

Game Theory II: Sequential and Repeated Games

Timing changes everything, when players move in sequence, or meet one another again and again.

What this chapter covers



14.2–14.4 Sequence

- Game trees
- Backward induction
- Credible threats & commitment



14.5 Repetition

- When cooperation survives
- Grim trigger & tit-for-tat
- Tacit collusion



14.6–14.7 Evidence

- Airline entry battles
- Axelrod's tournament
- Why reciprocity wins

THE BIG IDEA

These questions all turn on timing: players move in sequence, or meet one another repeatedly. This chapter extends the game theory of Chapter 13 to both settings.

14.1

Introduction

- An airline slashes fares, then raises them again
- Rivals who meet week after week
- A four-line program that won a famous tournament

Three puzzles about timing



Empty threats?

An incumbent slashes fares when a rival enters, then raises them once it retreats. Is the threat always believable?



Why repetition helps

Two rival supermarkets facing each other week after week sustain high prices that two one-time sellers could not.



A tiny winner

A four-line program won a famous tournament by repaying cooperation with cooperation and betrayal with betrayal.

WHAT THEY SHARE

Players move in sequence, or meet one another repeatedly, and that is enough to change what is possible.

14.2

Sequential Games and Game Trees

- When a payoff matrix is not enough
- Reading a game tree
- The entry game

14.2 SEQUENTIAL GAMES

When players move in sequence, we use a tree

■ Game tree

When the later mover sees what the earlier one did, a payoff matrix no longer captures the situation. The tree branches at each decision point, showing who moves, what they can choose, and the payoffs at the end of each path.

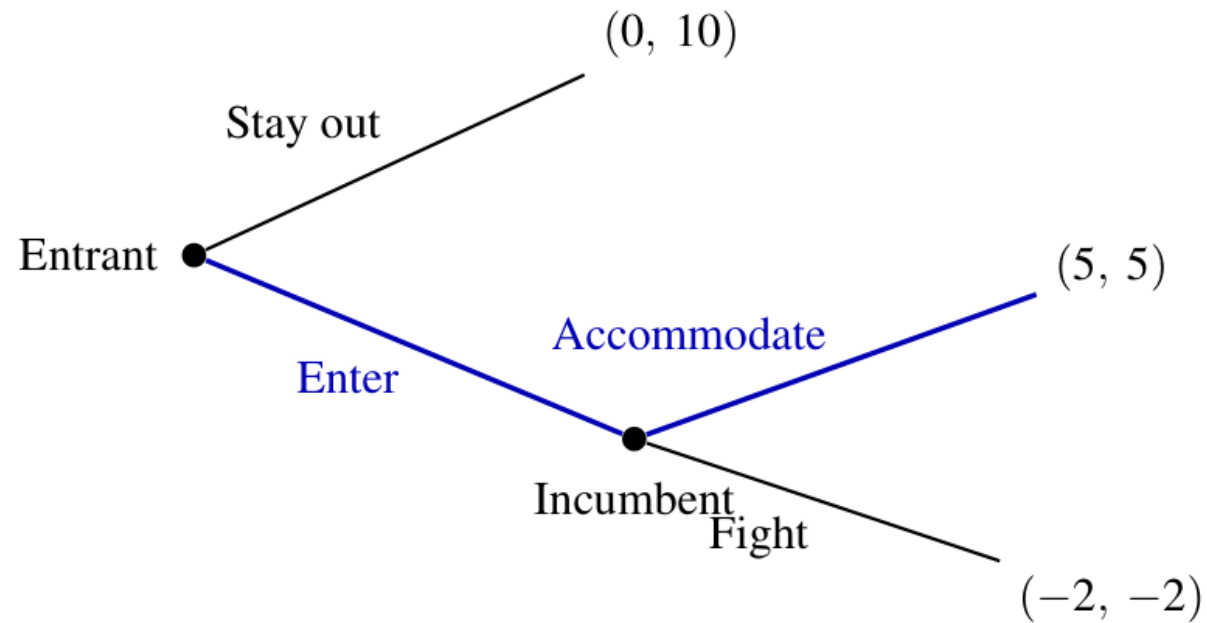
The entry game. A potential entrant first decides whether to enter the market.

Stay out. The incumbent keeps the market to itself.

Enter. The incumbent must accommodate (share the market) or fight a price war that hurts them both.

14.2 SEQUENTIAL GAMES

Figure 14.1: the entry game



- The entrant moves first: Enter or Stay out.
- If entry occurs, the incumbent chooses: Accommodate or Fight.
- Each path ends in a payoff pair (entrant, incumbent).

