# The Kleit Oligopoly Game: A Classroom Game for Chapter 14 [1]

The widget industry in Smallsville has $N$ firms. Each firm produces 150 widgets per month. All costs are fixed, because labor is contracted for on a yearly basis, so we can ignore production cost for the purposes of this case. Widgets are perishable; if they are not sold within the month, they explode in flames.

There are two markets for widgets, the national market, and the local market. The price in the national market is $20 per widget, with the customers paying for delivery, but the price in the local market depends on how many are for sale there in a given month. The price is given by the following market demand curve:

$$P = 100 - \frac{Q}{N},$$

where $Q$ is the total output of widgets sold in the local market. If, however, this equation would yield a negative price, the price is just zero, since the excess widgets can be easily destroyed.

$20 is the **opportunity cost** of selling a widget locally– it is what the firm loses by making that decision. The benefit from the decision depends on what other firms do. All firms make their decisions at the sme time on whether to ship widgets out of town to the national market. The train only comes to Smallsville once a month, so firms cannot retract their decisions. If a firm delays making its decision till too late, then it misses the train, and all its output will have to be sold in Smallsville.

### General Procedures

For the first seven months, each of you will be a separate firm. You will write down two things on an index card: (1) the number of the month, and (2) your LOCAL-market sales for that month. Also record your local and national market sales on your Scoresheet. The instructor will collect the index cards and then announce the price for that month. You should then calculate your profit for the month and add it to your cumulative total, recording both numbers on your Scoresheet.

For the last five months, you will be organized into five different firms. Each firm has a capacity of 150, and submits a single index card. The card should have the number of the firm on it, as well as the month and the local output. The instructor will then calculate the market price, rounding it to the nearest dollar to make computations easier. Your own computations will be easier if you pick round numbers for your output.

If you do not turn in an index card by the deadline, you have missed the train and all 150 of your units must be sold locally. You can change your decision up until the deadline by handing in a new card noting both your old and your new output, e.g., "I want to change from 40 to 90."

[1] 6 February 2006. Eric Rasmusen, Erasmuse@indiana.edu. Http://www.rasmusen.org.

**Procedures Each Month**

1. Each student is one firm. No talking.

2. Each student is one firm. No talking.

3. Each student is one firm. No talking.

4. Each student is one firm. No talking.

5. Each student is one firm. No talking.

6. Each student is one firm. You can talk with each other, but then you write down your own output and hand all outputs in separately.

7. Each student is one firm. You can talk with each other, but then you write down your own output and hand all outputs in separately.

8. You are organized into Firms 1 through 5, so N=5. People can talk within the firms, but firms cannot talk to each other. The outputs of the firms are secret.

9. You are organized into Firms 1 through 5, so N=5. People can talk within the firms, but firms cannot talk to each other. The outputs of the firms are secret.

10. You are organized into Firms 1 through 5, so N=5. You can talk to anyone you like, but when the talking is done, each firm writes down its output secretly and hands it in.

11. You are organized into Firms 1 through 5, so N=5. You can talk to anyone you like, but when the talking is done, each firm writes down its output secretly and hands it in. Write the number of your firm with your output. This number will be made public once all the outputs have been received.

| | | | | | |
|---|---|---|---|---|---|
| 11 | | | | | |

12. You are organized into Firms 1 through 5, so N=5. People can talk with anyone they like, and arrange to submit outputs jointly if they like. Write the number of your firm with your output. This number will be made public once all the outputs have been received.

| | | | | | |
|---|---|---|---|---|---|
| 12 | | | | | |

**Winners**

The instructor will congratulate (a) whichever student has the highest profits over all the months; (b) each member of the team with the highest profits over the team months; and (c) each member of the class if the average profit over all the months exceeds 3,700 (an average price of 30).

**Analysis**

If firm $i$ sells $Q_i$ locally, then local sales will be $\sum_{i=1}^{N} Q_i$. Industry revenue will be the sum of local and national-market revenues:

$$\Pi = \left(\sum_{i=1}^{N} Q_i\right)\left(100 - \frac{\sum_{i=1}^{N} Q_i}{N}\right) + \left(150 - \sum_{i=1}^{N} Q_i\right)(20). \quad (1)$$

If this is maximized (which can be done using calculus), then the average sales per firm is 40 and the price is 60, for any number N of firms.

