A GAME THEORETIC APPROACH OF CANADA'S POTENTIAL FOR LNG EXPORTS IN THE ASIA-PACIFIC REGION

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WDSI Annual Meetings 2020

April 2020

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Contents

- Huge demand for LNG in the Asia Pacific
- Canada's LNG export potential
- Literature review
- Research questions
- The Economic model: Assumptions and setting
- Solution and results
- Policy implications and Conclusion

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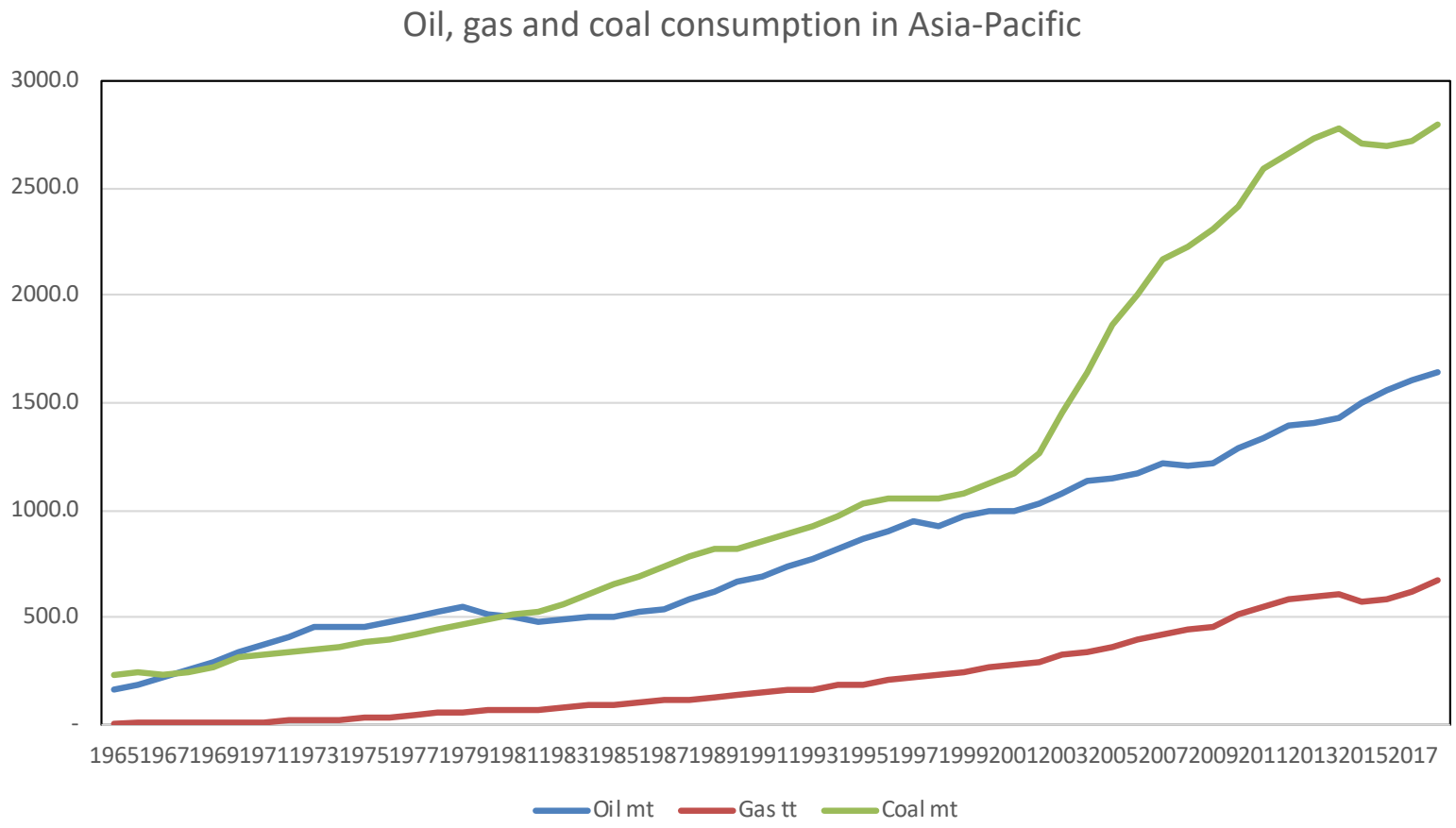
Motivations

- Huge demand for LNG in Asia Pacific:
  - Asia-Pacific region is the most energy-hungry region of the world due to its growing population and economy
  - In 2018, it imported nearly 75 percent of the world's traded LNG (322.8 bm3 out of 431.0 bm3)
  - Japan is currently the largest importer of natural gas, followed by China and South Korea:

RISING ENERGY DEMAND IN ASIA PACIFIC

- Demand for LNG is increasing rapidly in the Asia Pacific region:



Source: Author's own calculations based on several editions of BP Statistical review of World Energy

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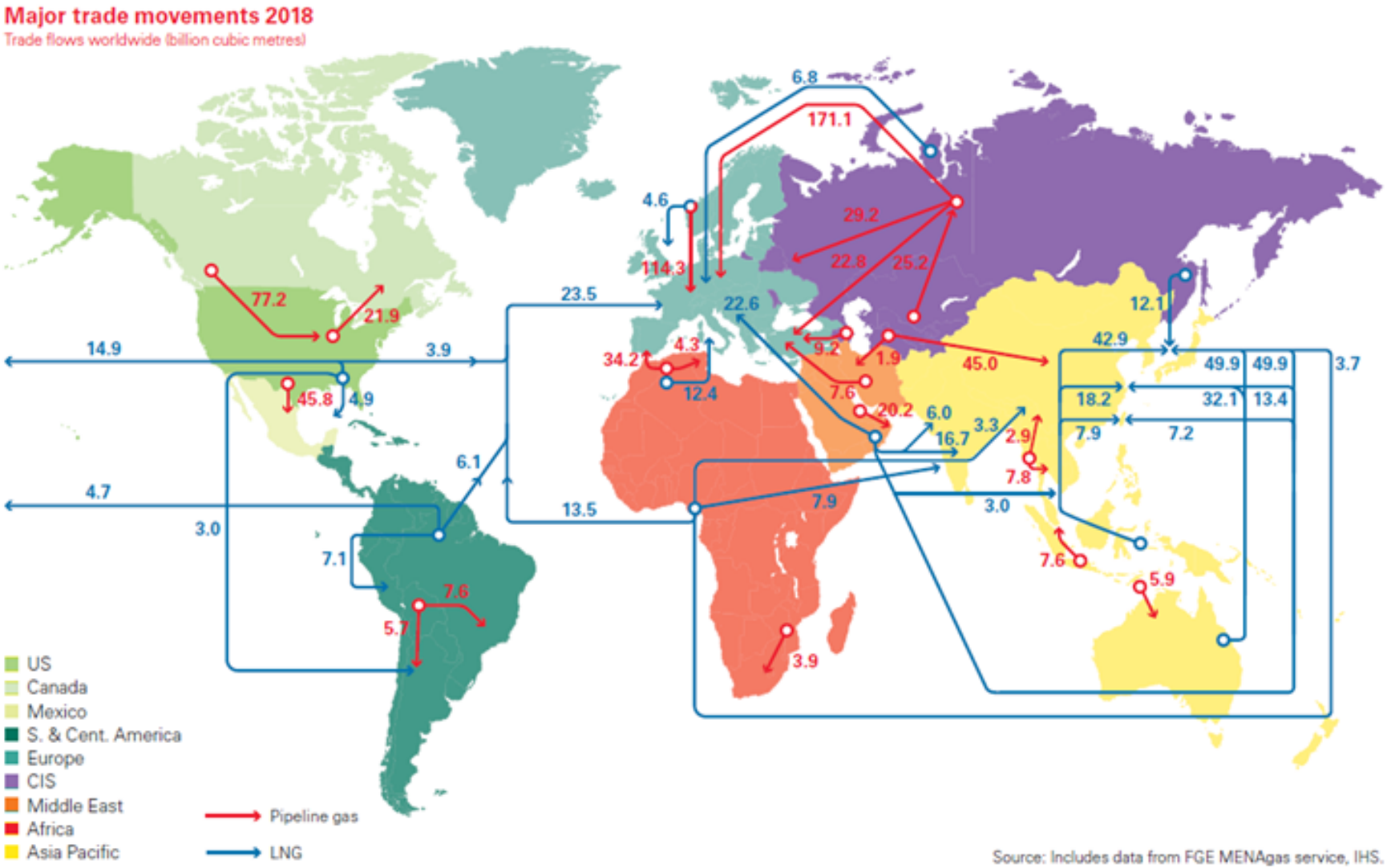
Major Trade movements of LNG (Source: BP 2019)



Canada's LNG Export potential

- Canada: fifth largest natural gas producer but only exports to US
- Canada has been planning to export LNG to Asian countries, but not yet done so.
- With the construction of LNG plant in place in Kitimat, BC, it is expected that Canada will be in the LNG export market soon.

Research Questions

The objective:

- Explore the potential for Canada`s entry in to Asia-Pacific LNG market.

Research Questions:

- How does Canada`s entry impact other incumbent players, i.e., Australian, Middle Eastern, Russian and US exporters?
- What possible policy scenarios may offer Canada additional advantage over other players?
- What possible policy actions can US take to reduce loss in market share due to entry by Canada?