Figure 14.1 The entry game. Payoffs are (entrant, incumbent). The equilibrium path is shown in bold: enter, then accommodate.

14.3

Backward Induction and Subgame-Perfect Equilibrium

- Reasoning from the last move backward
- Why sequence changes everything

14.3 BACKWARD INDUCTION

Solve from the end of the tree back to the start

- Look first at the incumbent's choice, which comes second.
- If entry has occurred, it compares accommodating (5) with fighting (-2). It prefers to accommodate.
- Knowing this, the entrant looks ahead: entering yields 5, which exceeds the 0 from staying out. So it enters.

■ Subgame-perfect equilibrium

The strategy combination produced by backward induction, in which each player acts optimally at every decision point.

14.3.1 WHY SEQUENCE CHANGES EVERYTHING

First-mover advantage and the exposed bluff



Simultaneous

Choosing at the same moment, the incumbent's threat to fight might frighten the entrant into staying out, it cannot be sure the incumbent will back down.



Sequential

The entrant reasons through what the incumbent does after entry: fighting only hurts the incumbent, so it will not fight. The entrant enters confidently.

THE KEY DISCIPLINE

Backward induction asks, at each stage, what a rational player will actually do when that stage arrives, not what she might threaten to do beforehand. A subgame-perfect equilibrium rules out threats the player would not want to carry through.

14.3.1 WHY SEQUENCE CHANGES EVERYTHING

Self-check: is the threat credible?

SELF-CHECK

In a sequential entry game, the incumbent threatens a price war if a rival enters, but fighting would lose it money. By backward induction, is the threat credible, and does the rival enter?

ANSWER

The threat is not credible: once entry has occurred, fighting only hurts the incumbent, so it accommodates instead. Anticipating this, the rival enters. Only a binding commitment could make the threat believable.

14.4

Credible Threats and Commitment

- Why an empty bluff fails
- Commitment that ties your own hands
- Commitment devices in the real world
- Regulatory hold-up

14.4 CREDIBLE THREATS

A threat backward induction exposes

■ Non-credible threat

The incumbent might threaten to fight any entrant. But once entry has occurred, fighting earns -2 and accommodating earns 5 , so it will not carry out the threat. A rational entrant ignores it.

THE REMEDY: COMMITMENT

What could make the threat credible? A prior action that changes the incumbent's own later incentives, so that fighting actually becomes its preferred response to entry.

14.4 CREDIBLE THREATS

Commitment makes the threat believable

■ Commitment

A prior action, extra capacity, signed contracts, a reputation for toughness, that makes fighting the incumbent's best reply once entry occurs.

THE LESSON

Limiting your own options can make you better off, by making a threat believable. A general who burns the bridge behind his army cannot retreat, and precisely because of that, his enemy may not attack.

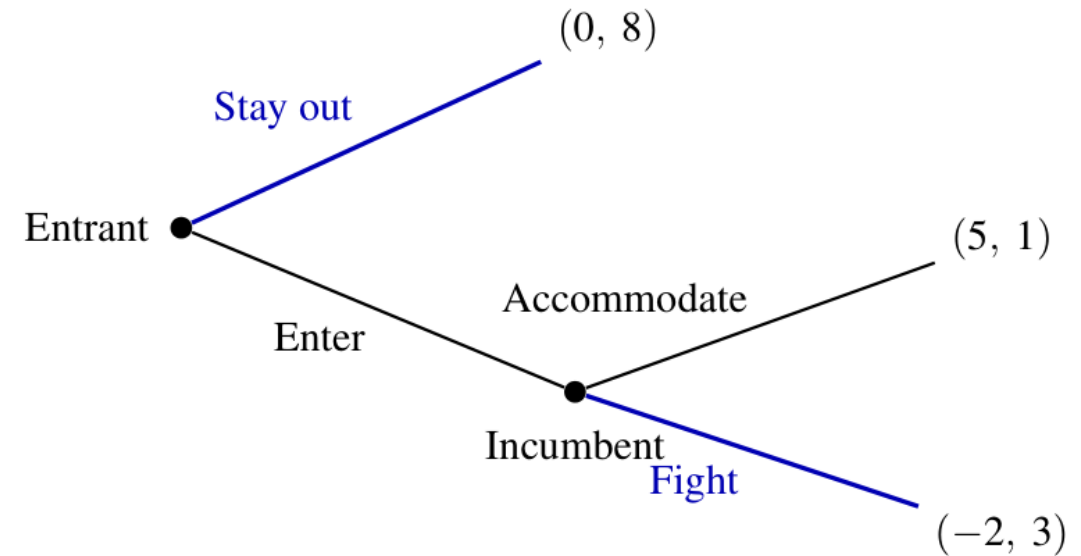


Figure 14.2 With a prior commitment that makes fighting worthwhile, the threat is credible and the entrant stays out.

