Managerial Economics & Business Strategy

Chapter 10

Game Theory: Inside Oligopoly

Revised 2/12 by DF

Overview

I. Introduction to Game Theory
II. Simultaneous-Move, One-Shot Games
III. Infinitely Repeated Games
IV. Finitely Repeated Games
V. Multistage Games

Normal Form Game

- A Normal Form Game consists of:
  - Players, at least 2.
  - Strategies or feasible actions: at least 2 for each player.
  - Payoffs for each player, for each strategy combination.

A Normal Form Game

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Normal Form Game: Scenario Analysis

- Suppose 1 thinks 2 will choose “A”.

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Normal Form Game: Scenario Analysis

- Then 1 should choose “a”.
  - Player 1’s best response to “A” is “a”.

Player 2

Player 1

Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Normal Form Game: Scenario Analysis

- Suppose 1 thinks 2 will choose “B”.

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Normal Form Game: Scenario Analysis

- Then 1 should choose "a".
  - Player 1's best response to "B" is "a".

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Normal Form Game
Scenario Analysis

- Similarly, if 1 thinks 2 will choose C…
  - Player 1's best response to "C" is "a".

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Dominant Strategy

- Regardless of whether Player 2 chooses A, B, or C, Player 1 is better off choosing "a"!
- "a" is Player 1's Dominant Strategy!

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

Putting Yourself in your Rival's Shoes

- What should player 2 do?
  - 2 has no dominant strategy!
  - But 2 should reason that 1 will play "a".
  - Therefore 2 should choose "C".

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

The Outcome

Player 2

Player 1 Strategy	A	B	C
a	12,11	11,12	14,13
b	11,10	10,11	12,12
c	10,15	10,13	13,14

- This outcome is called a Nash equilibrium:
  - "a" is player 1's best response to "C".
  - "C" is player 2's best response to "a".

Key Insights

- Look for dominant strategies.
- Put yourself in your rival's shoes.
- At Nash equilibrium, every player is best responding to the other players' strategies.

A Market-Share Game

- Managers of two rival firms want to maximize market share.
- Strategies are pricing decisions.
- Simultaneous moves.
- One-shot game.
  - [Owners might prefer for them to maximize profits, but the managers are empire builders…]

The Market-Share Game in Normal Form

Manager 2

Manager 1

Strategy	P=$10	P=$5	P = $1
P=$10	.5, .5	.2, .8	.1, .9
P=$5	.8, .2	.5, .5	.2, .8
P=$1	.9, .1	.8, .2	.5, .5

Market-Share Game Equilibrium

Manager 2

Manager 1

Strategy	P=$10	P=$5	P = $1
P=$10	.5, .5	.2, .8	.1, .9
P=$5	.8, .2	.5, .5	.2, .8
P=$1	.9, .1	.8, .2	.5, .5

Nash Equilibrium

Comment

- Game theory can be used to analyze situations where "payoffs" are non monetary
  - The bar scene in "A Beautiful Mind" is a (bad) example
- We will usually focus on situations where businesses want to maximize profits.
  - Hence, payoffs are measured in monetary units.
  - Expected NPV in $millions, say.

Examples of Coordination Games

- Industry standards
  - size of floppy disks.
  - size of CDs.
  - Etc.
- National standards
  - electric current.
  - traffic laws.
  - Etc.

A Coordination Game in Normal Form

Player 2

Player 1 Strategy	A	B	C
1	0,0	0,0	$10,$10
2	$10,$10	0,0	0,0
3	0,0	$10,$10	0,0

A Coordination Problem: Three Nash Equilibria!

Player 2

Player 1 Strategy	A	B	C
1	0,0	0,0	$10,$10
2	$10,$10	0,0	0,0
3	0,0	$10, $10	0,0

Comments.

- Not all games are games of conflict.
- Communication can help solve coordination problems.
- Sequential moves can help solve coordination problems.
- We'll play some games in class that are mainly coordination and others that involve conflicts of interest.

An Advertising Game

- Two firms (Kellogg's & General Mills) managers want to maximize profits.
- Strategies consist of advertising campaigns.
- Simultaneous moves.
  - One-shot interaction.
  - Repeated interaction.

A One-Shot Advertising Game

General Mills

Kellogg's

Strategy	None	Moderate	High
None	12,12	1, 20	-1, 15
Moderate	20, 1	6, 6	0, 9
High	15, -1	9, 0	2, 2

Equilibrium to the One-Shot Advertising Game

General Mills

Kellogg's

Strategy	None	Moderate	High
None	12,12	1, 20	-1, 15
Moderate	20, 1	6, 6	0, 9
High	15, -1	9, 0	2, 2

Nash Equilibrium

Can collusion work if the game is repeated 2 times?

