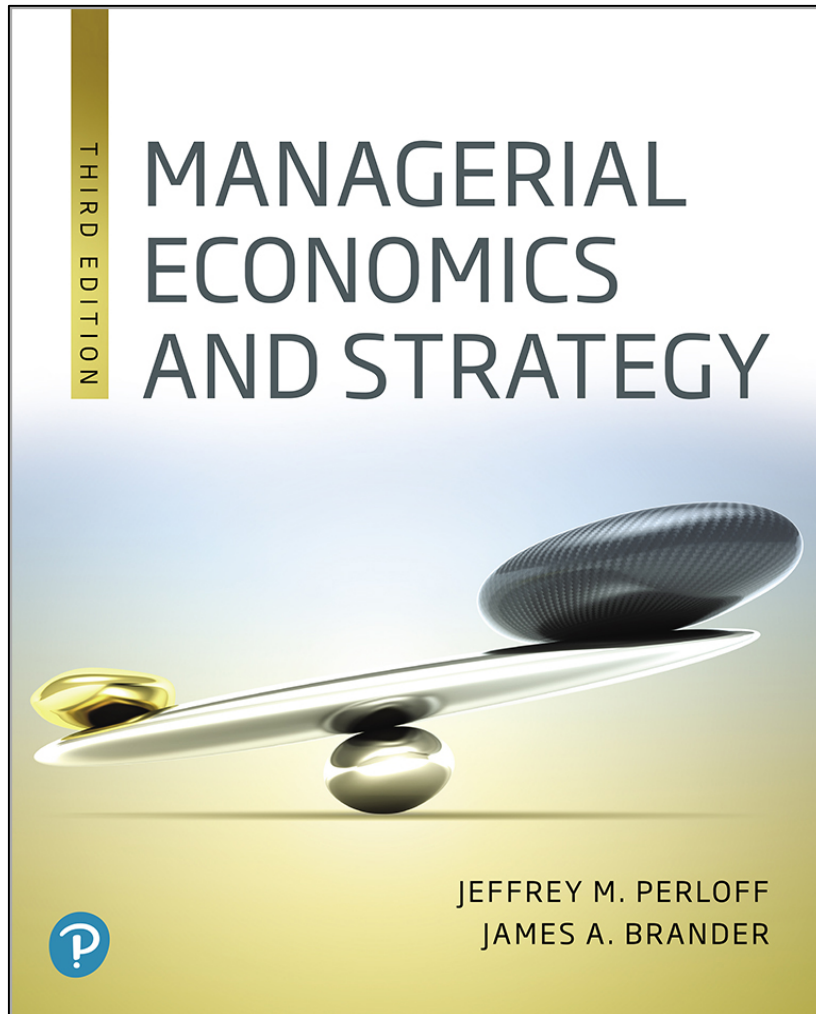


Managerial Economics and Strategy

Third Edition



Chapter 13

Strategies Over Time

Managerial Problem

Intel and AMD's Advertising Strategies

- Intel and AMD dominate the central processing unit (CPU) market for personal computers, making over 99% of total sales in 2018.
- Why have Intel's managers chosen to advertise aggressively while AMD engages in relatively little advertising?

Solution Approach

- We need to explore **dynamic games** where players play the game over and over, and move either **repeatedly** or **sequentially**.

Empirical Methods

- **Dynamic games** could be **repeated games** or **sequential games**.
- Under some conditions, firms may benefit from pursuing **detering entry** and **cost strategies**, or may find **disadvantages of moving first**.
- **Behavioral game theory** shows how managers may act based on simple rules or psychological factors rather than rational strategies.

Learning Objectives (1 of 2)

13.1 Repeated Games

Explain the differences between static and repeated games

13.2 Sequential Games

Analyze sequential games in which first one player acts and then another player acts

13.3 Deterring Entry

Use a dynamic game to show how the action of an incumbent firm may deter entry by a rival

Learning Objectives (2 of 2)

13.4 Cost and Innovation Strategies

Describe the methods an incumbent firm can use to gain a cost advantage over rivals

13.5 Disadvantages of Moving First

Discuss why moving first in a sequential game may be disadvantageous

13.6 Behavioral Game Theory

Illustrate the effects of psychological biases in dynamic games

13.1 Repeated Games (1 of 6)

Strategies and Actions in Dynamic Games

- The static constituent game might be repeated a finite and pre-specified number of times, or repeated indefinitely.
- In a repeated game, managers need to know the players, the rules, the information that each firm has, and the payoffs or profits.
- A manager must also distinguish between an action and a strategy.
 - An **action** is a single move that a player makes at a specified time, such as choosing an output level or a price.
 - A **strategy** is a battle plan that specifies the full set of actions that a player will make throughout the game. It may involve actions that are conditional on prior actions of other players or on new information available at a given time.

13.1 Repeated Games (2 of 6)

Cooperation in a Repeated Prisoner's Dilemma Game

- Table 13.1 repeats the American-United game of Chapter 12. The Nash equilibrium solution, if played only once, is both firms producing high (64 passengers) and making only \$4.1 (Prisoner's Dilemma game).
- Assume the same game is **repeated indefinitely**. Now, firms must consider current and future profits and must distinguish an action from a strategy.
- Strategies to Avoid a Prisoner's Dilemma Outcome
 - Firms can follow a **trigger strategy**, in which a rival's defection from a collusive outcome triggers a punishment.
 - If United uses this strategy, its action in the current period depends on American's observed actions in previous periods. Similarly for American.
 - In the next slide, we present an application of a trigger strategy for the American-United game.

