Mixed Oligopoly Competitive Model of the World Natural Gas Market

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Research Questions

- What is the impact of the U.S. shale gas development on the world natural gas markets?
- Will U.S. natural gas export occur? If yes, what is the equilibrium trade volume?
- What are the domestic and foreign price impacts of the U.S. natural gas exports?

To answer these questions

- Develop a model for world natural gas market where buyers and sellers are connected by a trading network
- Calibrate model parameters by using production, consumption, price, proved reserves and trade flow data in 2009

Solution Methodology

- Our model is a non-cooperative game with coupled payoff functions and coupled constraints
- Theorem 1: The Cournot game has a unique Nash equilibrium.
- 8 dominant producers \(\Rightarrow\) 8 capacity constraints \(\Rightarrow\) \(2^8 = 256\) cases to be checked for each scenario \(\Rightarrow\) computational challenge!
- We define our model in a centralized approach by showing that this game can be represented as a potential game and solve for its unique equilibrium

Scenario-I: Flat North American supply curve

**Key results**

- North America exports natural gas to Europe and Asia Pacific
- Dominant producers decrease their supply to both markets
- Total consumption in Europe \(\uparrow\) by 4.3 bcm \(\Rightarrow\) equilibrium price in Europe \(\uparrow\) by $5 million USD/bcm
- Total consumption in Asia Pacific \(\uparrow\) by 3.6 bcm \(\Rightarrow\) equilibrium price in Asia Pacific \(\downarrow\) by $3.7 million USD/bcm
- Due to decline in equilibrium prices, dominant producers make less profit

Scenario-II: Increase in Asia Pacific’s demand & 75% more elastic North American supply curve

**Key results**

- Dominant producers \(\uparrow\) their supply to Asia Pacific by \(\downarrow\) their supply to other markets
- North America exports 3.75 bcm of natural gas to Asia Pacific and does not import any
- Total consumption in Asia Pacific \(\uparrow\) by 80 bcm \& equilibrium price \(\uparrow\) by $29.2 million USD/bcm
- Equilibrium price in each region except in North America \(\uparrow\)
- Domestic price impact of 3.75 bcm of natural gas exports is $0.16 million USD/bcm increase

Scenario-III: Russia and Middle East collusion

**Key results**

- To exploit their market power Russia and Middle East \(\downarrow\) their supply to Europe and Asia Pacific
- Total consumption in North America \(\downarrow\) by 2 bcm \(\Rightarrow\) equilibrium price \(\uparrow\) by 1.4 million USD/bcm
- Total consumption in Europe \(\downarrow\) by 6.9 bcm \(\Rightarrow\) equilibrium price \(\uparrow\) by 4.9 million USD/bcm
- Total consumption in Asia Pacific \(\downarrow\) by 2.43 bcm \(\Rightarrow\) equilibrium price \(\uparrow\) by 2.3 million USD/bcm
- Joint profit of Russia and Middle East \(\uparrow\) by 1.5 billion USD (compared to our reference case)

Scenario-IV: Russia and Middle East collusion & flat North American supply curve

**Key results**

- North America exports natural gas to Europe and Asia Pacific
- Total consumption in Europe \(\uparrow\) by 0.64 bcm \(\Rightarrow\) equilibrium price \(\downarrow\) by 0.46 million USD/bcm
- Total consumption in Asia Pacific \(\uparrow\) by 3.03 bcm \(\Rightarrow\) equilibrium price \(\downarrow\) by 2.8 million USD/bcm
- Joint profit of Russia and Middle East \(\downarrow\) by 0.08 billion USD compared to our reference case (no shale & no collusion) but \(\uparrow\) by 0.06 billion USD compared to scenario with flat North American supply curve & no collusion

Conclusions

- North America exports natural gas when her supply curve is highly elastic
- Domestic price impact of exports from North America is very small
- Price impact of North American exports on importing countries is substantial
- Shale gas development in North America decreases market power of dominant producers \(\Rightarrow\) decreases the profitability of any gas cartel formation

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