General Mills

Kellogg's

Strategy	None	Moderate	High
None	12,12	1, 20	-1, 15
Moderate	20, 1	6, 6	0, 9
High	15, -1	9, 0	2, 2

No (by backwards induction).

- In period 2, the game is one-shot, so High Advertising is the equilibrium in the last period.
- This means period 1 is "really" the last period, since everyone knows what will happen in period 2.
- Equilibrium entails High Advertising by each firm in both periods.
- The same holds true if we repeat the game any known, finite number of times.

Can collusion work if firms play the game each year, forever?

- Consider the following "trigger strategy" by each firm:
  - "Don't advertise, provided the rival has not advertised in the past. If the rival ever advertises, "punish" it by engaging in a high level of advertising forever after."
- In effect, each firm agrees to "cooperate" so long as the rival hasn't "cheated" in the past. "Cheating" triggers punishment in all future periods.

Suppose General Mills adopts this trigger strategy. Kellogg's profits?

$$\Pi_{Cooperate} = 12 + 12/(1+i) + 12/(1+i)^2 + 12/(1+i)^3 + \ldots$$

$$= 12 + \boxed{12/i}$$

← Value of a perpetuity of $12 paid at the end of every year

$$\Pi_{Cheat} = 20 + 2/(1+i) + 2/(1+i)^2 + 2/(1+i)^3 + \ldots$$

$$= 20 + 2/i$$

General Mills

Kellogg's

Strategy	None	Moderate	High
None	12,12	1, 20	-1, 15
Moderate	20, 1	6, 6	0, 9
High	15, -1	9, 0	2, 2

Kellogg's Gain to Cheating:

- $\Pi_{Cheat} - \Pi_{Cooperate} = 20 + 2/i - (12 + 12/i) = 8 - 10/i$
  - Suppose $i = .05$
- $\Pi_{Cheat} - \Pi_{Cooperate} = 8 - 10/.05 = 8 - 200 = -192$
- It doesn't pay to deviate.
  - Collusion is a Nash equilibrium in the infinitely repeated game!

General Mills

Kellogg's

Strategy	None	Moderate	High
None	12,12	1, 20	-1, 15
Moderate	20, 1	6, 6	0, 9
High	15, -1	9, 0	2, 2

Benefits & Costs of Cheating

- $\Pi_{Cheat} - \Pi_{Cooperate} = 8 - 10/i$
  - 8 = Immediate Benefit (20 - 12 today)
  - 10/i = PV of Future Cost (12 - 2 forever after)
- If Immediate Benefit - PV of Future Cost > 0
  - Pays to "cheat".
- If Immediate Benefit - PV of Future Cost ≤ 0
  - Doesn't pay to "cheat".

General Mills

Kellogg's

Strategy	None	Moderate	High
None	12,12	1, 20	-1, 15
Moderate	20, 1	6, 6	0, 9
High	15, -1	9, 0	2, 2

Main Idea

- Cooperation can be sustained as a Nash Eq. even when there is a conflict of interest.
  - E.g., collusion in oligopoly
- Requires repeated interaction into the indefinite future.
  - Won't work if everyone knows the end date.
- Works better given:
  - Ability to monitor actions of rivals
  - Ability (and reputation for) punishing defectors
  - Low interest rate
  - High probability of future interaction

Real World Examples of Collusion

- Garbage Collection Industry
- OPEC
- NASDAQ
- Airlines

Garbage Collection Industry

- Homogeneous products
- Bertrand oligopoly
- Identity of customers is known
- Identity of competitors is known

Normal Form Bertrand Game

Firm 2

Firm 1	Strategy	Low Price	High Price
	Low Price	0,0	20,-1
	High Price	-1, 20	15, 15

One-Shot Bertrand (Nash) Equilibrium

Firm 2

Firm 1	Strategy	Low Price	High Price
	Low Price	0,0	20,-1
	High Price	-1, 20	15, 15