Table 13.1 An Airlines Prisoners' Dilemma Game with Two Actions

		<i>American Airlines</i>	
		$q_A = 64$	$q_A = 48$
<i>United Airlines</i>	$q_U = 64$	4.1	3.8
	$q_U = 48$	5.1	4.6

Note: Quantities are in thousands of passengers per quarter; (rounded) profits are in millions of dollars per quarter.

13.1 Repeated Games (3 of 6)

A Trigger Strategy for an Airline Repeated Game

- American cheap talks United that it will produce the 48 collusive or cooperative quantity in the 1st period. But then its action will depend:
 - If United produces 48 in period t , American will produce 48 in $t + 1$.
 - If United produces 64 in period t , American will produce 64 in $t + 1$ and all subsequent periods.
- The solution to this game is Nash-equilibrium with no prisoner's dilemma
 - As it is seen in Table 13.1, United's best response strategy is to produce 48 in each period: the incremental profit from producing 64 one time does not compensate all future losses.
 - If both firms follow the trigger strategy, the Nash-equilibrium is the best outcome.
- In reality, cooperation may fail because of regulation, bounded rationality, or if a firm cares little about future profits.

13.1 Repeated Games (4 of 6)

Another Possible Trigger Strategy: Tit-for-Tat

- A **tit-for-tat strategy** for repeated prisoners' dilemma games sets cooperation in the 1st round, then copies the rival's previous action in each subsequent round.
 - A tit-for-tat strategy is a punishment strategy weaker than the previous trigger strategy.
- A **Tit-for-Tat may not induce cooperation** in the Airline repeated game if the extra profit in period t is greater than the loss from the punishment in period $t + 1$.
- However, if the tit-for-tat strategy is modified to extend the punishment for more than one period, then it may ensure cooperation.
 - The extension of time should be enough to more than compensate the one time extra profit.

13.1 Repeated Games (5 of 6)

Implicit Versus Explicit Collusion

- In most modern economies, explicit collusion among firms in an industry is illegal.
- However, antitrust laws do not strictly prohibit choosing the cooperative (cartel) quantity or price as long as no **explicit** agreement is reached.
- Implicit collusion: Firms may be able to engage in such **implicit collusion** or **tacit collusion** using trigger, tit-for-tat, or other similar strategies, as long as firms do not explicitly communicate each other.
 - Tacit collusion lowers society's total surplus just as explicit collusion does.

13.1 Repeated Games (6 of 6)

Finitely Repeated Games

- American and United know that the game in Table 13.1 will be repeated only a finite number of times, T . They cheap talk the trigger strategy mentioned before.
- Both firms know there is no punishment in the final period T . So it is basically a static Prisoner's Dilemma and both firms have a dominant strategy: produce 64.
- The solution is going backwards from the last to the 1st period.
 - Period T : Each firm 'cheats' and produces 64 for certain.
 - Period $T - 1$: Nothing will avoid the punishment in period T . So, it is better to 'cheat', produce 64 and earn extra profit.
 - Period $T - 2$ up to the 1st period: Same logic.
- The only Nash equilibrium is 64 & 64 to occur in every period, and there is no cooperation again.
 - Thus, maintaining an agreement to cooperate in any prisoners' dilemma game is more difficult if there is a known end point and players have complete foresight.

13.2 Sequential Games (1 of 4)

Sequential Games and Basic Concepts

- **Sequential game:** many stages or decision points and players alternate moves
- **Extensive form:** a branched diagram that shows the players, the sequence of moves, the actions players can take at each move, the information that each player has about previous moves, and the payoff function over all possible strategy combinations
- **Subgame:** At any given stage, players play a **subgame** (actions and corresponding payoffs).
- **Subgame perfect Nash equilibrium:** if the players' strategies form a Nash equilibrium in every subgame (including the overall game)
- **Backward induction** for subgame perfect Nash-equilibrium:
 - First determine the best response by the last player to move, then determine the best response for the player who made the next-to-last move, and so on until we reach the first move of the game.

