EFFECT OF CANADA'S ENTRY IN THE ASIA-PACIFIC LNG MARKET

Subhadip Ghosh, School of Business, MacEwan University, 10700 – 104 Avenue, Edmonton, AB T5J 4S2, Canada, 780-633-3147, ghoshs3@macewan.ca

Shahidul Islam, Department of Economics, MacEwan University, 10700 – 104 Avenue, Edmonton, AB T5J 4S2, Canada, 780-497-4792, islams@macewan.ca

ABSTRACT

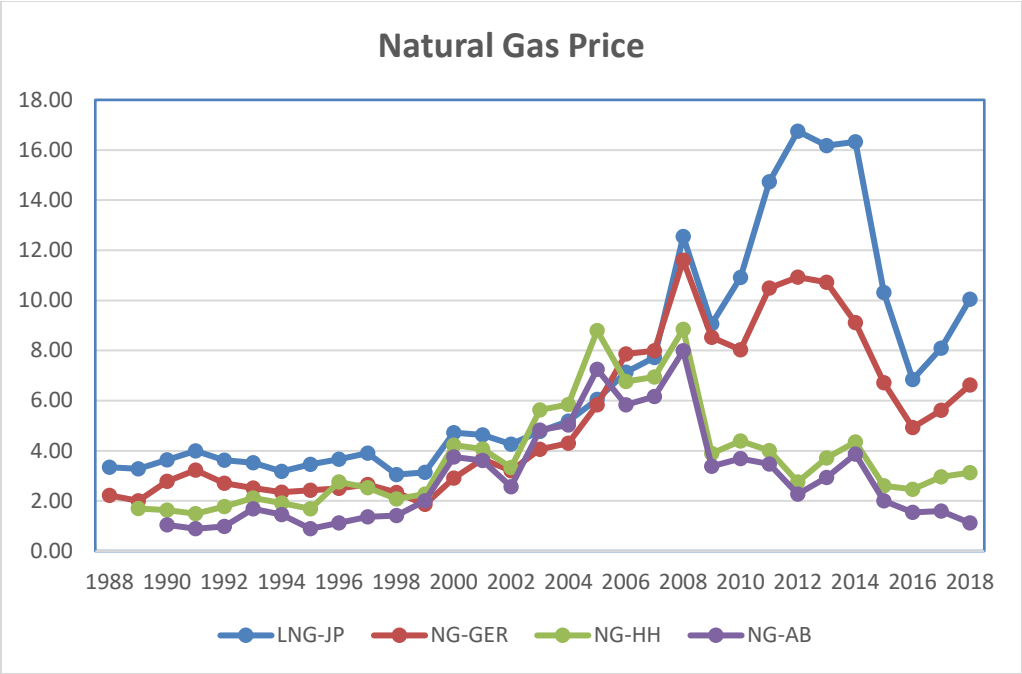
Asia-Pacific region holds nearly half of the world's population, which has been growing relatively faster than other regions. It also experiences the fastest economic growth. Both these factors is increasing its energy demand at an exponential rate. At the same time, this region is deficient in all fossil energy resources – coal, oil and natural gas, which leads to higher imports. This paper examines Canada's entry in the LNG export markets of the Asia-Pacific. The competition for capturing the ever-growing market for these countries has been primarily concentrated between Australia, Middle East (Qatar), Russian Federation and USA. Using a game theoretic export competition of LNG among exporting countries, we explore the effect of Canada's entry on profitability of the incumbent countries, Australia, Middle East, Russian Federation and USA.

Keywords: Game theory, Oligopoly, LNG,

INTRODUCTION

Since 2005, Canada's proven natural gas reserves have increased by 25 percent, from 1.6 TCM to 2.0 TCM. It is the fifth largest natural gas producer but only exports to US after fulfilling its own consumption as it does not have liquefactions and liquefied natural gas (LNG) export facility. As a result, its production did not grow, rather remains steady from 187.1 BCM in 2005 to 184.7 BCM in 2018 with even lower production in between [2]. It has been planning to export LNG to Asian countries for the last several years with little success primarily due to its internal issues as well as to the impact of international energy prices. However, with the construction of LNG plant being underway in Kitimat, BC, it is expected that Canada will be in the LNG export market soon. Now the question is how much potential Canada has in capturing a share of the Asia Pacific LNG demand. This paper examines Canada's potential for LNG export in these markets using a game theoretic export competition framework.