Potential Repeated Game Equilibrium Outcome

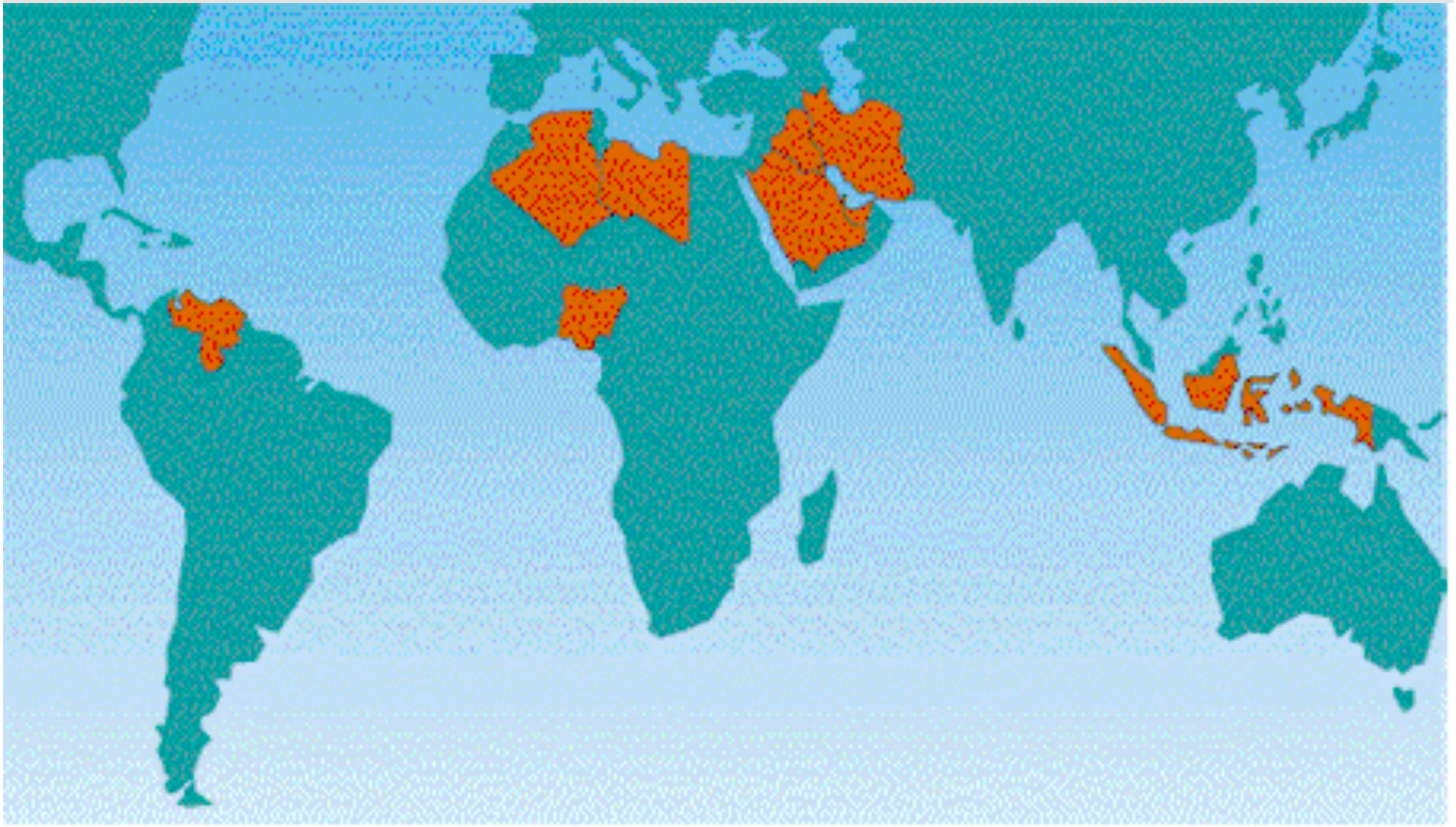
Firm 2

Firm 1	Strategy	Low Price	High Price
	Low Price	0,0	20,-1
	High Price	-1, 20	15, 15