13.2 Sequential Games (2 of 4)

Stackelberg Oligopoly

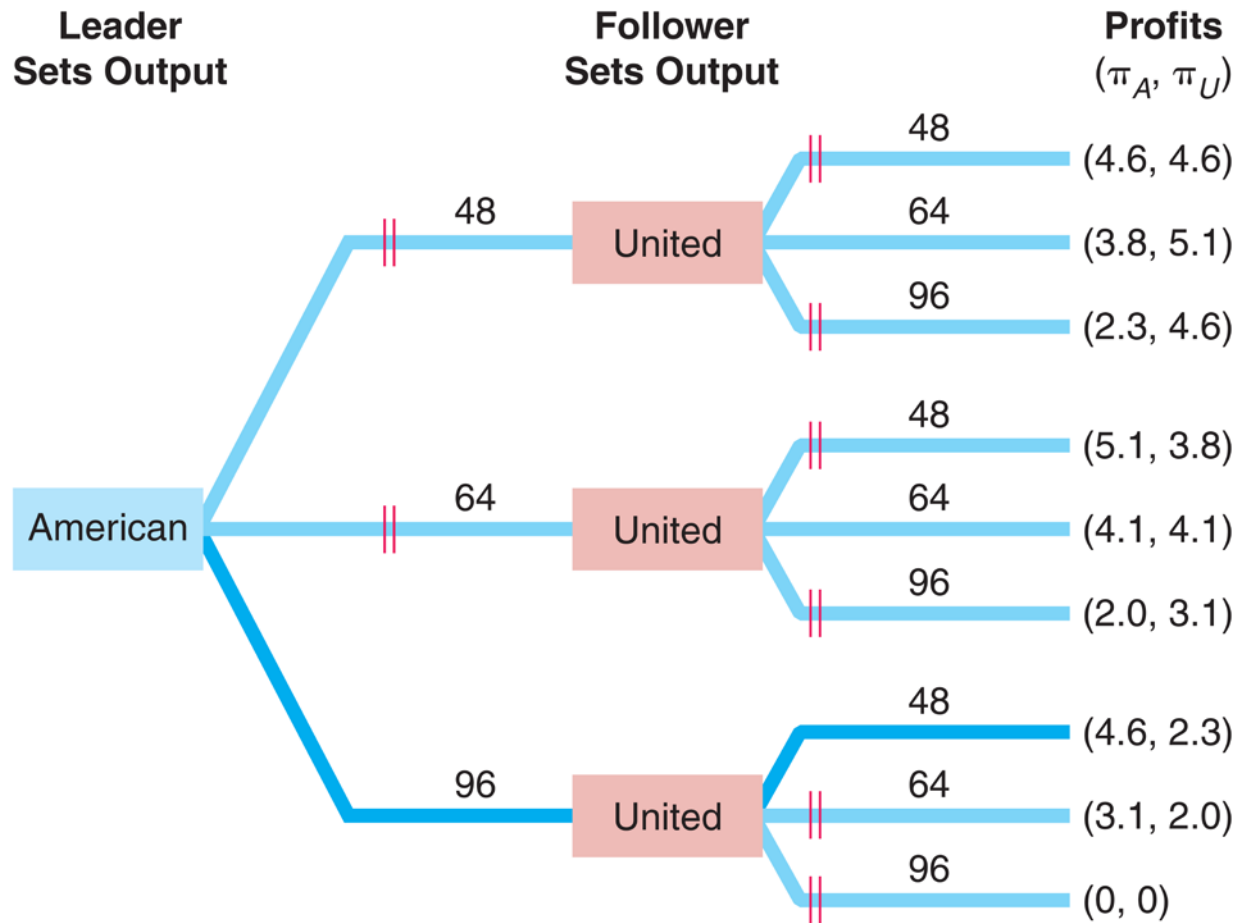
- Two-stage, sequential-move oligopoly game: American, the **leader** firm, chooses its output level first. Given American's choice, United, the **follower**, picks an output level.
 - Table 13.2 shows the corresponding profits but it doesn't show the sequential nature of this game. The extensive form is in Figure 13.1.
- Backward Induction and Subgames
 - American determines what United, the follower, will do in the 2nd stage at the tree subgames (right in Figure 13.1): q_U with highest profit at each node.
 - American determines its best action in the 1st stage given the choices of United in the 2nd stage (left in Figure 13.1): q_A with the highest profit.
- Subgame Perfect Nash-Equilibrium
 - American chooses $q_A = 96$ in the 1st stage and United chooses $q_U = 48$ in the 2nd stage. In this equilibrium, neither firm wants to change its strategy.

Table 13.2 An Airlines Prisoners' Dilemma Game with Three Actions

		American Airlines		
		$q_A = 96$	$q_A = 64$	$q_A = 48$
United Airlines	$q_U = 96$	0 0	2.0 3.1	2.3 4.6
	$q_U = 64$	3.1 2.0	4.1 4.1	3.8 5.1
	$q_U = 48$	4.6 2.3	5.1 3.8	4.6 4.6

Note: Quantities are in thousands of passengers per quarter; (rounded) profits are in millions of dollars per quarter.