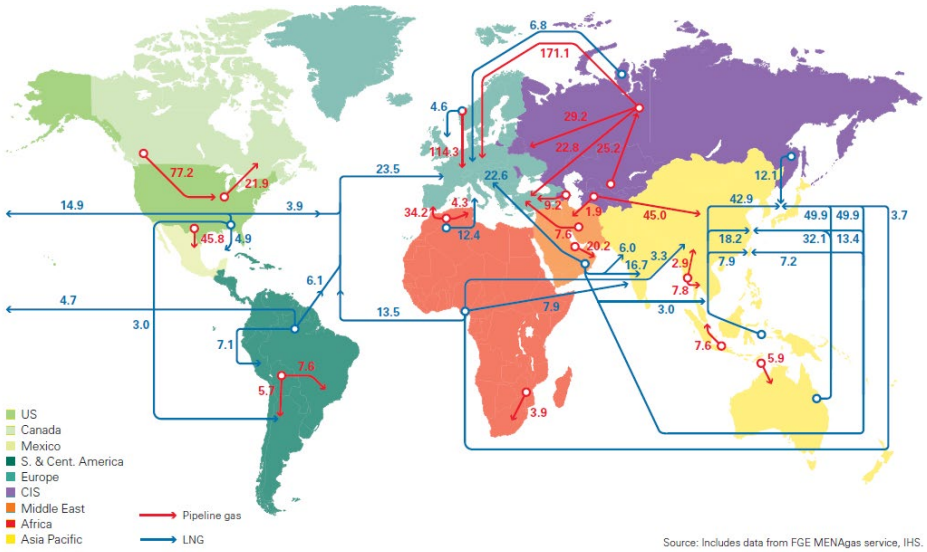
Canada has the lowest natural gas price in the world, which provides a natural advantage for Canadian natural. The figure below shows comparative LNG and natural gas prices in major markets. LNG prices are based on cost plus insurance plus freight. Natural gas prices are average German import price, US Henry Hub price and Alberta natural gas price. Compared to natural gas prices, Alberta (Canada) exhibits the lowest price.



Source: BP, 2019

Natural gas market in Canada and US are integrated. Canada exports natural gas to US in the west coast but it also imports a fraction of that in the east coast [2]. Canada's net exports of natural gas to the U.S. have fallen over 35% since 2007, now at their lowest level since 1993. The net import by US is predicted to decrease to near zero as the US import from Canada's west coast continues to decline and export in the east coast continues to rise [5]. With US's active liquefaction and export facility in the Gulf of Mexico, Canada's gas market may have some effect depending on the market price. However, without its own LNG export terminal, Canada cannot exploit its full potential of LNG export. Within North American LNG market, Canada is a relatively late entrant and loses its advantage to US. On the economic side, Canada has a slow growing population, along with sluggish economic growth and incremental energy needs. So, even though natural gas is about 30% of Canada's total energy supply, the country's gas export capacity will expand in the years ahead. At present Canada is ranked 4th in gas production after US, Russian Federation and Iran [2]. It has big plans to export liquefied natural gas (LNG), but all 6.7 Bcf/day of Canada's current natural gas exports are sent to the US market through pipelines [3]. Given the saturation of US demand for Canadian natural gas, Canada will need new markets for its natural gas. Seeking other markets for Canada requires liquefaction capacity to produce LNG and to ship to other countries as Canada does not have land border with countries other than US.

Although LNG remains a smaller portion (just over 10 percent) of total natural gas, its volume and proportion continues to increase. In 2018, total LNG trade was 316.5 MT with a worldwide existing liquefaction capacity of 393 MTPA and an additional proposed capacity of 843 MTPA (IGU, 2019). Principal exporting countries were Qatar (104.8 m^3), Australia (91.8 m^3), USA (28.4 m^3) and Russian Federation (24.9 m^3), which comprised 58 percent of total LNG export. The major importing countries are Japan (113.0 m^3), China (73.5 m^3), South Korea (60.2 m^3), India (30.6 m^3) and Taiwan (22.8 m^3) imports 70 percent of the total LNG trade. Although increasing number of countries joining LNG trade, both on import and export side, few exporters and importers remain dominant [2]. Figure below shows LNG trade in 2018. It is to be noted that the world LNG production growth is dominated by Australia and US, with another proposed capacity of 329 MTPA in US.