Literature: LNG Export Competition

- *LNG Trade*

- *LNG Trade with game theoretic model:*

  Gkonis and Psaraftis (2009),
  Ikonnikova and Zwart (2014)
  Jansen et al (2012),
  Boots et al (2004)
  Growitsch et al (2014)
  Dorigoni et al (2010)

- ***Contribution of this research:***
  - *Effect of a Canada's entry as a new entrant to the LNG market under an Cournot oligopoly framework.*
  - *Impact of unit cost of exports of LNG to Asia Pacific, & how its affects what impact Canadian LNG export will have to the existing exporters in the Asia Pacific market.*
  - *Potential of Canada's LNG exports*

Model settings & assumptions

- LNG competition in the Asia Pacific symmetry
  - Only a limited number of firms compete: oligopoly and strategic interaction
- Information symmetry
  - All firms have the same information about market demand and costs of each player
- Status quo: Firms for four countries exporting LNG in the Asia Pacific market
  - For simplicity assume one firm from each country
  - Competition in Cournot Nash fashion

- Entry by the Canadian firm:
  - Consider a setting where the fixed costs of production and export are sufficiently low so that all firms can co-exist.
  - Canada's costs are lower than some of the existing firms, like the US
  - From 4 player Cournot, we now consider 5 player Cournot competition

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Notations

Stackelberg Leader (Incumbent) firms : Firms A, M, R and U Stackelberg Follower (Entrant): Firm E
P: market price in Asia Pacific
q_i: amount exported by firm i; $i = A, M, R, U, E$
Q: total quantity of LNG sold in the Asia Pacific market = $\sum q_i$
t_i: unit transport cost of exporting LNG to the Asia Pacific market for firm i; $i = A, M, R, U, E$
L_i: unit liquefaction cost for firm i; $i = A, M, R, U, E$
r_i: unit regasification cost for firm i; $i = A, M, R, U, E$
h_i: unit inventory holding cost in Asia Pacific market for firm i
ei: extraction costs for firm i, including environmental protection costs
$c_i = L_i + r_i + h_i + e_i + t_i$: cost/unit of exporting LNG to the Asia Pacific market for firm i
F_i: Fixed cost of exporting in the Asia Pacific market for firm i

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Status Quo: Before Entry by Canadian firm

- Demand function: $P = a - Q$;
  - where $Q = q_A + q_M + q_R + q_U$
- One from each from Australia (*A*), Middle East (*M*), Russian federation (*R*) and USA (*U*).
- Four firm Cournot oligopoly competition
- Objective function of firm i (where $i = A, M, R, U$):

  Maximize $\pi_i = Pq_i - c_i q_i - F_i$; with w.r.t. q_i.
- Maximizing, we obtain the best-response function of firm i (where $i = A, M, R, U$), as a function of the output of other firms.

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Status Quo: Equilibrium Before Entry by Canadian firm

- Solving the best response functions, we get the equilibrium output and profit of each firm:

  For example, for firm A, the equilibrium output and profit is:

$$q_A{}^* = \frac{a - 4c_A + c_M + c_R + c_U}{5}$$

$$= \frac{a - r - l + h_M + (t_M + t_R + t_U - 4t_A) + (e_M + e_R + e_U - 4e_A)}{5}$$

- Similarly for firm A, the equilibrium profit is:

$$\pi_A{}^* = \left(\frac{a - 4c_A + c_M + c_R + c_U}{5}\right)^2 - F_A$$

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After Entry by Canadian firm

- The Canadian firm is a late entrant to the A-P LNG market.
- We now have a 5 firm Cournot Model.
- Comparing the output and profit of the incumbent firms before and after the Canadian firm's entry, we get our first key proposition
- ***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.

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Comparative Statics

- Suppose there is an increase in perceived political risk in the Middle East:

$$h_M \uparrow \rightarrow c_M \uparrow: \rightarrow \pi_M \downarrow, \pi_A \uparrow, \pi_R \uparrow, \pi_U \uparrow$$

- Suppose there is an increase in environmental standards in any country, say Australia:

$$e_A \uparrow \rightarrow c_A \uparrow: \rightarrow \pi_A \downarrow, \pi_M \uparrow, \pi_R \uparrow, \pi_U \uparrow$$

- Similarly, a decrease in environmental standards with increase the output and profit of that country's firm, while reduce the profits of the firms from other countries.

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Comparative Statics

- 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.
  - 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.

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Insights and future research

- Conclusion:
  - 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.
- Future research
  - Simulations using reasonable values of parameters like different component of unit costs
  - Empirical evidence

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Thank you!

Questions?