Figure 13.1 Airlines' Stackelberg Game Tree



13.2 Sequential Games (3 of 4)

Credible Threats



13.2 Sequential Games (4 of 4)

Credible Threats

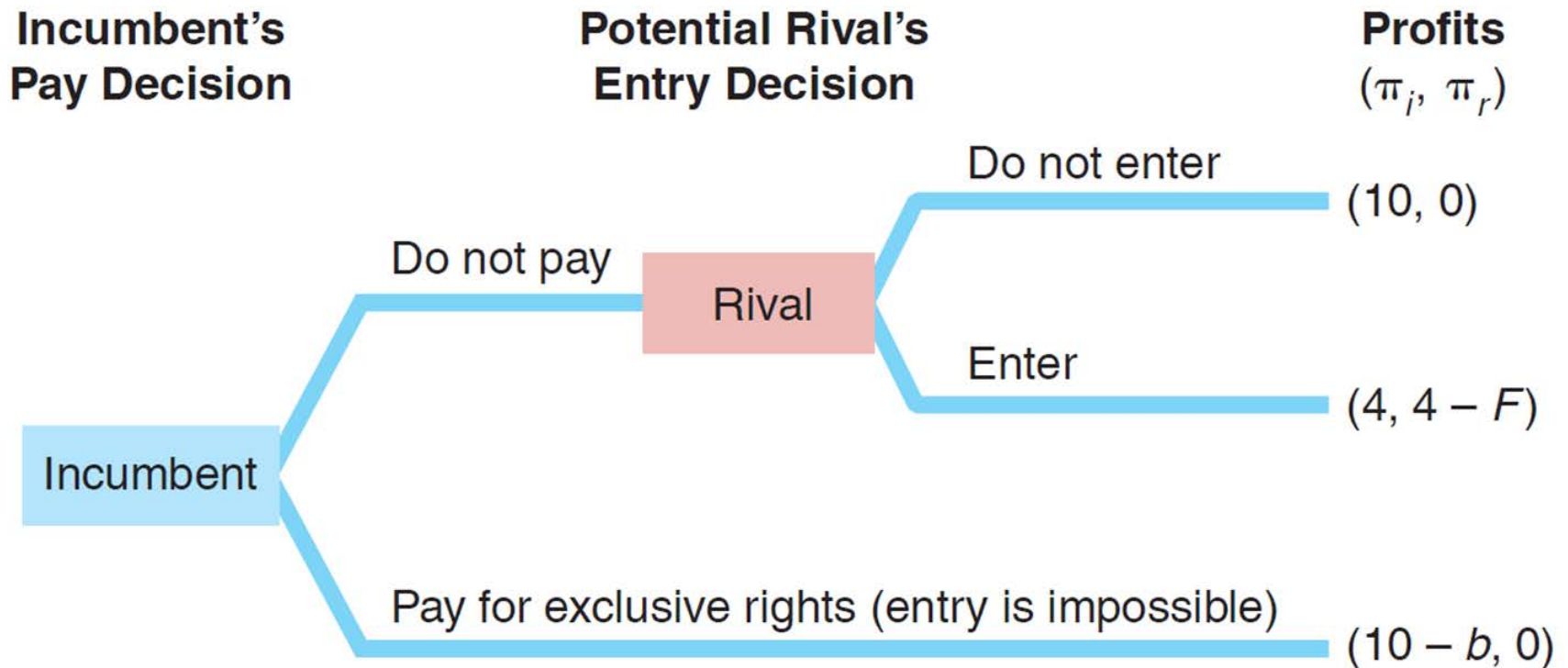
- The Nash equilibrium of the American-United static **simultaneous** game (Cournot with 3 options) was $q_A = q_U = 96$ and both firms earned \$4.1 million (Chapter 12).
- The Subgame Perfect Nash Equilibrium of the American-United **sequential** game (Stackelberg) is $q_A = 96$, $q_U = 48$. American earns \$4.6 million, but United only \$2.3 million.
- Why the simultaneous and sequential games have different solutions?
- Because of credible threat and first mover advantage
 - For a firm's announced strategy to be a **credible threat**, rivals must believe that the firm's strategy is rational (works in the firm's best interest).
 - In the simultaneous-move game, United will not believe a threat by American that it will produce 96. However, in the sequential game because American makes the 1st move, its commitment to produce 96 is credible.

13.3 Detering Entry (1 of 6)

Exclusion Contracts

- A mall has a single shoe store, the **incumbent** firm. The incumbent may pay the mall's owner to add a clause to its rental agreement that guarantees **exclusivity**. So, if b is paid, the landlord agrees to rent the remaining space only to a no-shoe firm.
- The game tree, Figure 13.2, shows the **two stages** of the game.
 - In the 1st stage, the **incumbent** decides whether to pay b to prevent entry.
 - In the 2nd stage, the **potential rival** decides whether to enter. If it enters, it incurs a fixed fee of F to build its store in the mall.
- Backward induction for subgame perfect Nash-equilibrium
 - Last decision made by potential rival in 2nd stage: in Figure 13.2, the rival only plays one subgame. It enters if $F \leq 4$ because $\pi_r = 4 - F$. Otherwise, stays out with $\pi_r = 0$.
 - Decision made by incumbent in 1st stage knowing what potential rival will do in 2nd stage: in Figure 13.2, the incumbent has one subgame, but the decision to pay depends on the values of the exclusivity fee b and fixed cost F .

Figure 13.2 Paying to Prevent Entry



13.3 Detering Entry (2 of 6)

- Three possible outcomes that depend on b and F :
 - **Blockaded entry** ($F > 4$): Potential rival will stay out ensuring $\pi_r = 0$. So, the incumbent avoids paying b and still earns the monopoly profit, $\pi_i = 10$.
 - **Deterred entry** ($F \leq 4, b \leq 6$): Potential rival will enter unless the incumbent pays the exclusivity fee. The incumbent chooses to pay b because $b \leq 6$ ensures a profit at least as large as the duopoly profit of $4(\pi_i = 10 - b \geq 4)$.
 - **Accommodated entry** ($F \leq 4, b > 6$): Potential rival will enter to earn a positive profit of $\pi_r = 4 - F$. The incumbent does not pay the exclusivity fee because b is so high that it is better to ensure $\pi_i = 4$ than earn less ($\pi_i = 10 - b < 4$).
- When to pay the exclusivity fee?
 - The incumbent does not pay it if the potential rival's cost of entry is prohibitively high ($F > 4$) or if the cost of the exclusive contract is too high ($b > 6$).

13.3 Detering Entry (3 of 6)

- **Common Confusion:** A firm invests in new equipment only if the variable cost savings outweigh the fixed cost of the investment.
- However, this is not true. If managers cannot deter entry, they may try to delay entry.
- For example, pharmaceutical companies pay large amounts to delay the entry of generic competitors following the expiration of a drug patent.
 - The U.S. Federal Trade Commission (FTC) has charged that some drug makers had either paid generic firms directly or promised not to introduce their own generic versions if a potential rival delayed its entry into the market.
 - The industry contended that these pay-for delay deals are legal business decisions, but the U.S. Supreme Court ruled that such deals were illegal if they violate antitrust laws.
 - Thus, the FTC could take legal action against the companies on a case-by-case basis.