Source: BP, 2019

Canada has approved LNG projects with capacity of 211 MTPA, a significant portion of the world's proposed liquefaction capacity. Most LNG projects proposed in Canada are in the west coast of BC with only 47 MTPA in the Atlantic coast. Since Asia-Pacific market is closer from west coast, it is anticipated that the west coast LNG development is targeted toward the Asia-Pacific markets. Several factors contribute to the cost of production of LNG in Canada's west coast affecting international competitiveness. In addition to the proximity to the Asian markets, its closeness to abundance natural gas reserves, competitive cost of natural gas feedstock, lower temperature regime and lesser operating cost provide advantage over other exporters. However, relatively high capital cost due to remote areas, required pipeline in mountain train, necessary support from indigenous people and taxation regime contribute toward increased cost [3]. An accumulation of all these factors show a net advantage.

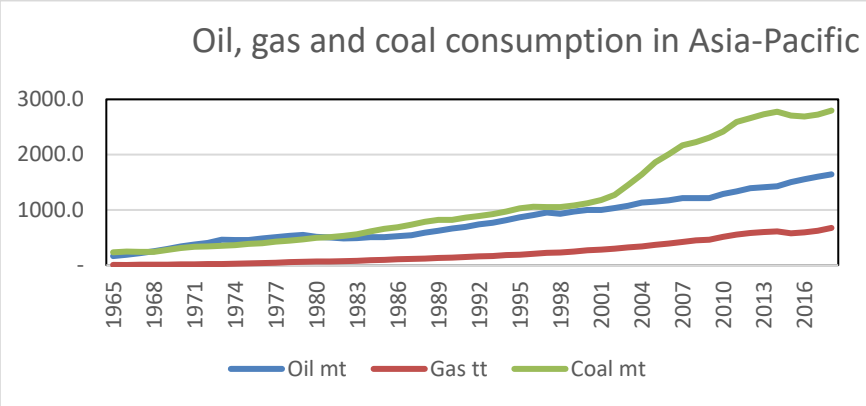
Aside from competing with US, Canada also has to compete with the world LNG market. Many countries export LNG to Asia Pacific. However, Australia, Middle East, Russian Federation and North America are the major players. At times, LNG market was dominated by bi-lateral monopoly with one exporter and one importer with a long-term contract. This eventually became monopsony with Asia Pacific the primary importer and Australia, Middle East and North America are primary exporters. Over time, with the increase in the number of importers and exporters, and with the expiration of long-term contracts, the world LNG market is increasingly becoming competitive. However, Australia, Middle East, Russian Federation and North America remain the major exporters of LNG to the Asia Pacific.

As there are only few major exporters, the LNG market is far from competitive though there is an increasing trend toward more and more competitiveness due to the addition of new producers. In 2018, Cameroon joined as a new LNG exporter, and Bangladesh and Panama joints as new importers [9]. However, Asia-Pacific region with China, South Korea and Japan remains the major importer, and Australia, Middle East (Qatar), Russian Federation and US remain the major exporters. In a market dominated by few players, the behavior of one player affects the profit margins of other players in the market, which can be explained by oligopoly behavior as originally formulated by Augustine Cournot (1801-1877) and then expanded and much popularized by John Nash (1928-2015). We develop an oligopoly model using four LNG exporters, Australis, Middle East, Russian Federation and US. As our objective is to examine Canada's potential, we expand the model splitting North America into Canada and

US. The existing four-player model and the prospective five-member model with the entry of Canada analyze LNG trade following a generalized Cournot model with different costs.