(Using calculus: Industry revenue if each firm produces $q$ is $Nq(100 - Nq/N) + N(150 - q)(20)$, which equals $100Nq - Nq^2 + 3000N - 20Nq$ . Setting the derivative with respect to $q$ equal to zero yields $100N - 2Nq - 20N = 0$, which can be simplified to $q = 40$).

Suppose, however, that $(N - 1)$ of the firms are selling 40 each, but Firm N is still making up its mind. Firm N faces the following demand curve, which substitutes 40 for the output of each of the other firms:

$$P = 100 - \frac{40(N-1)}{N} - \frac{Q_N}{N} = 100 - 40 + \frac{40}{N} - \frac{Q_N}{N} = 60 - \frac{Q_N - 40}{N}.$$

If $N = 5$, firm $N$ maximizes its profit by choosing $Q_N = 120$, something which also needs calculus to calculate. This means that it may be difficult to create an environment in which each firm sells just 40 locally.

Table 2 shows what happens at various levels of local sales per firm if all firms maintain the same level, given that the national price is fixed at 20 and a firm's national sales are 150 minus its local sales.

| **Local Sales per Firm** | **Local Price** | **Local-Market Revenues per Firm** | **National-Market Revenues per Firm** | **Total Revenues per Firm** |
|---|---|---|---|---|
| 0 | 100 | 0 | 3,000 | 3,000 |
| 10 | 90 | 900 | 2,800 | 3,700 |
| 20 | 80 | 1,600 | 2,600 | 4,200 |
| 30 | 70 | 2,100 | 2,400 | 4,500 |
| **40** | **60** | **2,400** | **2,200** | **4,600** |
| 50 | 50 | 2,500 | 2,000 | 4,500 |
| 60 | 40 | 2,400 | 1,800 | 4,200 |
| 70 | 30 | 2,100 | 1,600 | 3,700 |
| 80 | 20 | 1,600 | 1,400 | 3,000 |
| 90 | 10 | 900 | 1,200 | 2,100 |
| 100 | 0 | 0 | 1,000 | 1,000 |

TABLE 2: PRICES AND OUTPUTS

## Cournot Equilibrium

To find the Nash equilibrium (the Cournot equilibrium, this model), set up the payoff function of the individual firm. Suppose all the other firms choose local sales of $q$, but the first firm chooses $q_1$. Firm 1's payoff is then

$$\begin{aligned}\pi_1 &= Pq_1 + 20 * (150 - q_1) = (100 - \tfrac{Q}{N})q_1 + 20 * (150 - q_1) \\ &= 100q_1 - \tfrac{((N-1)q+q_1)q_1}{N} + 20 * (150 - q_1) \\ &= 100q_1 - \tfrac{(N-1)qq_1}{N} - \tfrac{q_1^2}{N} + 3000 - 20q_1.\end{aligned}$$

Differentiating with respect to $q_1$ yields the first order condition

$$\frac{d\pi_1}{dq_1} = 100 - \frac{(N-1)q}{N} - \frac{2q_1}{N} + 0 - 20 = 0,$$

which can be solved to yield $80N = (N-1)q + 2q_1$. If we furthermore guess that the equilibrium is symmetric, so $q = q_1$, then we can write $80N = (N+1)q$, and $q = \frac{80N}{N+1}$.

If $N = 1$, the firm produces $q = \frac{80}{2} = 40$, and the price is 60.

If $N = 2$, each firm produces $q = \frac{160}{3} = 53\ 1/3$, and the price is $46\ 2/3$.
If $N = 3$, each firm produces $q = \frac{240}{4} = 60$, and the price is 40.
If $N = 4$, each firm produces $q = \frac{320}{5} = 64$, and the price is 36.
If $N = 5$, each firm produces $q = \frac{400}{6} = 66\ 2/3$, and the price is $33\ 1/3$.

$N = 20$: each firm produces $q = \frac{1600}{21} = 76.19$; price =23.8.