13.3 Detering Entry (4 of 6)

Limit Pricing

- A firm is **limit pricing** if it sets its price (or, equivalently, its output) so that another firm cannot enter the market profitably.
- To successfully limit price, a firm must have an advantage over its rivals.
- Example: an incumbent firm is making a large monopoly profit, which attracts the interest of a potential rival. The incumbent could announce that, after entry, it will charge a price so low that the other firm will make a loss.
 - This threat is credible only if the incumbent has a cost advantage over its rival.
- Another example: a Stackelberg leader acts first and produces a large quantity so that the follower produces a smaller quantity with no profit.
 - The leader makes limit pricing credible by committing to provide a very large output level.

13.3 Detering Entry (5 of 6)

Entry Deterrence in a Repeated Game



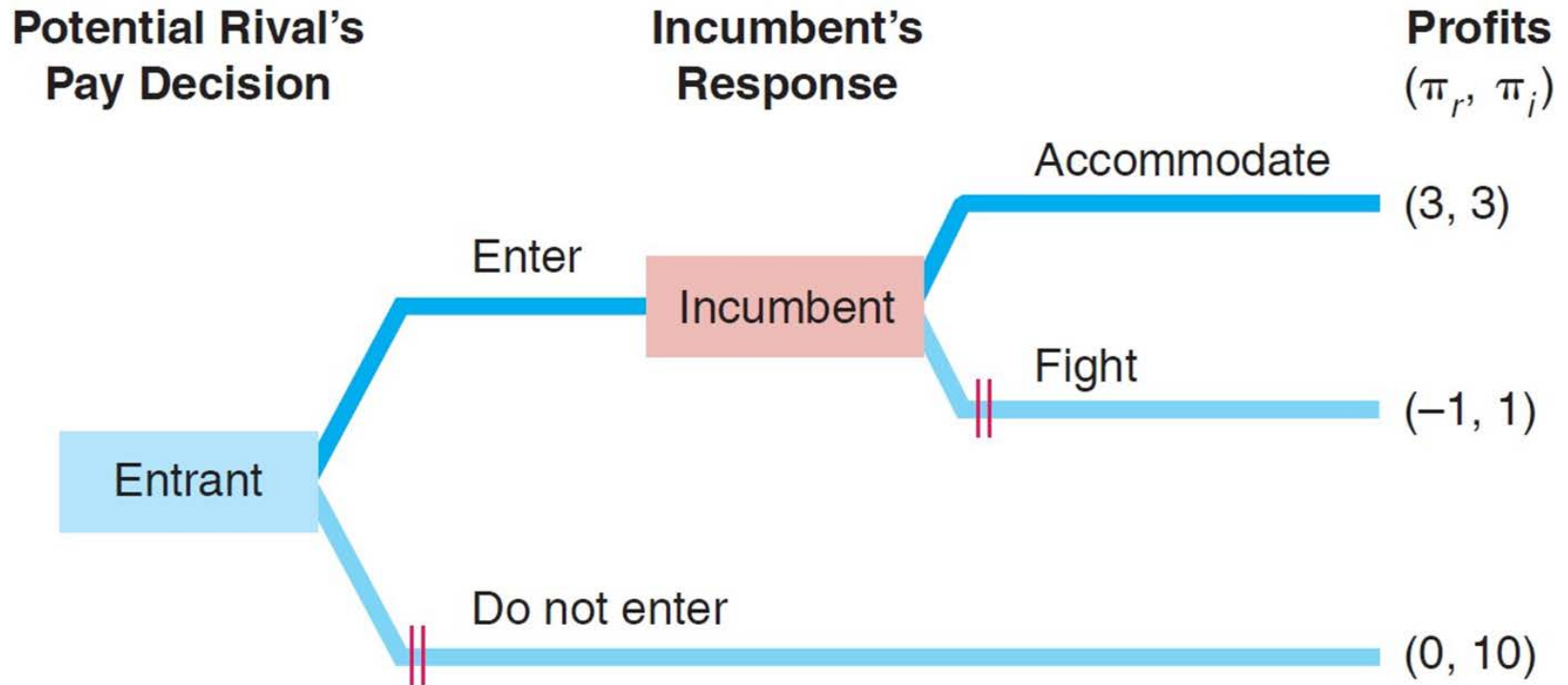
*"Yes, I pay you to keep rivals out of our territory.
But, I don't want to hear all the gory details."*

13.3 Detering Entry (6 of 6)

Entry Deterrence in a Repeated Game

- A grocery chain with a monopoly in many small towns faces potential entry by other firms in some or all of these towns.
 - Figure 13.3 shows the game in only one town. In the 1st stage, the rival decides to enter the town or not. In the 2nd stage, the incumbent decides between fighting with the rival (price war) or accommodating the rival.
- Accommodation if Game Played only Once
 - If this game is played only once and if the profits are common knowledge, then the only subgame perfect Nash equilibrium is for entry to occur and for the incumbent to accommodate entry.
- Price War if Repeated and Incomplete Information
 - If the chain's profits are not common knowledge and the game is played in many towns, the incumbent may want to fight back to build reputation.
 - Fighting the first rival is part of a rational long-run strategy and can be part of a subgame perfect Nash equilibrium in which entry is successfully deterred.