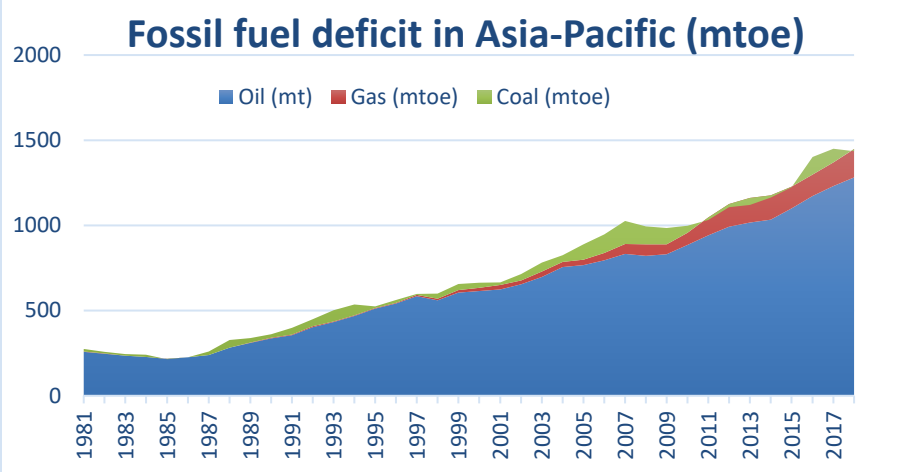
INCREASE IN DEMAND FOR LNG IN THE ASIA-PACIFIC REGION

Asia-Pacific region holds nearly half of the world's population, which has been growing relatively faster than most other regions, though has slowed down in recent years. In terms of economic growth, it is also one of the fastest growing regions in the world and is often considered as the economic engine of the world. It is the most energy-hungry region as well, since economic growth is tied to energy demand. This region is deficient in all fossil energy resources – coal, oil and natural gas. From 1965 to 2018, China's primary energy consumption increased from 131.4 mtoe to 3273.5 mtoe, an increase of over 2300 percent. Similarly, Japan experienced an increase of 206 percent (from 149.0 mtoe to 454.1 mtoe), India experienced an increase of over 1400 percent (from 52.7 mtoe to 809.2 mtoe), and Korea experienced an increase of over 4600 percent (from 6.4 mtoe to 301.0 mtoe) during the same period [2]. During the same period, total world's energy consumption increased by 270 percent (from 3728.0 mtoe to 13864,9 mtoe). So, energy consumption in China, India and Korea increased at a much higher rate than the rest of the world.



Source: Authors' calculation from several editions of BP Statistical Review of World Energy

Energy production growth in the region is slower than the rest of the world which widens the gap between production and consumption and as such increasing reliance of import.



Source: Authors' calculation from several editions of BP Statistical Review of World Energy

Japan is the only country, where energy consumption increase was relatively modest as they were originally developed. No matter what, Japan is almost entirely dependent on imported energy. Already the biggest three importers of LNG in the world are Japan, China and India. Although China is Asia's largest consumer of gas, gas only accounts for seven percent of China's energy demand. Similarly, gas only accounts for 6 percent of energy demand in India. However, with increasing environmental concern, demand for natural gas is expected to increase faster than oil and coal as natural gas is considered relatively less environmentally polluting than oil and coal. Increase use of gas could meet the needs of Asia's large and growing economies while providing significant associated benefits. The replacement of coal by natural gas will reduce local pollution because of the lower levels of sulfur, mercury, and nitrogen oxide released from burning natural gas. Increased use of natural gas will make it easier for Asian countries to curtail their GHG emissions and meet international climate commitments; without embracing gas, such achievements will be nearly impossible. This is where a strategic approach could help Canada to tap into this huge potential market for LNG.

Global LNG trade continues to grow reaching a total volume of 431.0 billion cubic meters in 2018 from 226.51 in 2008 [2], over 90 percent increase in 10 years. Increased demand from Asia-Pacific and increased production in Australia and other countries led the expanded LNG market. China and South Korea represent nearly 80 percent of LNG import growth in 2018 [9]. There are many small countries (i.e., Yemen, Cameroon, Egypt, PNG, etc.) went to LNG production and export. Similarly, many small countries (i.e., Bangladesh, Egypt, Belgium, etc.) also started importing LNG. However, the big contributors in export and import remain dominant. There are two noticeable implications. LNG trade is becoming more and more competitive through short-term contracts. Over the past two decades, non-long-term trade contract increased from a few percent to over 50 percent [9]. The second implication is on the issue of environmental concern. Natural gas is considered relatively less polluting compared to coal and oil. With increasing environmental concern, there is an upward pressure toward substituting other non-renewable energy resource (coal and oil) with natural gas. However, North American LNG export would face competition with Australia, Russian Federation and the Middle East. Within North America, US is already in the LNG export market and Canada is in the process of entering, and as such Canada would be a follower of LNG export with US as the leader. Given this complicated situation, the Canadian government agencies need to work together with the private oil companies to capture this market.

