover all aspects of the natural gas supply chain, for example domestic high pressure and distribution networks are not considered, LNG ships are represented by distance- dependent cost term and losses, and projected production increases are exogenously determined. No investments are needed in the model to increase production capacity or supply more gas to end users. Therefore the following values should be considered with care: total investments in liquefaction, re-gasification, pipelines and storage amount to 742 $bln in the years 2005-2030 in the Base Case, and in the Cartel Case the total amount is 634 $billon, 17% lower.

5.5 Results of an alternative Cartel Case

Since our model specification is only an approximation of a standard textbook cartel, in this section, we present some results of a sensitivity simulation run (CC+) to give an indication of what the effects of stronger collusion could be. In this specification, we have fixed the production capacity levels of the GECF countries to their 2005 levels, implying a reduction in production capacity of 50% in 2030 relative to the Base Case. This represents a situation where the cartel players withhold any additional capacities from the market in the long run. There is some spare capacity in the first model years, so that the effects from GEC restricting additional supplies is felt only in later periods.

Naturally the impact of the stronger collusion is more severe. Figure 11 shows the price increases in all three cases. Relative to the Base Case, in the sensitivity case the prices are 11, 29 and 44% higher in 2010, 2020 and 2030 respectively. Detailed results (not indicated graphically here) show European average prices of $816, North American prices of $975 and Japanese prices of $690 per 1000 m^3 in 2030: 87%,86% and 29% higher than the Base Case results in Table 1.

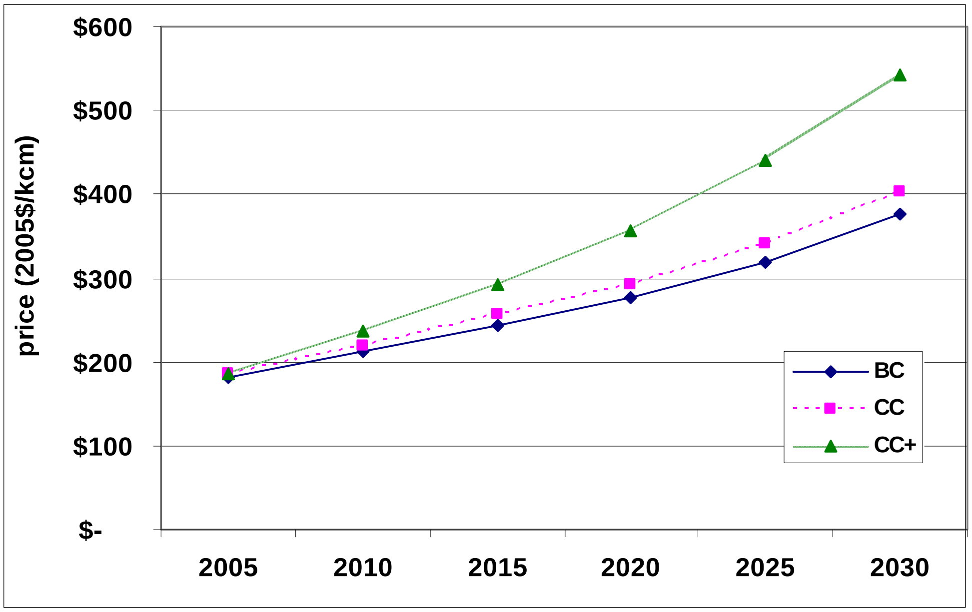

Figure 11: Volume-weighted world average gas prices for three cases

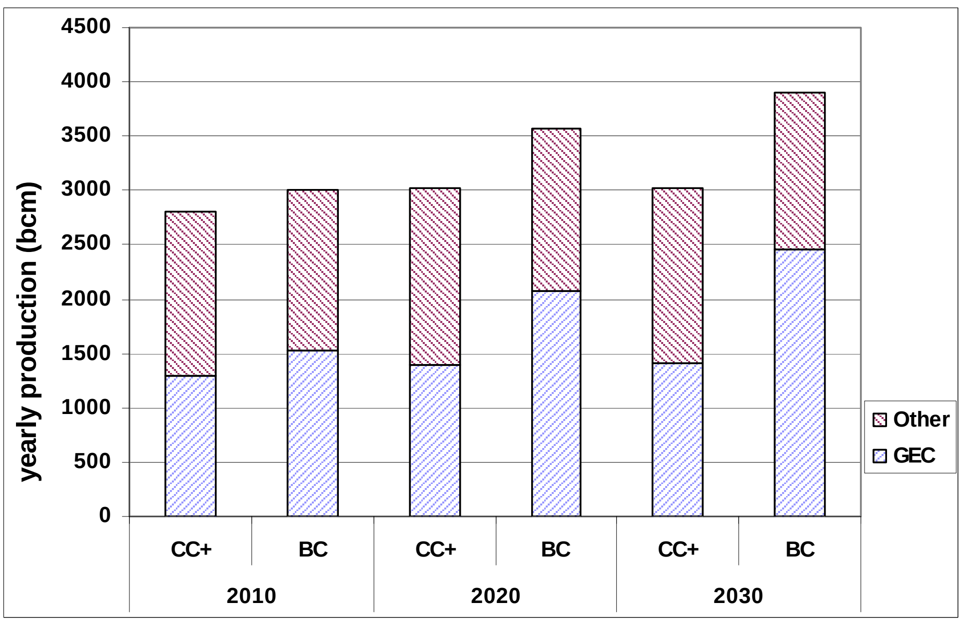

Figure 12: Yearly production by GEC and non-GEC (bcm) in sensitivity case vs. Base Case

Relative to the Base Case, in the sensitivity case the GEC production levels are 16, 33 and 42% lower in 2010, 2020 and 2030, respectively. Production levels of non-GEC countries are only 3, 9 and 11% higher in those respective years, by no means enough to compensate for the withheld supplies.

Also in the sensitivity case there are regional differences in the impact on prices and consumption. The case results suggest that Europe and North America are in a more vulnerable position relative to a cartel in the natural gas market than Japan.

6 Conclusions and Future Directions

In this paper, we have applied the dynamic version of the World Gas Model (WGM) to analyze an important issue in international natural gas trade: the potential impact of a closer cooperation by the Gas Exporting Countries Forum (GECF). The model allows for modeling capacity investments endogenously, which is a particularly interesting feature when combined with strategic behavior of some of the market participants.

Intensified collusion between a group of gas exporting countries would reduce production, thus raising prices as confirmed in the modeling. North American and European price levels are shown to be 15-20% higher, losing $180 billion yearly in consumer surplus, and allowing upstream gas suppliers an extra $150 billion in yearly profits. Interestingly, more than half of the $150 billion additional yearly profits is for non-GEC members that would supply more natural gas at higher prices in a cartel situation. Since most non-GEC members have relatively low reserve- to-production ratios, they would probably not be able to sustain the higher production levels for decades to come. The low reserve bases of non-GEC countries are illustrated further by the results of a sensitivity case with production capacities of GEC countries fixed to the 2005 levels. Even much higher price levels in end user markets (+44% in 2030) only induce an eleven percent higher production in non-GEC countries.

Future possible research directions include analysis of the production and demand projections that were used to calibrate the dynamic model. In particular, there may be a secular shift away from natural gas as the "bridging fuel" on the way to a low-carbon energy system. Natural gas has been identified as a "dirty" source of energy in the post-Kyoto world. Long-term demand projections are currently revised downwards by all major national and international forecasts. When taking into account the reserve constraints, potential limits to expanded natural gas production and consumption become even more restrictive. Upcoming research should take this new, sustainability-oriented perspective into account.

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