Figure 13.3 A Constituent Game of a Repeated Entry Game



13.4 Cost & Innovation Strategies (1 of 4)

Moving First

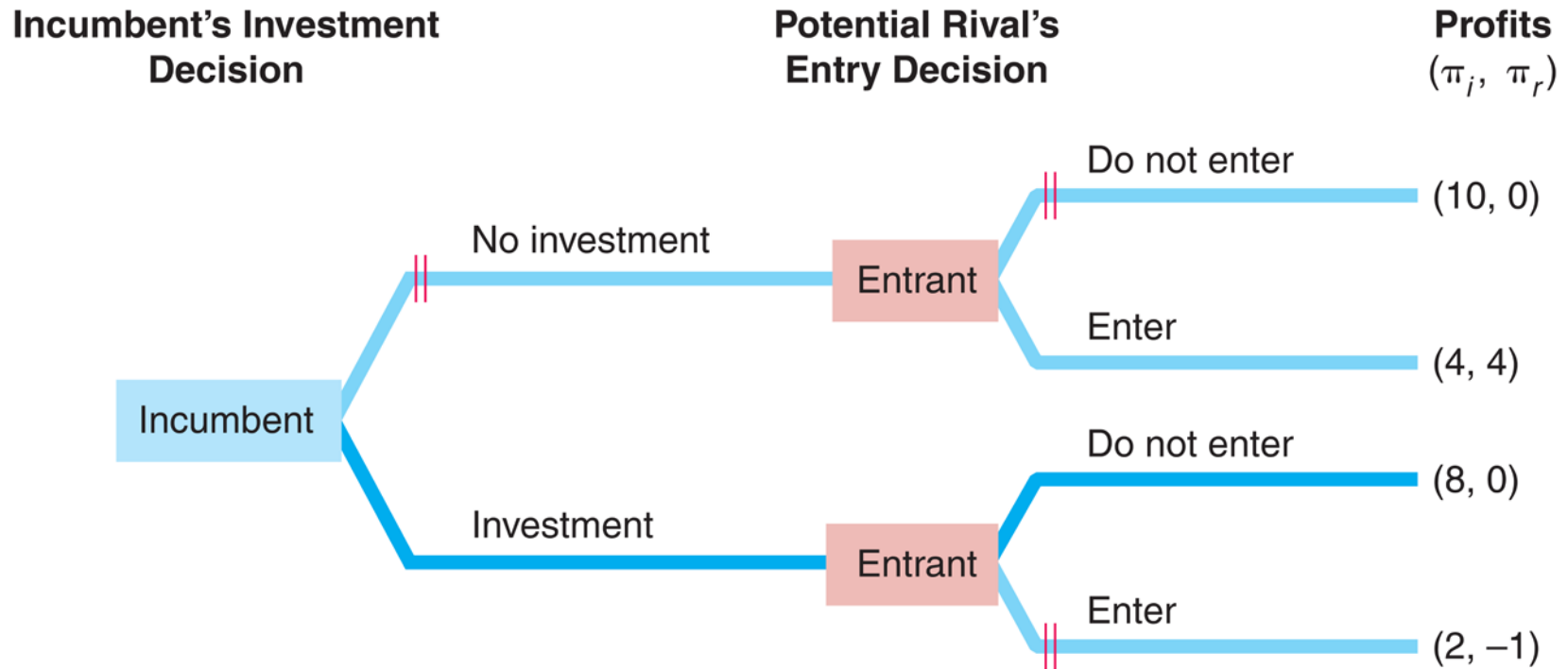
- A firm may be able to gain a cost advantage over a rival by moving first.
- We start by examining two cases:
- Moving First and Own Marginal Cost
 - A firm moves first to gain a marginal cost advantage over its rivals.
 - It can lower its own marginal cost by using a capital investment or increasing the rate of learning by doing.
- Moving First and Rival's Marginal Cost
 - A firm moves first to increase the rivals' marginal cost by more than its own.

13.4 Cost & Innovation Strategies (2 of 4)

Investing to Lower Marginal Cost

- A monopoly considers investment in a **process innovation** (installing robots on its assembly line) that would lower its *MC*.
 - Under normal conditions, this investment does not pay (investment cost > extra profit). But, a rival threatens to enter the market.
 - In Figure 13.4, the incumbent decides whether to invest in the 1st stage and the potential rival decides whether to enter in the 2nd stage.
- Backward induction
 - First, rival decides entry decision in 2nd stage: rival plays two subgames and decides the best action for each subgame based on highest profit values π_r .
 - Second, incumbent decides investment decision in 1st stage after rival decided in 2nd stage: incumbent plays one subgame and decides to invest ($\pi_i = 8 > \pi_i = 4$).
- Subgame perfect Nash equilibrium
 - The incumbent makes the ‘unprofitable’ investment to deter the entry of potential rivals and earns $\pi_i = 8$.

Figure 13.4 Investing to Prevent Entry



13.4 Cost & Innovation Strategies (3 of 4)

Learning by Doing

- **Learning by doing:** the more cumulative output a firm has produced, the lower its marginal cost, as its workers and managers learn by doing.
- In the presence of learning by doing, the first firm in a market may want to produce more than the quantity that maximizes its short-run profit so that its marginal cost is lower than that of a late-entering rival.
- Two Real Examples: Aircraft and Computer Chips
 - An aircraft manufacturer may price below current marginal cost in the short run because of its steep learning curve. The price of the Lockheed L-1011 was below the static *MC* for its entire 14-year production run (Benkard, 2004).
 - AMD's cost of computer chips was about 12% higher than Intel's cost. AMD had less learning by doing because it had produced fewer units (Salgado, 2008).

13.4 Cost & Innovation Strategies (4 of 4)

Raising Rival's Costs

- A firm may benefit from using a strategy that raises its own cost but raises its rivals' costs by more.
- Such strategies usually favor the first mover or incumbent against the rivals.
- Strategies for incumbents to raise rival's costs:
 - **Lobby** the government for more industry regulations that raise costs, as long as the legislation **grandfathers** existing firms' plants (exemption).
 - Increase the **cost of switching** by imposing a switching fee to customers that take their business elsewhere or designing products that don't work with the rival's.
 - Use **patents** to prevent rivals entering the market and increasing competition.