In this paper, we plan to address a few research questions in this regard. First, we would like to explore the potential for Canada`s entry into Asia-Pacific LNG market given its stringent environmental regulations. Then we study the impact of Canada`s entry on other incumbent players, i.e., Australian, Middle East, Russian Federation and US exporters. With different scenarios of Canada's relative potential cost situations, we also examine relative profitability and competitiveness of different regions including Canada. Finally, we would like to explore possible domestic policy scenarios that may offer Canada additional advantage over other players.

LITERATURE AND MODEL OVERVIEW

The four regions, Australia, Middle East, Russian Federation and US, compete for the share of the LNG market in the Asia Pacific. Given the constant demand, a gain of one region is the pain for another, which can be best modeled by oligopoly behavior, where the behavior of one player affects the pay-off of another player. This oligopolistic behavior can best be explained by game theoretic analysis. Gkonis and Psaraftis [7] apply game theoretic approach to LNG shipping using simple two oligopoly players (duopoly). Using Cournot and Stackelberg models, they provide an insight of a simple model applied to LNG shipping.

However, a simple duopoly is unrealistic to represent the current LNG trade as there are more than two regions exporting LNG. In addition, Gkonis and Psaraftis [7] focus only on the shipping, which is one component of the entire process of LNG trade. The entire process contains extraction, transportation by pipeline to the liquefaction facility, liquefaction (preparation of LNG), shipping LNG to the regasification plant in the importing country, regasification and then distribution to consumers [13]. Any realistic model for comparing profitability among players need to incorporate the entire process, from the extraction of natural gas to the distribution of its end use (households or businesses).

Ikonnikova and Zwart [10] applied a bilateral oligopoly model to explain the natural gas market within Europe using three major exporters and three major importers and imposed quota as trade restrictions. Jansen et al [11] used a modified Cournot model in European gas market citing Russian Federation as a player with objectives beyond profit maximization. In an earlier paper, Boots et al [1] used a successive oligopoly model to explain natural gas market in Europe. Although these examples of the use of oligopoly models are useful to illustrate the gas market in Europe, it is less appropriate to represent the situation we model. European countries, especially the ones used as exporters and importers, are so close that LNG is purely infeasible.

Growitsch et al [8] examined a spatial oligopoly model to analyze total natural gas market using both LNG and natural gas movement through pipelines and examined the impact on prices due to supply shock. Although their findings favor Cournot setting over perfect competition setting, a mixed model is less appropriate and lacks accuracy as evident through sensitivity analysis. Focusing on Cournot competition, Dorigoni et al [4] analyze the entry of LNG in the natural gas market. While this model is appropriate for new entrant, it is less suitable in examining the existing LNG market. Nevertheless, this provides a good starting point for analyzing LNG market, and in the development of our model, Dorigoni et al [4] have substantial influence. The difference between our model and that of Dorigoni et al [4] are our model addresses the perspective of exporters and expands further using a more-realistic multi-leader scenario. We used downstream market as competitive but Dorigoni et al [4] used the downstream market as oligopoly.

THE MODEL

The four LNG exporting regions are Australia (A), the Middle East (M), US (U) and Russian Federation (R). We will include Canada (E) as a new entrant later in the paper. We begin by defining the following notations used in the paper.

q_i: Quantity of LNG export by firm from country *i*, where *i = A, M, U* or *R*.
Q: Total quantity sold in the Asia Pacific Market, $Q = q_A + q_M + q_U + q_R$;
P: Unit price of LNG in the Asia Pacific Market
t_i: Unit transport/shipping cost for firm from country *i*, where *i = A, M, U* or *R*.
l_i: Unit production cost for firm from country *i*, where *i = A, M, U* or *R*. This includes, extraction costs, liquefaction and regasification cost, as also environmental regulation costs for player *i*, where *i* = A, M, U or R.
c_i: Total unit cost of exporting LNG in the Asia-Pacific market by firm from country *i*, where *i = A, M, U* or *R*.
F_E: Fixed entry cost to export in the Asia Pacific market for a new entrant firm. This includes any fixed production or setup costs involved to export to the Asia Pacific market.

