CHAPTER 11

Game Theory

Lecture 6: Game Theory

Introduction to Game Theory

- The most important goal for this course involves learning how to use economic models to think critically and carefully about managerial problems.
- To date, we have considered the following issues:
  - What conditions characterize competitive outcomes and efficient allocation of resources?
  - How does firm cost structure and the nature of the market determine prices and production?
  - How can firms with pricing power can exploit variation in demand to price discriminate and maximize profits?

Lecture 6: Game Theory

Introduction to Game Theory

- Next, we apply strategic thinking to decision-making and learning how to use it to analyze firm and individual choices; game theory is a method for studying strategic situations.

- After this short introduction to game theory, the remainder of the course will be devoted to learning about risk and its implications for decision-making.

Introduction to Game Theory

- Some Highly Recommended Game Theory Resources
  - Book: "The Art of Strategy", by Avinash Dixit and Barry Nalebuff
  - Online Course: Yale Professor Ben Polak's "principles of game theory" video course.
  - Mind Your Decisions Blog – excellent source for real world game theory examples.

Introduction to Game Theory

- What's *not* a strategic situation?
  - Perfect Competition – All firms are price takers; they don't have to worry about actions of competitors
  - Monopoly – Since there is no competition, so there is no need to worry about actions of competitors.

- What *is* a strategic situation?
  - Oligopoly – With a small number of firms, your outcomes are affected not only by your own actions, but also by actions of your competitors.

Introduction to Game Theory

- Game theory is relevant and applicable whenever the consequence of a manager's decision depends on both the manager's own action and the actions of others

- There are no unconditional "optimal" strategies in game theory; the optimality of a strategy depends on the situation in which it is implemented.

Strategy Basics

- All game theoretic models are defined by the following five parameters:

1. <u>The players</u>: A player is an entity that makes decisions; models describe the number and identities of players.

2. <u>The feasible strategy set</u>: Actions with a non-zero probability of occurring comprise the feasible strategy set.

Strategy Basics

- All game theoretic models are defined by five parameters. (Continued)

3. <u>The outcomes or consequences</u>: The feasible strategies of all players intersect to define an outcome matrix.

4. <u>The payoffs</u>: Every outcome has a defined payoff for every player. Players are assumed to be rational, that is, to prefer a higher payoff to a lower one.

5. <u>The order of play</u>: Play may be simultaneous or sequential.

Lecture 6: Game Theory

Equilibrium

- In an equilibrium, no player has an incentive to unilaterally change his or her strategy; i.e., conditional on the choices of others, we are doing the best we can!

- Equilibria are rational, optimal, and stable.

- In what follows, we study various ways for finding equilibria.

Dominant Strategies

- <u>Strong Dominance</u>: A strategy whose payout in any outcome is higher relative to all other feasible strategies is *strongly dominant*.

- <u>Weak Dominance</u>: A strategy is *weakly dominant* if it does at least as well as any other strategy for some outcomes (i.e., it's tied with another for the highest payoff) and better than any strategy for the remaining outcomes.

Dominant Strategies

Allied's pricing strategies

Barkley's pricing strategies		$0.95	$1.30	$1.55
	$1.00	3, 6	7, 1	10, 4
	$1.35	5, 1	8, 2	14, 7
	$1.65	6, 0	6, 2	8, 5

Iterative Dominance

A. Barkley's $1.00 strategy is eliminated.

Allied's pricing strategies

Barkley's pricing strategies		$0.95	$1.30	$1.55
	$1.35	5, 1	8, 2	14, 7
	$1.65	6, 0	6, 2	8, 5

B. Allied's $0.95 and $1.30 strategies are eliminated.

Allied's pricing strategies

Barkley's pricing strategies		$1.55
	$1.35	14, 7
	$1.65	8, 5

The Nash Equilibrium

- How can managers anticipate behavior in games in which a dominant strategy equilibrium does not exist?

- John Nash's answer to this question is the most widely used solution concept in game theory: the Nash equilibrium.

  - Assuming that players are rational, every player chooses the "best" strategy conditional on all other players doing the same.