13.5 Disadvantages of Moving First (1 of 4)

- **Common Confusion:** A firm that moves first always has an advantage.
 - Moving first is not always an advantage.
 - We discuss two possible drawbacks to moving first: the holdup problem and acting too quickly.

The Holdup Problem

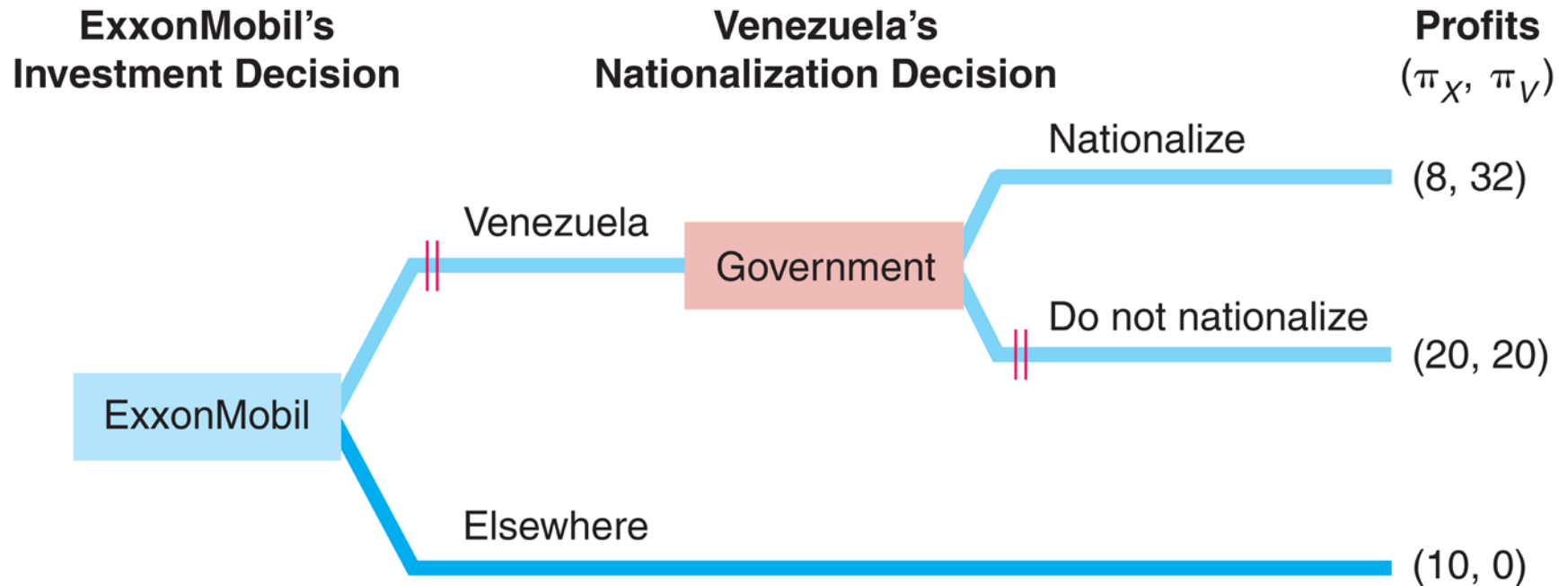
- The **holdup** problem arises when two firms want to contract or trade with each other but one firm must move first by making a **specific investment** (can only be used in its transaction with the 2nd firm).
 - Problem: the 2nd firm takes advantage of the 1st firm.
 - Consequences: If the 1st firm does not anticipate the opportunistic behavior of the 2nd firm and invests, it may earn no profit. If the 1st firm anticipates it, then they will not invest and both firms lose.

13.5 Disadvantages of Moving First (2 of 4)

The Holdup Problem

- Oil nationalization example in Figure 13.5: ExxonMobil moves 1st. It must decide to invest billions to obtain rights to drill for and refine oil in either Venezuela or another country. The Venezuelan government moves 2nd and decides to nationalize or not.
 - Problem: After ExxonMobil invests, it becomes a hostage of Venezuela because the investment cannot be transferred to other country.
 - Outcome: Using backward induction, the Venezuelan government will nationalize in the 2nd stage (profit π_v of 32 > 20). Given this, ExxonMobil should invest in another country in the 1st stage (profit π_x of 10 > 8).

Figure 13.5 Venezuela–ExxonMobil Holdup Problem



13.5 Disadvantages of Moving First (3 of 4)

Managerial Implication: Avoiding Holdups

- Managers should seek ways to avoid losing money due to holdups.
- We illustrate five approaches with GM (car maker) and Fisher Body (parts manufacturer) below.
 - **Contracts:** The 2nd-mover firm guarantees the 1st-mover firm that it will not be exploited; GM gave a 10 year **exclusive** cost-plus contract to Fisher Body.
 - **Vertical integration:** After years of holdup problems, GM bought Fisher Body.
 - **Quasi-vertical integration:** GM paid for and owned the specific capital assets.
 - **Reputation building:** GM can show its record of not acting opportunistically.
 - **Multiple or open sourcing:** Firms using open-source software are not subject to a holdup problem.

