Oligopoly

ECON 370: Microeconomic Theory

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Oligopoly: Introduction

- Alternative Models of Imperfect Competition
  - Monopoly and monopolistic competition
  - Duopoly - two firms in industry
  - Oligopoly - a few (> 2) firms in industry
- Essential Features
  - Nature of interaction between firms (beyond those captured in price) is essence of theories
  - No single "grand theory"

Oligopoly: Analysis

- Simplest Model of Oligopoly: Duopoly
  - Assume only two firms (to limit interactions)
  - Assume homogeneous output
    - No product differentiation
    - Single market price
    - No competition in quality
  - Equilibrium: Solve for output, price of each firm

Oligopoly Models

- We use Game Theory to model *strategic behavior*
  - *Strategic Behavior* takes into account how others will react to one's actions
- Non-cooperative simultaneous games
  - Simultaneously choose quantities (or prices)
- Non-cooperative sequential games
  - Quantity (or price) leader (dominant/barometric firm)
  - Quantity (or price) follower
- Cooperative games
  - Collusion -- jointly set quantities (or prices)

Quantity Competition: Introduction

- Assume firms choose output and allow prices to adjust to clear markets
- Each firm chooses output to max profits, given output level of competitor
- "Firms compete in outputs"
- Firm 1: y_1 units; Firm 2: y_2 units
  - total quantity supplied is $y_1 + y_2$
  - market price will be $p(y_1 + y_2)$
  - total cost functions are $c_1(y_1)$ and $c_2(y_2)$

Quantity Competition: Profits

- Firm 1 maximizes profit, given y_2
- Firm 1 profit function:
- $\pi_1(y_1; y_2) = p(y_1 + y_2)\, y_1 - c1(y_1)$
- Firm 1 "Reaction Function"
  - What output y_1 maximizes firm 1 profit?
  - Given y_2 (expected or observed)
  - Solve for reaction function $y_1 = f(y_2)$

Quantity Competition: Example

- Let market inverse demand function be
  - $p(y_T) = 60 - y_T$
  - $y_T = y_1 + y_2$
- Let firms' (different) total cost functions be
  - $c_1(y_1) = y_1^2$
  - $c_2(y_2) = 15y_2 + y_2^2$

Example: Firm 1

- Firm 1 profit function is
  - $\pi_1(y_1; y_2) = (60 - y_1 - y_2)y_1 - y_1^2$
- So, given y_2, solve for firm 1 profit-maximizing y_1

$$\frac{\partial \pi_1}{\partial y_1} = 60 - 2y_1 - y_2 - 2y_1 = 0$$

- Firm 1's reaction function (best response) is

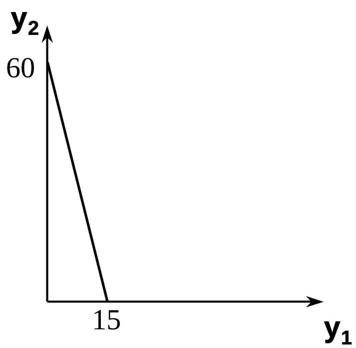
$$y_1 = R_1(y_2) = 15 - \frac{1}{4}y_2$$

Graph: Firm 1

Firm 1's "Reaction Curve" $R_1(y_2)$

$$y_1 = R_1(y_2) = 15 - \frac{1}{4} y_2$$

$$(or\, y_2 = 60 - 4 y_1)$$



Example: Firm 2

- Similarly, given y_1, Firm 2's profit function is
  - $\pi_2(y_2; y_1) = (60 - y_1 - y_2)y_2 - 15y_2 - y_2^2$
- To get Firm 2's profit-maximizing output

$$\frac{\partial \pi_2}{\partial y_2} = 60 - y_1 - 2y_2 - 15 - 2y_2 = 0$$

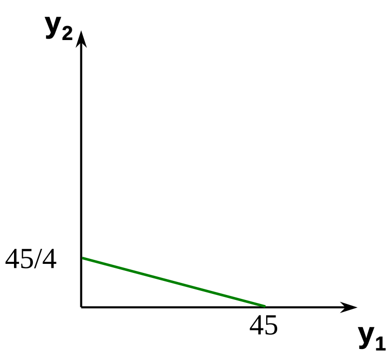
- Firm 1's reaction function (best response) is

$$y_2 = R_2(y_1) = \frac{45 - y_1}{4}$$

Graph: Firm 2

Firm 2's "Reaction Curve" $R_2(y_1)$

$$y_2 = R_2(y_1) = \frac{45 - y_1}{4}$$



Equilibrium

- Equilibrium is a *Cournot-Nash* equilibrium
- Each firm's output level is best response to other firm's output level
- Stable: neither firm wants to change output
- Thus, (y_1^*, y_2^*) such that
  - $y_1^* = R_1(y_2^*)$ and
  - $y_2^* = R_2(y_1^*)$
- Essentially solving a pair of simultaneous equations

Equilibrium

$$y_1^* = R_1(y_2^*) = 15 - \frac{1}{4} y_2^* \qquad y_2^* = R_2(y_1^*) = \frac{45 - y_1^*}{4}$$