New Product Introduction

		Allied		
		Product alpha	Product beta	Product zeta
Barkley	Product lambda	4, 6	9, 8	6, 10
	Product pi	6, 8	8, 9	7, 8
	Product sigma	9, 8	7, 7	5, 5

New Product Introduction – Nash Equilibrium

		Allied		
		Product alpha	Product beta	Product zeta
Barkley	Product lambda	4, 6	(B) 9, 8	6, 10 (A)
	Product pi	6, 8	8, 9 (A)	(B) 7, 8
	Product sigma	(B) 9, 8 (A)	7, 7	5, 5

Prisoners dilemma

Clyde

	Don't Confess	Confess
Bonnie Don't Confess	-5, -5	-30, -3
Confess	-3, -30	-20, -20

"Prisoners" dilemma – when rational choice produces a bad outcome

Allied's pricing strategies

Barkley's pricing strategies		Price high	Price low
	Price high	5, 5	1, 20
	Price low	20, 1	3, 3

Real world examples of Prisoners Dilemmas

- Athlete A uses steroids, which gives him a competitive advantage. Other athletes are forced to use steroids to retain parity. As a result, no athlete is given a competitive advantage, but all are subjected to the hazards of steroids.

- A depositor hears that a bank is in trouble, and goes to pull out his savings. Others are forced to pull out their savings as a "run" begins on the bank's savings, and the bank collapses.

- Mr. A pirates software/movies/music. So does Mr. B. So does Mr. C. As a consequence, the software/movies/music that would have been otherwise been produced for the benefit of Messrs. A, B, and C is not produced, due to a diminished market for software/movies/music.

- The pollution which results from the collective actions of individual drivers who believe that their one act of driving "doesn't matter," resulting in air no one wants to breathe.

Class Problem 11.1

1. Two soap producers, the Fortnum Company and the Maison Company, can stress either newspapers or magazines in their forthcoming advertising campaigns. The payoff matrix is as follows:

		Maison Company	
		Stress Newspapers	**Stress Magazines**
Fortnum Company	**Stress Newspapers**	Maison's Profit: $9 million Fortnum's Profit: $8 million	Maison's Profit: $8 million Fortnum's Profit: $7 million
	Stress Magazines	Maison's Profit: $8 million Fortnum's Profit: $9 million	Maison's Profit: $7 million Fortnum's Profit: $8 million

a. Is there a dominant strategy for each firm? If so, what is it?
b. What will be the profit of each firm?
c. Is this game an example of the prisoner's dilemma?

Split or Steal

- On a UK game show called "Golden Balls", two contestants are each presented with two golden balls. One has "SPLIT" printed inside it and the other has "STEAL" printed inside it.

- If both contestants choose SPLIT, the jackpot is split equally between them.

- If one contestant chooses SPLIT and the other chooses STEAL, the stealer gets all the money.

- If both contestants choose STEAL, they both leave empty-handed.