13.5 Disadvantages of Moving First (4 of 4)

Too-Early Product Innovation

- The advantage of being the 1st mover is **consumer loyalty**: later entrants find it difficult to take market share from the leader firm.
- However, **entering early** has disadvantages too: the cost of entering quickly is higher, the odds of miscalculating demand are greater, and later rivals may build on the pioneer's research to produce a superior product.
- Example:
 - Tagamet, 1st entrant of a new class of anti-ulcer drugs, was extremely successful when it was introduced.
 - Zantac, the 2nd entrant, rapidly took the lion's share of the market.
 - Tagamet moved too early: Zantac works similarly to Tagamet but has fewer side effects, can be taken less frequently, and was promoted more effectively.

13.6 Behavioral Game Theory (1 of 5)

Ultimatum Games

- Business people often face an **ultimatum**, where the **proposer** makes a “take it or leave it” offer to the **responder**. Once an ultimatum is issued, the responder cannot make a counter-offer.
- Ultimatum game: sequential, proposer moves 1st, responder moves 2nd

An Experiment: Dividing \$10

- Students are seated in a computer lab. Each one is designated as either a proposer or a responder and matched anonymously using computers.
- Each proposer makes an ultimatum offer of an x amount. If accepted, the responder gets x and the proposer $\$10 - x$. If rejected, both get nothing.
- If players were rational and going backwards: in the 2nd stage, the responder accepts any $x > 0$. So, in the 1st stage, the proposer offers the lowest possible x .
- Real Results of Dividing \$10
 - The lowest possible offer is never made. When made, it is rejected.
 - Offers under \$2 are relatively rare. When made, rejected 1/2 of time.
 - Most common offers between \$3 and \$4. These are not “rational.”

13.6 Behavioral Game Theory (2 of 5)

Reciprocity

- Most people believe in **reciprocity**: If others treat us well, we want to return the favor. If they treat us badly, we want to “get even”(at no excessive cost).
 - Some responders who reject lowball offers feel the proposer is being greedy, get angered by low offers, feel insulted and should oppose “unfair” behavior.
 - Most people accept that the advantage of moving first should provide some extra benefit to proposers but not too much.
- In labor situations, good managers often take account of reciprocity by providing benefits over and above the minimum needed.
 - Such an approach makes sense if workers who feel exploited might quit or go on strike even when it is against their economic interest. Conversely, workers who feel well treated often develop a sense of loyalty that causes them to work harder than needed or expected by contract—such as staying late to get a job finished.

13.6 Behavioral Game Theory (3 of 5)

Levels of Reasoning

- Keynes suggested that deciding which stock to buy is like predicting the outcome of a beauty contest: Your prediction should not be based on what **you** think of the contestants; it should be based on what you think **other people** will think.
 - ‘What you think other people will think’ depends on your levels of reasoning.
- A Beauty Contest Game: The FT invited readers to choose an integer between 0 and 100. The submission closest to $\frac{2}{3}$ of the average of all numbers submitted would win. So, the objective is to predict the average and pick a number that is $\frac{2}{3}$ of it.
 - The rational, unique Nash equilibrium to this game is for everyone to choose zero.
- Real Results of the Beauty Contest Game
 - The average was 18.9 and the winning submission was 13.
 - Only 5% of participants chose zero. A large number chose 33 and 22.
 - This experiment has been repeated many times. The overall average is usually about 22, implying a winning number of about 15.

13.6 Behavioral Game Theory (4 of 5)

- Explaining the results with levels of reasoning:
 - Level 0: Guess the average randomly. Some in the experiment.
 - Level 1: Think most people will guess randomly. So, mean = 50, number 33. A large group in the experiment.
 - Level 2: Think most people will use level 1 reasoning. So, mean = 33, number 22. Many people in the experiment.
 - Level 3: Think most people will use level 2 reasoning. So, mean 22, number 15. The winner is usually in this category.
 - Most sophisticated: Think most people are fully rational. So, mean = 0, number 0. Only 5% of people in the experiment.
- Lessons from these results:
 - On average, participants seem to exhibit level-2 reasoning. To win the game, it is therefore usually necessary to go through 3 layers of reasoning—not more and not less—so as to be one step ahead of most other players.
 - A manager who under/over estimates the capability of rivals for strategic thinking will make mistakes. The best is to have a good sense of exactly how sophisticated others are and stay one step ahead.

13.6 Behavioral Game Theory (5 of 5)

Managerial Implication:

Taking Advantage of Limited Strategic Thinking

- Managers should consider the level of strategic sophistication of customers (and rivals).
- For example, successful managers of Hollywood movie studios anticipate limited strategic thinking by moviegoers.
 - Normally, Hollywood studios release movies for prescreening by critics before general release to generate buzz through positive reviews.
 - If a studio is not confident about a movie's quality, it can use a cold opening, releasing the movie with no prescreening for movie critics.
 - A fully rational moviegoer understands this tactic and is less likely to go to movies with cold opens. However, Brown, Camerer, and Lovallo (2012) found that while some moviegoers instantly understand the system, some never catch on to this pattern.
 - Thus, a manager should not overestimate the reasoning ability of the general movie-going public.

Managerial Solution

Intel and AMD's Advertising Strategies

- Why have Intel's managers chosen to advertise aggressively while AMD engages in relatively little advertising?

Solution

- A plausible game to explain the problem is in Figure 13.4: Intel decides on how much to invest in its advertising campaign before AMD can act. AMD then decides whether to advertise heavily.
- Backward induction for the subgame perfect Nash equilibrium: Given how it expects AMD to behave, Intel **intensively advertises** because doing so produces a higher profit ($\pi_I = 8$) than does the lower level of advertising ($\pi_I = 4$).
- Thus, because Intel acts first and can commit to advertising aggressively, it can place AMD in a position where it makes more with a low-key advertising campaign.

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