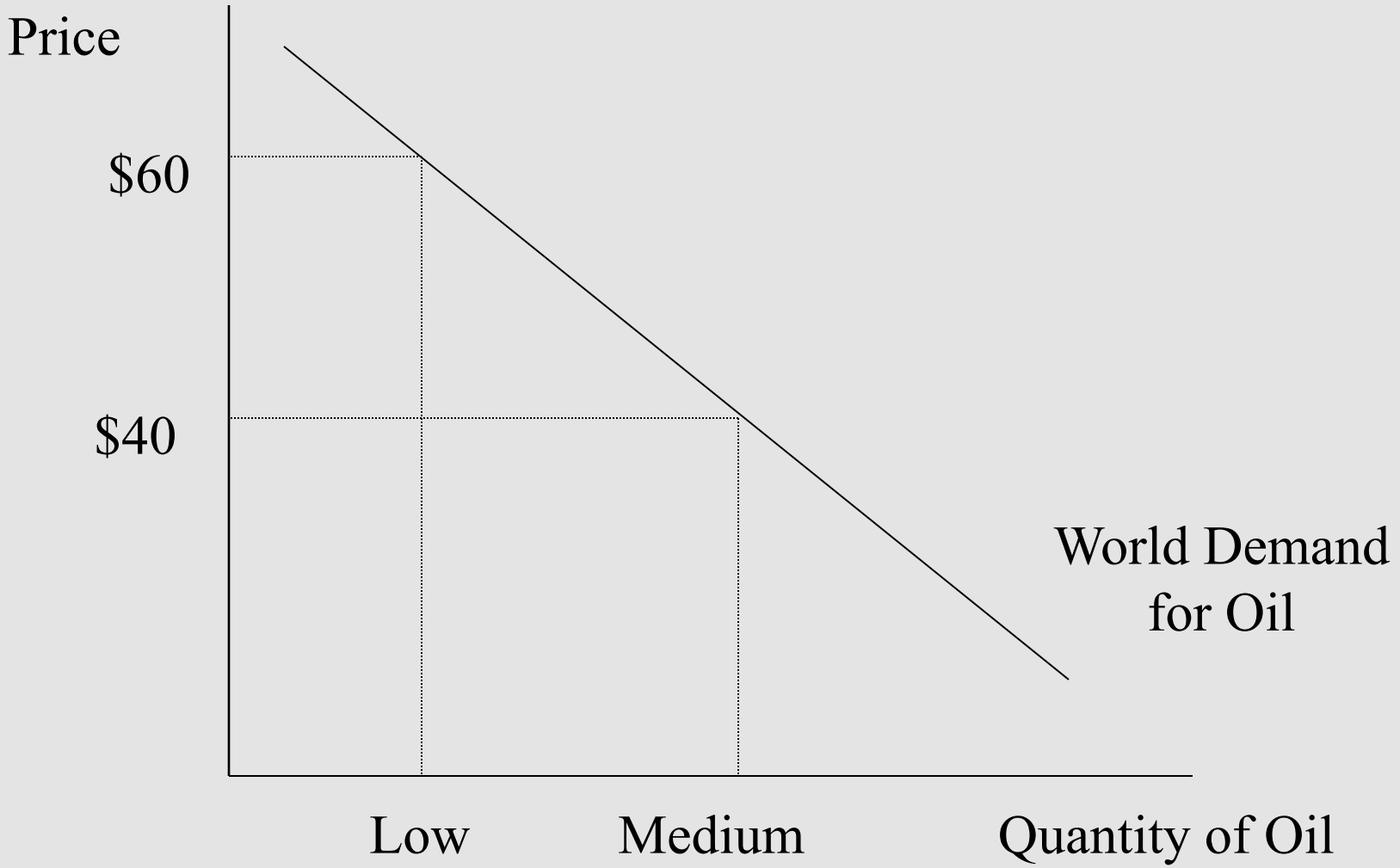
OPEC

- Cartel founded in 1960 by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela
- Currently has 11 members
- "*OPEC's objective is to co-ordinate and unify petroleum policies among Member Countries, in order to secure fair and stable prices for petroleum producers…"* (www.opec.com)
- Cournot oligopoly
- Absent collusion: $P^{Competition} < P^{Cournot} < P^{Monopoly}$

Current OPEC Members



Effect of Collusion on Oil Prices



Cournot Game in Normal Form

Venezuela

Saudi Arabia

Strategy	High Q	Med Q	Low Q
High Q	5, 3	9,4	3, 6
Med Q	6, 7	12,10	20, 8
Low Q	8, 1	10, 18	18, 15

One-Shot Cournot (Nash) Equilibrium

Venezuela

Saudi Arabia

Strategy	High Q	Med Q	Low Q
High Q	5, 3	9,4	3, 6
Med Q	6, 7	12,10	20, 8
Low Q	8, 1	10, 18	18, 15

Repeated Game Equilibrium*

Saudi Arabia \ Venezuela	High Q	Med Q	Low Q
High Q	5, 3	9,4	3, 6
Med Q	6, 7	12,10	20, 8
Low Q	8, 1	10, 18	18, 15

* *(Assuming a Low Interest Rate)*

Caveat

- Collusion is a felony under Section 2 of the Sherman Antitrust Act.
- Conviction can result in both fines and jail-time (at the discretion of the court).
- Some NASDAQ dealers and airline companies have been charged with violations
- OPEC isn't illegal; US laws don't apply