Split or Steal

Player 2

	Steal	Split
Steal	0,0	100,0
Split	0,100	50,50

Player 1

Split or Steal, Episode 1

Lecture 6: Game Theory
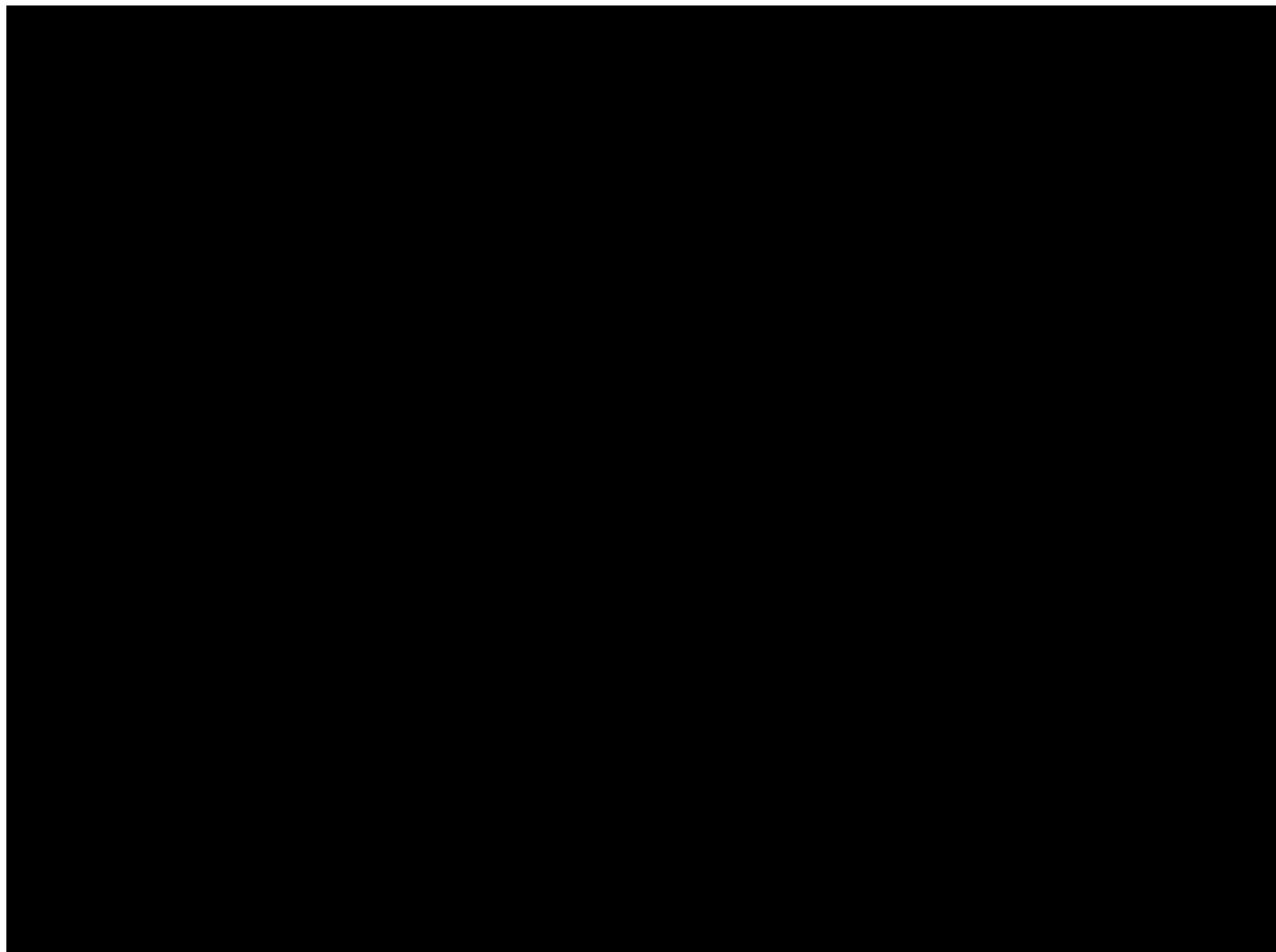
Split or Steal, Episode 2

An Example of Strategic Thinking: Guaranteed Lowest Price Offer

- Firms will often make the following offer:
  If you buy now, and the price is subsequently lowered, you will be refunded the difference!

- Why???

- Consider the following game which is a PRISONER'S DILEMMA.

- Both firms would like to charge a price of 2 and each make a profit of 5.

- BUT there is temptation for each to cheat.

- The Nash Equilibrium is for both firms to charge 1

- Each firm ends up with a profit of 2.

	Column Charges 2	Column Charges 1
Row Charges 2	5 5	-2 8
Row Charges 1	8 -2	2 2

An Example of Strategic Thinking: Guaranteed Lowest Price Offer

- Now suppose BOTH firms adopt GUARANTEED LOWEST PRICE OFFERS; the NASH EQUILIBRIUM is for both to Charge 2 and make profit of 5.

- The effect of the offer is to lower the payoffs from Charge 1 from $8 to $4; this occurs because with the offer, you are obligated to reimburse previous customers which lowers the profit from cheating.

- The lesson here is that competitors will be less likely to engage in price competition because it will not yield a competitive advantage!

	Column charges 2	Column charges 1
Row charges 2	5 5	-2 8 / 4
Row charges 1	8 /4 -2	2 2

Strategic Foresight: The Use of Backward Induction

- Definitions

  - <u>Strategic foresight</u>: A manager's ability to make decisions today that are rational given what is anticipated in the future

  - <u>Backward induction</u>: Used to solve games by looking to the future, determining what strategy players will choose (anticipation), and then choosing an action that is rational, based on those beliefs

    - In *sequential* games, backward induction involves starting with the last decisions in the sequence and then working backward to the first decisions, identifying all optimal decisions.

