Cooperative and Competitive Gas Processing: Further Empirical Evidence

Yuanshun Li and Gordon Sick*

March 1, 2012

Abstract

Natural gas producers drill their own wells, but need gas plants to process gas for shipping to market. These facilities are built by a first-mover, which can lease its facility to adjacent producers to enable production of their gas. The first-mover advantages are that the plant can be customized to the builder's needs and economic rents can be earned on leases. If gas prices are high or field reserves are large, a second mover can (and often does) build its own plant.

This paper extends the earlier models of Li and Sick [2007, 2010, 2011] with more empirical evidence.

1 Earlier Work

Li and Sick [2007, 2010, 2011] develop a model of cooperative and competitive games occurring between firms that need infrastructure, which can be shared. We refer to the economies of sharing as a "network effect". A firm can

- Build its own infrastructure along with its own plant and operate as a stand-alone entity.
- Build infrastructure with sufficient capacity to share with other firms, achieving economies of scale. It also builds its own private assets to have a complete project. There is a cooperative game to determine a lease rate and capacity that can be shared between the infrastructure owner and the lessee. The builder is a first mover, and can achieve an

*Rogers School of Management, Ryerson University and Haskayne School of Business, University of Calgary.

advantage by customizing the infrastructure to operate more efficiently with its own business.

- The firm can accept an offer from a leader that has built or will build infrastructure to lease the infrastructure and also build its own private assets to complete the project. This firm is a second mover. It also has the option to build its own infrastructure if the leasing conditions of the leader are too onerous.

The natural leader in this model is the firm with larger reserves, if discoveries in a region are simultaneous, or the first firm to discover, otherwise.

1.1 Theory

The theory provides the following hypotheses:

- The probability of cooperation is decreasing in gas price, conditional on development by both the follower and leader. For high gas prices, the follower has high enough value to develop independently. For low gas prices, the follower cannot afford to develop independently.

- Cooperation is more likely with small reserves, in order to achieve the network effects of economies of scale.

- The probability of cooperation is decreasing in field reserves, because two or more gas plants are more likely to be viable with larger reserves.

- The duration of time between discovery and development could be increasing or decreasing in the number of discovery wells in the field. A large number of discovery wells provides more competition to become the leader in developing a gas plant, which tends to induce earlier development. But a large number of discovery wells makes a second mover more viable, and the ability to move second removes the incentive to develop early.

- For the same reasons, the probability of cooperation may be increasing or decreasing in the number of discovery wells.

1.2 Empirical Evidence

The previous empirical analysis Li and Sick [2010] only examined plants and fields that were connected with each other, so it misses the important decisions about the potential for a field to connect to a plant, even though it ultimately did not connect.[1] That paper considered:

[1] This leads to a survival bias.

- The date of discovery of a field
- Initial estimate of field reserves (quantity)
- Depth of well, which proxies for cost of development
- The number of discovery wells registered for the same field, which proxies for both the network cooperation effect and the level of competition

We used this to explain three different endogenous variables:

- Duration of time between discovery and initial production, where the date at which field production begins, is identified as the date at which the field is first registered to some gas plant for production
- Market price of gas at the time of discovery and the time of initial production, which is a "trigger price"
- A dummy variable for a gas plant that is 1 if there is cooperation, which is defined to mean that gas from more than one field is processed in the same plant and that it serves multiple operators. A non-cooperative plant either serves one field or one operator or both.
- The capacity of the gas plant, which proxies for the construction cost of the plant and is a result of the leader's expectation of the likelihood of cooperation with a follower

This analysis is lacking for the following reasons:

- There is no ability to distinguish network cooperation effects from competition effects.

2 Our New Empirical Analysis

2.1 Inflation

Since the time period of the analysis extends over 100 years, we introduce an inflation adjustment for gas prices.