At first, we assume that there are firms from four countries (or regions) competing in the LNG market in the Asia Pacific. The four players Australia (A), Middle East (M), Russian Federation (R) and US (U) enter the Asia Pacific market. Each of the countries is assumed to have one exporting firm, for simplicity. Our results will go through if we allow multiple firms from the same country, if the number of firms from each country remains the same. For now, we assume that US is a player although Canada's natural gas may get exported as LNG through US. This may be justified in the sense that almost all of Canada's natural gas exports are to US. In turn, the firm from US may export part of Canadian gas as LNG as there is a natural gas flow through pipeline from Canada to US through the West coast. Hence, an increase in LNG exports by US may have a positive correlation with more Canadian natural gas export to US.

We assume that the market structure for LNG is oligopolistic. One firm from each of the four countries exporting to the Asia Pacific natural gas market. They compete strategically in quantities in Cournot-Nash fashion. As mentioned before, c_i denotes the unit cost of the exporter from country i to supply in the Asia Pacific market, where $i = A, M, R$ or U. For simplicity, we assume that the unit production costs (defined l_i for firm i) are the same for each of the four firms, i.e., $l_A = l_M = l_R = l_U = l$. We further assume realistically that, regarding LNG shipping costs, $t_M = t_R = t_A = t < t_U$, since the shipping costs of reaching the Asia Pacific market is the highest for US. Since LNG production and export to the Asia Pacific from Western Canada has a cost advantage over US Gulf of Mexico (by approximately a dollar/mmbtu), Canada's entry will substantially affect production and profitability of other firms [3]. We also acknowledge that the environmental standards and extraction costs are lowest in the Middle East but ignore it for the time being. We will discuss it later in the paper.

Suppose that LNG is a homogenous product, so that all sellers need to sell it at the same price to the consumers. Let P denote the unit price paid to the LNG sellers in the final market. Let the inverse demand function for LNG in the Asian market be denoted by a simple linear demand function: $P = a - Q$, where $Q = q_A + q_M + q_R + q_U$; and a (> 0) is the demand parameter representing market size.

The unit cost of supplying LNG to the consumers in Asia Pacific for the exporter of LNG from Middle East is denoted by c_M, where $c_M = l + t_M + h_M$; where h_M denotes the inventory holding cost for the firm in the Middle East. We assume that there is more risk involved in exporting LNG from the Middle East, since there could be supply disruptions due to relatively low political stability in the region. Hence, firm M is assumed to hold more inventories in the Asia Pacific compared to its competitors to ensure it can supply the product to its consumers without delay in case of supply disruptions. Formally, $h_M > h_A = h_R = h_U$. Without loss of generality, we assume $h_A = h_R = h_U = 0$.

Therefore, the unit of supplying LNG to the consumers for the exporters of LNG from Australia, Middle East, Russian Federation and the USA is given by c_A, c_M, c_R and c_U respectively, where:

$$c_A = l + t_A; c_M = l + t_M + h_M; \; c_R = l + t_R \; ; c_U = l + t_U;$$

Analysis of LNG export Competition between Australia, Middle East, Russian Federation and US

We assume that the firms compete in Cournot Nash fashion. The key elements of this LNG export competition game are the following:

- Players: One exporting firm from each of the 4 countries, denoted firm A, M, R and U respectively.
- Strategies: Each player i chooses the amount it exports in the Asia pacific market, denoted q_i.
- Payoffs: The payoff functions of the 4 players are the following:

- *Firm A:* Profit function of Australian LNG exporter firm *A* in the Asia pacific market is: $\pi_A = P.q_A - c_A q_A = (a - q_A + q_M + q_R + q_U)q_A - (c_A)q_A$; objective of firm A is maximize π_A with respect to q_A
- *Firm M:* Similarly, the profit function of LNG exporter firm M (from Middle East): $\pi_M = P.q_M - c_M q_M = (a - q_A + q_M + q_R + q_U)q_M - (c_M)q_M$, which firm M aims to maximize with respect to q_M.
- *Firm R:* The profit function of the Russian exporting firm R: $\pi_R = P.q_R - c_M q_R = (a - q_A + q_M + q_R + q_U)q_R - (c_R)q_R$; which it maximizes w.r.t. q_R.
- *Firm U:* The profit function of US exporting firm U: $\pi_U = P.q_U - c_U q_U$, which it aims to maximize w.r.t. q_U.