Allied-Barkley Expansion Decision

Lecture 6: Game Theory
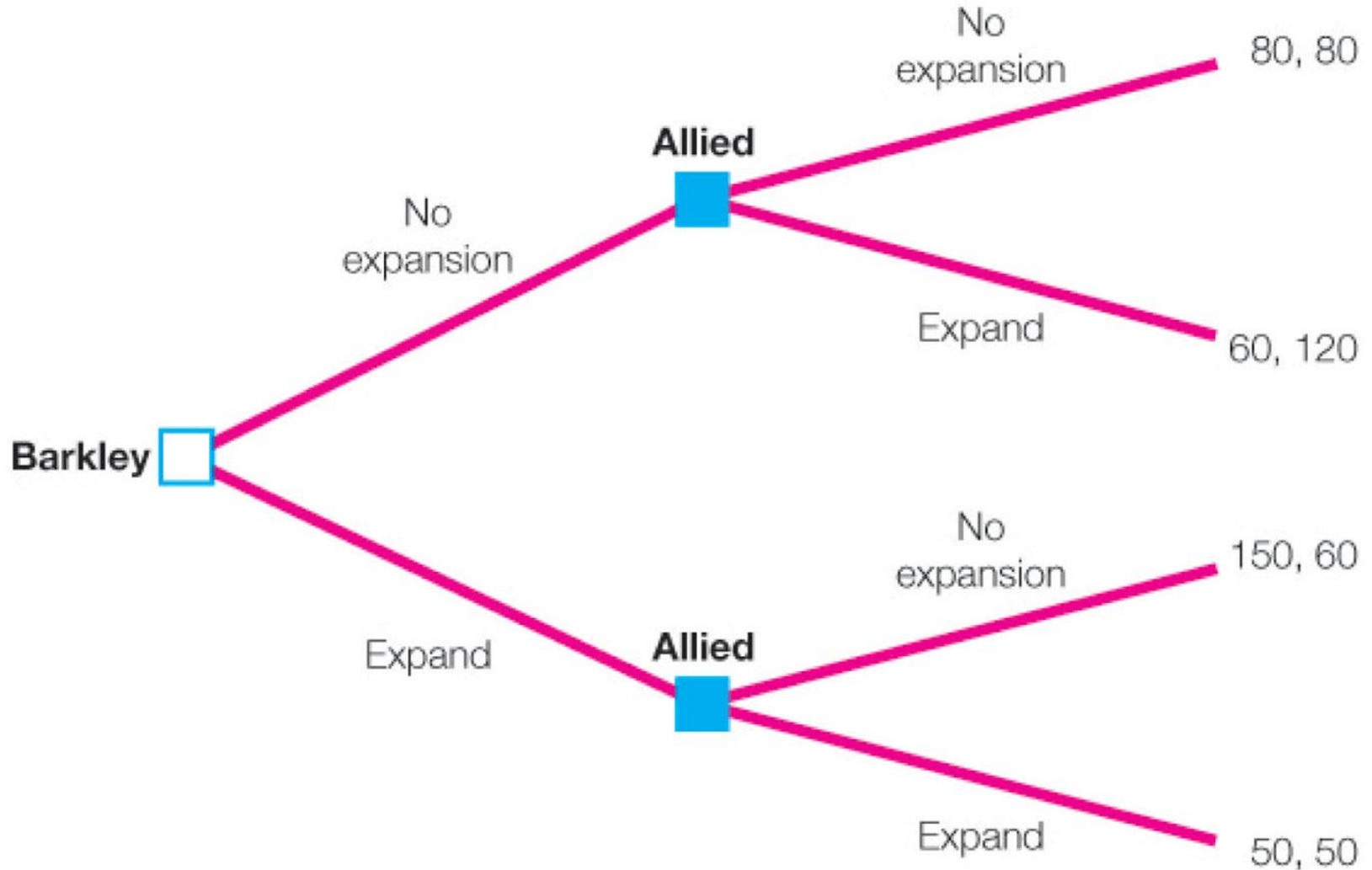
Class Problem 11.2

- The *New York Times* reports that Wal-Mart has decided to challenge Netflix and enter the online DVD-by-mail market. Because of economies of scale, Wal-Mart has a slight cost advantage relative to Netflix. Wal-Mart is considering the use of a limit pricing strategy. It can enter the market by matching Netflix on price. If it does, and Netflix maintains its price, then both firms would earn $5 million. But if Netflix drops its price in response, Wal-Mart would have to follow and would earn $2 million; Netflix would earn $3 million. Or Wal-Mart could enter the market with a price that is below Netflix's current price but above its marginal cost. If it does, Netflix would make one of two moves. It could reduce its price to below that of Wal-Mart. If it does, Wal-Mart will earn a profit of $0, and Netflix will earn a profit of $2 million. Or Netflix could keep its present price. If Netflix keeps its present price, Wal-Mart can keep its present price and earn $6 million (while Netflix earns $4 million). Or Wal-Mart can increase its price and earn $2 million while Netflix earns $6 million.