2.2 Competitor Plants

Each plant initiates production with a particular inaugural field. The competitors to that plant are all the plants that are at least as "close" to the inaugural field as the given plant, and that were in existence at the time of first production from the given plant. We use three different measures of "close" to obtain three alternative measures of the number of competitors.

An L_1 *Competitor* is a plant that is no farther from the inaugural field than is the given plant that started production with that field.

The other definitions of the number of competitors depends on the historic distribution (Table 1) of the distances between plants an fields in Alberta. An L_2 *Competitor* is a plant that no farther from the inaugural field than the average distance (21.99 km) between plants and their inaugural field. An L_3 *Competitor* is a plant that no farther from the inaugural field than 100 kilometers. Only 1.79% of the plants were more than 100 km from their inaugural field, and this may be an inflated figure, because of outliers in the location (distance) data that we have.

These definitions of a competitor immediately provide a counting measure of the number of competitor gas plants, as in Tables 2 and 3. We intend to extend this to a continuous variable describing competition by computing the inverse distance between each plant and field pair. The distance is proportional to the cost of shipping the gas from the field to the plant, and a more distant plant is not as effective a competitor as a nearby plant.

Thus, the inverse distance between plants is a measure that varies positively with the potential of the plants to compete with each other and the inverse distance between fields and plants is a measure that varies positively with the potential benefits from cooperation in shipping all the gas to one plant.

We plan to use the average inverse distance between plants that are $L_1, L_2 L_3$ competitors, respectively as measures of competition between plants. Similarly, we will use the average inverse distance for the comparable categorizations of plants and fields as a measure of potential cooperation.

These new variables will allow us to distinguish the potential for cooperation from the potential for competition, which was lacking in Li and Sick [2010].

2.3 Proposed Analysis

This analysis will be done prior to the conference and added to this paper.

2.3.1 Two-stage logit model of the probability of cooperation

The capacity of the plant is a decision variable by the lead and is endogenous, so it will be projected onto the depth of the discovery well in the first stage. In the second stage, the predicted capacity, competition variables (number of

Table 1: Distribution distances between Alberta gas processing plants and their inaugural production field.

Distance (km)	Frequency
0–10	602
10–20	486
20–30	242
30–40	137
40–50	60
50–60	36
60–70	12
70–80	8
80–90	7
90–100	3
More than 100	29
Total	1622

Table 2: Distribution of L_1 and L_2 Competitors for gas plants in Alberta

Number of Competitors	L_1 Frequency	L_2 Frequency
0	731	176
1–2	433	530
3–4	163	325
5–6	77	262
7–8	52	152
9–10	31	97
11–12	24	46
13–14	15	17
15–16	19	10
17–18	10	3
19–20	7	3
More than 20	60	1
Total	1622	1622

Table 3: Number of L_3 Competitors for gas plants in Alberta

Number of Competitors	Frequency
0–50	145
51–100	125
101–150	113
151–200	99
201–250	87
251–300	70
301–350	95
351–400	104
401–450	117
451–500	118
501–550	99
551–600	79
601–650	99
651–700	75
701–750	60
751–800	47
801–850	38
851–900	23
901–950	17
More than 951	12
Total	1622

L_n competitors) will be used as explanatory variables for the logistic function of the dummy variable for cooperation.

2.4 Hazard model for the duration of time between discovery and investment

The duration of the time between discovery and investment will be explained by the same variables used in the previous analysis.

3 Conclusion

This is an extended abstract of work that we intend to complete for the conference. We have the data and need to complete the analysis.

4 References

Yuanshun Li and Gordon A Sick. Real options, sequential bargaining game and network effects in natural gas production. March 2007. URL http://ssrn.com/paper=972606.

Yuanshun Li and Gordon A Sick. Equilibrium of a real options bargaining game: Evidence from natural gas. March 2010. URL http://realoptions.org/papers2010/273.pdf.

Yuanshun Li and Gordon A Sick. Investment under uncertainty: Equilibrium between competition and cooperation. February 2011. URL http://realoptions.org/papers2011/75.pdf.