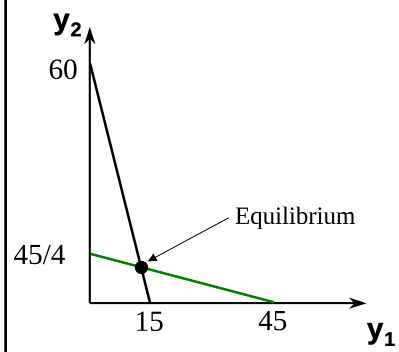
Substitute for y_2^* to get

$$y_1^* = 15 - \frac{1}{4}\left(\frac{45 - y_1^*}{4}\right) \Rightarrow y_1^* = 13$$

$$y_2^* = \frac{45 - 13}{4} = 8$$

Cournot-Nash equilibrium is $(y_1^*, y_2^*) = (13, 8)$

Graph: Equilibrium



Cournot v Monopoly

- Price
  - Less than monopoly
  - Greater than perfect competition
- Quantity
  - Greater than monopoly
  - Less than perfect competition
- Total profit
  - Less than monopoly
  - Greater than perfect competition

Price Competition: Bertrand Games

- Alternative strategic behavior
- Firms compete using only price (not quantity)
- Bertrand games
  - Simultaneous game
  - Firms use price as strategic variable
- Get results dramatically different from quantity competition

Bertrand Games: Introduction

- Example of Bertrand game
  - Each firm's MC = c, constant
  - All firms simultaneously set their prices
- Nash Equilibrium: All firms set $p = c$
  - All firms have same p, or high p loses all sales
  - Any $p > c$, slight price reduction yields big profit
  - Any $p < c$, lose money

Sequential Games

- Sequential games
- One firm (larger firm) moves first
- Then "follower firms" react
- Both consider reactions of other
- Can compete in
  - Quantity—von Stackelberg Model
  - Price—Price leadership models

The von Stackelberg Model

- Outputs are strategic variables
- Firm 1—*leader* firm—chooses y_1 first
- Firm 2—*follower*—then reacts
- Leader anticipates reaction of follower (doesn't assume y_2 constant as in C-N)
- Issues
  - What are prices, outputs, profits
  - Is there a "first mover" advantage?

The von Stackelberg Model

- Follower firm will choose y_2 to maximize profit, given leader firm y_1 (C-N assumption)
- Thus, follower reaction function: $y_2 = R_2(y_1)$
- Leader firm (1) anticipates follower firm's (2) reaction function, so chooses y_1 to max profit
  - $\pi_1^s(y_1) = p[y_1 + R_2(y_1)]y_1 - c_1(y_1)$

Von Stackelberg Game: Profits

- Note: leader firm makes a profit at least as large as Cournot-Nash profit
  - Can always choose y_1 = C-N output
  - Follower will respond with y_2 = C-N output
  - So, can at least achieve C-N profit
- Return to duopoly example w / different MC's
  - Leader firm 1 has lower costs $c_1(y_1) = y_{12}$
  - Follower firm 2 has higher costs $c_2(y_2) = 15y_2 + y_2^2$

Von Stackelberg Game: Example

- Same characteristics as before
- Market inverse demand function is
  - $p = 60 - y_T$
- The firms' cost functions are
  - $c_1(y_1) = y_1^2$ and $c_2(y_2) = 15y_2 + y_2^2$
- Firm 2 is follower, with reaction function

$$y_2 = R_2(y_1) = \frac{45 - y_1}{4}$$

Von Stackelberg Game: Example

Leader's profit function is

$$\pi_1^s(y_1) = [60 - y_1 - R_2(y_1)]y_1 - y_1^2$$

$$= \left(60 - y_1 - \frac{45 - y_1}{4}\right)y_1 - y_1^2$$

$$= \frac{195}{4}y_1 - \frac{7}{4}y_1^2$$

For a profit-maximum, first order condition is

$$\frac{195}{4} = \frac{7}{2}y_1 \Rightarrow y_1^s = 13.9$$

Von Stackelberg Game: Example

- Follower firm's response to y_1=13.9 is

$$y_2^s = R_2(y_1^s) = \frac{45 - 13.9}{4} = 7.8$$

- Recall C-N outputs are $(y_1^*, y_2^*) = (13,8)$
- So leader produces more than C-N output, follower produces less than its C-N output
- First mover advantage to leader (but modest because leader also has cost advantage)

Sequential Price Games: Introduction

- *Price-leadership*
  - Sequential game
  - Price-leader firm sets its price
  - Typically large, respected firm
    - Dominant firm
    - Barometric firm
  - Follower firms – usually smaller – react to leader
- Note: Follower firms are price takers
  - Analogous to competitive firms

Price Leadership

- Market demand function is $D(p)$
- Given leader price p, follower firms supply $Y_f(p)$, anticipated by leader
- So leader gets residual demand
  - $L(p) = D(p) – Y_f(p)$
- Leader's chooses p to max profit
- $\pi_L(p) = \text{p}[D(p) - Y_f(p)] – c_L[\text{D}(p) - Y_f(p)]$

Price Leadership Results

- Followers act as competitors
  - P=MC
  - Economic profit of each is zero
- Leader acts as monopolist w/ residual demand
  - $MR_L=MC_L$
  - Only leader earns monopoly profits

Co-operative Behavior: Collusion

- Collusion is illegal in US
- But not for international cartels
  - OPEC
  - Bauxite, copper, tin, coffee, tea, mercury, iodine
- Goal of cartel: Joint profit maximization
  - Can achieve (joint) monopoly profits
  - Must divide among cartel members
  - If cartel is part of market, like dominant firm model

Co-operative Behavior: Collusion

- Fundamental tension for cartels
- Stability: Higher profits (share of joint max)
- Instability
  - Successful cartel has p >> MC
  - One member alone faces nearly fixed p
  - Gets huge profits if lowers own price while others hold price constant (cheat on agreement)

Co-operative Behavior: Collusion

- Factors that promote cartel cohesion
  - Similar costs, expectations of demand, motives so can agree on strategy
  - Inelastic demand so potential profits large (disincentive for cheating)
  - Inelastic demand in LR so profits maintained
  - Little expansion of supply by non-members in LR