$N = 40$: each firm produces $q = \frac{3200}{41} = 78.05$; price = 21.95.

$N = 400$: each firm produces $q = \frac{32000}{401} = 79.80$; price = 20.2.

**Instructor's Notes**

This game is adapted from one developed by Professor Andrew Kleit of Louisiana State University. A version was published as Meister, Patrick, " 'Oligopoly' - An In-Class Economic Game," *Journal of Economic Education*, 30, 4:383-391 (Fall 1999).

Equipment:
1. A buzzer (optional)
2. Index cards
3. A calculator or computer (Google will do calculations for you)

Students are very unlikely to achieve an average revenue of 3,700 (which means an average price of 30).

Rather than just congratulating the students, you may wish to give real rewards— a coffee mug for the individual winner, cans of pop for the five-firm winners, and donuts for the entire class if they achieve over a threshold of 3,700. Since students often make arithmetic errors in adding up their scores, wait to give the prizes till the next class.

I can get through all the rounds in a 75-minute class, but it is a tight squeeze.

The first rounds can go by very quickly. They are so the students will learn how the demand curve works. Students will usually start with cautiously low local outputs. Allow more time per month for the later months, since the students will spend more time talking.

You may wish to stop and discuss strategies after the first 5 rounds, which are silent.

I like to leave an overhead on the projector during the game with what happens in each of the 12 months. I write the prices on it month by month.

Make the point that in Month 12, cartels are legal, but not inevitable. There is still a holdout problem. If 4 firms agree to produce 40 each, the 5th firm will hold out and produce 80. Or, you might find that total cartel output is 200, but one firm insists that the others each produce 30 and it produce 80.

Also make the point that the Nash equilibrium price is not 20, but 33 1/3. Explain that this is because if a firm deviates and sells more, then it will drive the price down enough that its own profits will fall too. If, however, firms had unlimited capacities *and* they chose prices instead of quantities, the result would be different.

Miscellaneous Notes.

1. Professor John Maxwell says that in the Kleit game, he has found prices falling with fewer firms. Variance of outputs falls too. The reason: The risk takers dominate their new teams.

2. This game works equally well, or better, if some students have played it before. Most likely, the experienced students will all choose high outputs in the first period, leading to low prices and

losses for them. You can make the point that a moderate amount of sophistication can be worse than none at all.

3. Explain to the students that ordinarily just two local amount might be optimal: either 0 or 150. If a firm thinks that the price will be more than 20 (even just 21) if it chooses 150, then it should choose 150. If the firm thinks the price will be less than 20, it should choose 0. Intermediate amounts are best responses only if the firm thinks that its own sales would tip the price from being above 20 to being below.

Humans have a psychological tendency to choose intermediate amounts even when bang-bang solutions are optimal. This can also result from risk aversion, but the moderation effect, called "probability matching" is distinct, and well- known in psychology (see Herrnstein & Prelec [1991]).

4. One benefit from being able to talk is that students who understand the situation can explain it to those who do not. Some students will realize that the cartel optimum is when each firm produces 40, but others will get the number wrong, and not realize it till the open discussion begins.

R. J. Herrnstein and D. Prelec (1991) "Melioration: A Theory of Distributed Choice," *Journal of Economic Perspectives*, 5(3): 137-156 (1991).

Below are some pages you may wish to use for handouts or overhead slides.

Your Name:
Your Firm:

| Month | Your Local Sales | Local Price | Local Revenue | Your National Sales | Nat. Price | National Revenue | Total Revenue | Cumulative Revenue |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |

Table 1: Scoresheet

The local price depends on local output. Cumulative revenue is the sum of that month's revenue plus every preceding month's revenue.

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| 50 | 50 | 2,500 | 2,000 | 4,500 |
| 60 | 40 | 2,400 | 1,800 | 4,200 |
| 70 | 30 | 2,100 | 1,600 | 3,700 |
| 80 | 20 | 1,600 | 1,400 | 3,000 |
| 90 | 10 | 900 | 1,200 | 2,100 |
| 100 | 0 | 0 | 1,000 | 1,000 |

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