In what follows, each firm *i* maximize their respective objective functions with respect to (w.r.t) their export quantity (q_i) to the Asia Pacific. This will give us the best reaction functions of each firm as a function of the other firm's output. Solving the reaction functions, we obtain the Cournot-Nash equilibrium export levels and corresponding profits for each firm.

Effect of Entry by Canadian firm

In this section, we relax the assumption that North America has a single firm US. Instead, there are two firms in North America, one from US and one from Canada, who compete non-cooperatively with other exporting firms for the Asia-Pacific market. Thus, there are now five competitors. However, while including Canada in this LNG export game, it must be noted that the other four players, namely Australia, the Middle East, Russian Federation and US are already in the Asia Pacific market, and enjoy a head start over Canadian LNG producers. To capture this situation, we assume that to enter the Asia Pacific export market, the Canadian firm E will face an additional sunk cost of $F_E \geq 0$. However, we assume that this sunk cost is not high enough that the Canadian firm will not be able to enter the Asia Pacific market. Other than this fixed entry cost, we assume that the Canadian firm has fixed costs F_E, and unit cost c_E, where $c_E = l_E + t_E$, where the notations have their usual meanings as explained before, like the other incumbent firms. After entry, the Canadian firm compete in Cournot Nash fashion with the incumbent 4 firms. Assume that the inverse demand function is the same as before: $P = a - Q$; with $Q = q_A + q_M + q_R + q_U + q_E$; where q_E is the quantity sold by the Canadian exporter.

The objective function of firm *E* is to maximize profits with respect to its output q_E, given the production and export to the Asia Pacific by the incumbent firms,

$$\pi_E(q_E;\ q_A, q_M\ q_R, q_U) = q_E(a - q_A - q_M - q_R - q_U - q_E) - c_E q_E - F_E$$

We consider this objective function with the objective function of the other four firms, to obtain the best response functions. Solving the best response functions, we obtain the equilibrium output and profits of each firm under this 5 player Cournot game. The results are available in Appendix 2.

How does the entry by the Canadian firm affect the incumbent firms, given that their costs are different? Does the Canadian firm's entry reduce the profits of each of the incumbent firm, or only the less efficient ones? We intend to examine this issue in this section.

To focus exclusively on the above question, let us assume that the unit costs of each of the incumbent firms are same in all respects, except for the US firm, which has a higher transport cost $t_u = t + \Delta t$, where *t* is the transport cost of the firms A, M and R, i.e. $t_A = t_M = t_R = t$. This is justifiable, since the distance to ship LNG from US to Asia Pacific through Panama Canal is much higher than that of the other four countries.

Given these assumptions we compare the output and profit levels of the incumbent firms before and after entry by the Canadian firm. This gives us the following result.

Proposition 1: *After entry by the Canadian firm E, the output and profit of each incumbent firms fall due to increased competition. The reduction in output and profits are same for each of the incumbent firms. in the sense that their output and profits are higher compared to the case when the Canadian firm did not enter.*

COMPARATIVE STATICS AND POLICY IMPLICATIONS

With the development of pipeline and liquefaction terminals at the coast of British Columbia, Canada will have reduced cost for the export of LNG to the Asia Pacific market. In terms of our model and notations, this will mean a decline in c_E, which means a decrease of the unit cost c_E for the Canadian firm E. From the above expressions (12)-(17), this implies an increase in the Canadian firm's equilibrium output (market share) and profit in the Asia pacific market, and a decrease in that of the other firms. A similar effect happens in case of a decrease in environmental standards.

Canada has several advantages of exporting LNG to the Asia Pacific. It has a large liquid-rich natural gas reserve in Alberta and British Columbia which can be converted to LNG in a naturally competitive low temperature regime [3]. The operating costs of LNG projects in the Western Canada are $0.52/mmbtu lower than the costs of Sabine Pass LNG project in Texas [3]. In addition, its proximity to Asia Pacific markets offers a transportation cost advantage over its nearest competitor, US. However, there are hurdles to overcome before reaping the benefits. Building pipelines and the liquefaction facilities in the rugged mountainous regions and remote areas are challenging. Building and maintaining pipelines requires indigenous peoples as partners as those often cross their territories. Canadian taxation regime and environmental regulations are also, in general, more stringent than many other regions, which pose additional challenge.