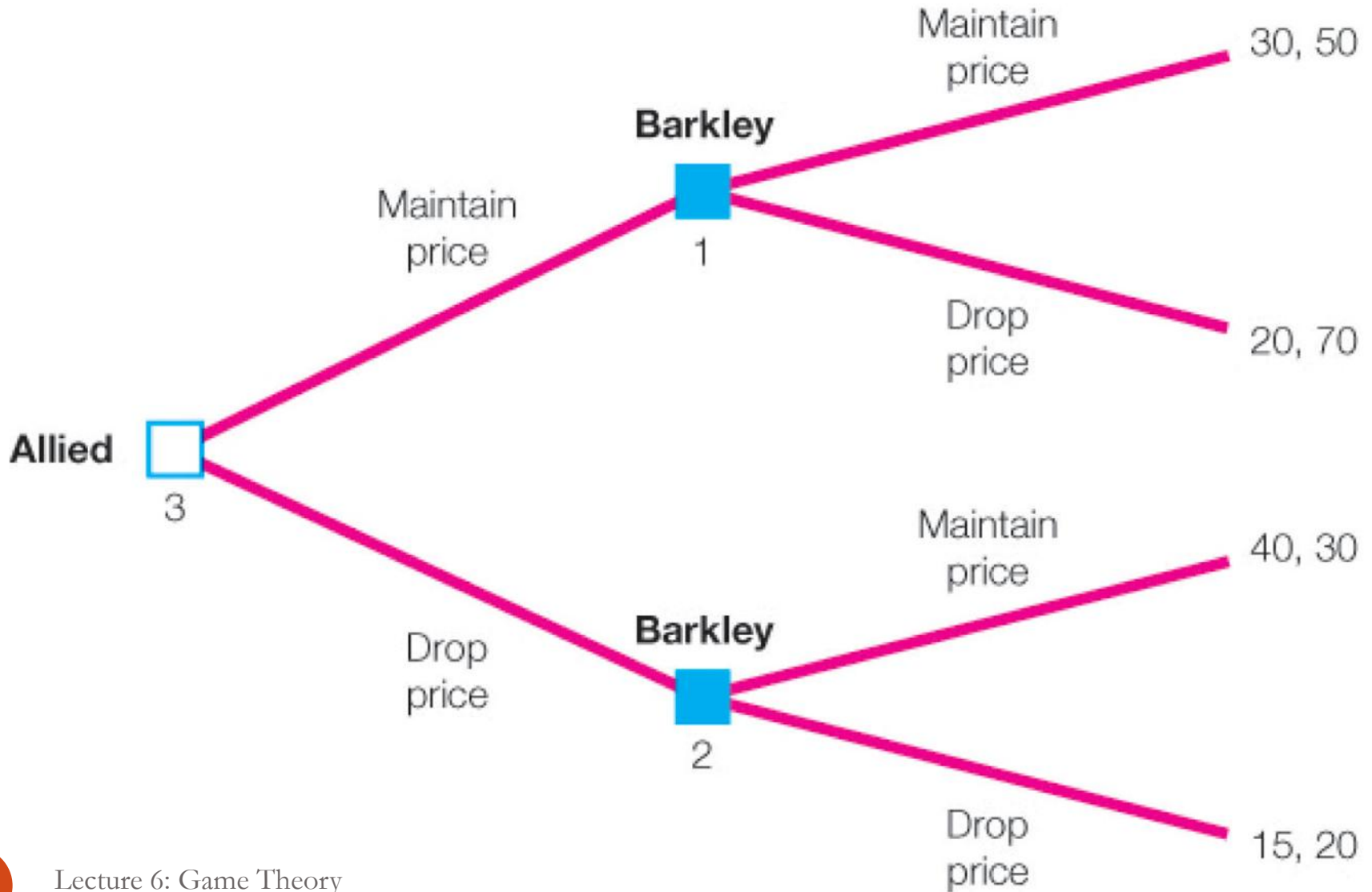# Class Problem 11.2

Lecture 6: Game Theory
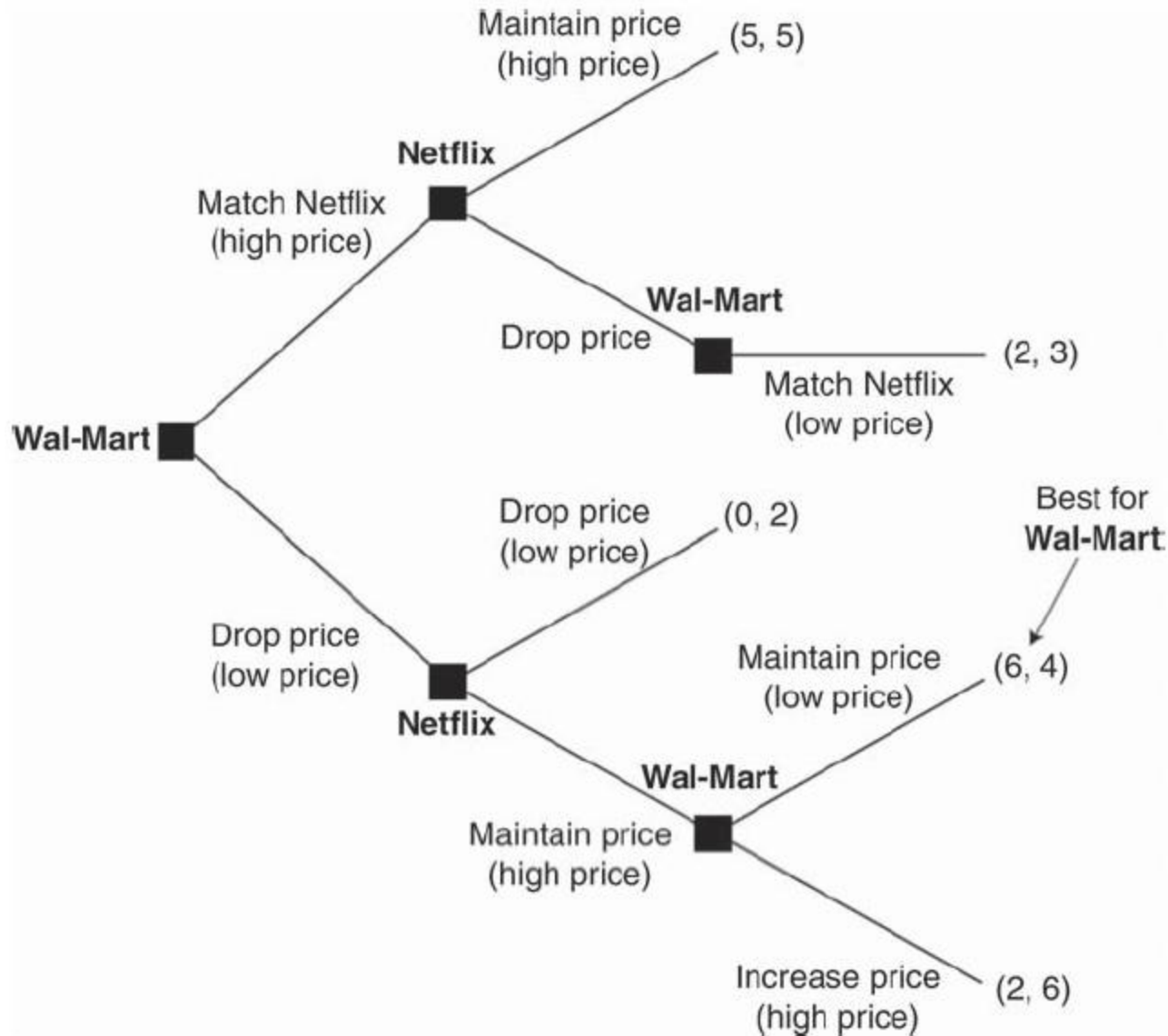
Class Problem 11.2

Netflix

Wal-Mart

	Drop	Maintain
Drop	0,2	6,4
Match	2,3	5,5
Increase	--	2,6

Credibility of Commitments

Zero-Sum Game

		Allied		
		Campaign A	Campaign B	Campaign C
Barkley	Campaign 1	−5, 5	20, −20	−22, 22
	Campaign 2	−3, 3	7, −7	4, −4
	Campaign 3	−4, 4	−6, 6	17, −17