An increase in the perceived political risk in the Middle East: This is captured by an increase in the parameter h_M, which in turn increase the unit cost of supplying to the Asia pacific market for firm M. From our results, it shows that this will lead to a reduction in the equilibrium output and profit of firm M and an increase in the equilibrium output and profits of firms A, E, U and R, with a reduction in overall output. The market price goes up. The magnitude of positive effect on firms in A, E, U and R depends on oligopoly behavior among the three firms.

Increase in Canadian LNG import from US: With the entry of Canadian firm in the Asia Pacific market, the US firm stands to lose market share. Thus, the US firm has an incentive to prevent entry by the Canadian firm in that market. One way to achieve could be to increase the share of Canadian LNG import in US. It can be proved that an increase in Canadian LNG import to US increases the opportunity cost of LNG export to the Asia Pacific market for the Canadian LNG exporter.

Discussion

Our model is general and is based on the current LNG trade in the world. The four regions included in the model are responsible for nearly 60 percent of the world's LNG export. In addition, they all are major exporters to the Asia Pacific. There may be concerns about the inclusion of Russian Federation in the model as there are arguments that Russian Federation does not follow free-market economic principles. Many previous studies suggested that the energy sector in Russian Federation is controlled by the government, and it uses energy trade for pursuing geo-political motives, rather than profit motives of firms [6, 11]. However, Russian Federation is a signatory of WTO and follows usual principles of international trade. In addition, our model stands even if the Russian Federation is excluded.

[Detailed calculations are available from the authors upon request]

REFERENCES

[1] Boots, Maroeska G., Fieke A. M. Rijkers and Benjamin F Hobbs. 2004. Trading in the downstream European gas market: a successive oligopoly approach. The Energy Journal 25(3):73-102.

[2] BP. 2019. Statistical Review of World Energy, 68th Edition. https://www.bp.com/.../bp/.../en/.../statistical-review/bp-stats-review-2019-full-report.pdf

[3] CERI, 2018. Competitive Analysis of Canadian LNG. Canadian Energy Research Institute, Study No. 172. July 2018.

[4] Dorigoni, Susana, Clara Graziano and Federico Pontoni. Can LNG increase competitiveness in the natural gas market?, *Energy Policy*, 38 (2010), 7653-7664.

[5] EIA. 2019. Annual Energy Outlook 2019 with projections to 2050. US energy Information Administration. #AEO 2019. January 2019. https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf

[6] Finon, D. and C. Locatelli. 2008. Russian and European gas interdependence: could contractual trade channel geopolitics? Energy Policy 36:423-442.

[7] Gkonis, Konstantinos G. and Harilaos N. Psaraftis. The LNG market: A Game-theoretic approach to competition in LNG shipping, *Maritime Economics and Logistics*, 11(2) (2009), 227-246.

[8] Growitsch, Christian, Harold Hecking and Timo Panke. 2014. Supply disruptions and regional price effects in a spatial oligopoly – an application to the global gas market. Review of International Economics 22(5):944-975. DOI: 10.1111/roie.12138.

[9] IGU 2019. 2019 World LNG Report. International Gas Union. Barcelona. Spain. https://www.igu.org/.../IGU%20Annual%20Report%202019_23%20loresfinal.pdf

[10] Ikonnikova, Svetlana and Gijsbert T. J. Zwart. 2014. Trade quotas and buyer power, with an application to the E.U. natural gas market. Journal of the European Economic Association 12(1):177-199. DOI: 10.1111/jeea.12064.

[11] Jansen, Thijs, Arie van Lier, Arjen van Witteloostuijn and Tim Boon von Ochssee. 2012. A modified Cournot model of the natural gas market in the European Union: Mixed-motives delegation in a politicized environment. Energy Policy 41:280-285. DOI: 10.1016/j.enpol.2011.10.047

[12] Mukherjee, Arijit and Laixun Zhao. Profit Raising Entry, *The Journal of Industrial Economics*, Volume 65, Issue 1, March 2017, 214-219.

[13] Raj, Ratan, Ravi Suman, Samane Ghandehariun, Amit Kumar and Manoj K. Tiwari. 2016. A techno-economic assessment of the liquefied natural gas (LNG) production facilities in Western Canada. Sustainable Energy Technologies and Assessments 18:140-152. Doi: http://dx.doi.org/10.1016/j.seta.2016.10.005