How people and firms tie their own hands

■ Commitment device

Any prior, hard-to-reverse action that changes one's own future incentives, so that a threat or promise becomes believable.



Firms

Build a large factory or sign long-term supply contracts, committing to high volume, warning entrants it will fight.



Savers & quitters

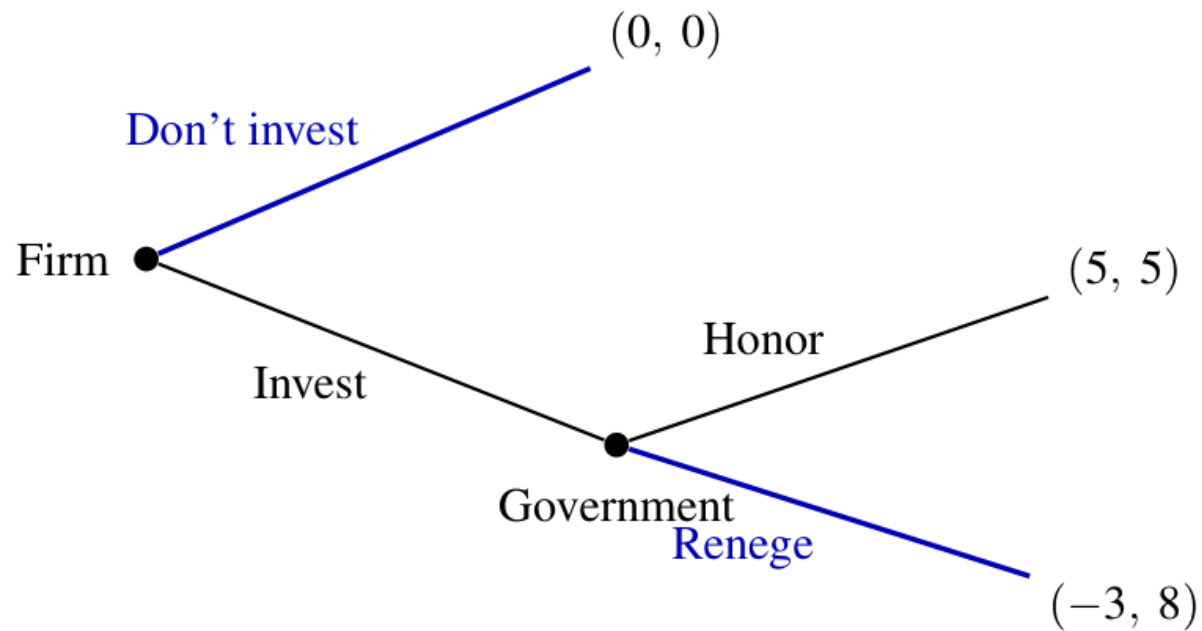
Lock money in a plan you cannot touch; bet a friend \$1,000 you will quit smoking, raising the cost of backsliding.



Announcing a goal

Even a public announcement is a mild device: breaking it now carries the extra cost of embarrassment.

The hold-up problem, as a sequential game



- Many valuable projects need a huge, irreversible sunk investment first.
- The firm chooses to invest or not; if it does, the government honors the deal or reneges.
- A government free to act after investment prefers to renege (8 against 5 for honoring).

Figure 14.3 The regulatory hold-up problem. Foreseeing that the government reneges once investment is sunk, the firm does not invest.

The hold-up problem, and its cure

■ Hold-up problem

Anticipating that the government will renege after the investment is sunk, the firm refuses to invest, and the project, worth 5 to each side, never happens.

INDEPENDENT REGULATORS

The cure is the commitment of Section 14.4.1: the government must credibly tie its own hands so renegeing becomes costlier. In developed economies this is done through independent regulators, Britain created Ofgem (energy) and Ofwat (water), setting prices by formulas fixed years in advance.

14.4.2 REGULATORY COMMITMENT

Where commitment is weak, hold-up is sharper

- Guasch and colleagues studied ~1,000 Latin American infrastructure concessions, mid-1980s to 2000.
- About 30% were renegotiated after the fact, far more in some sectors.
- Sometimes governments squeezed firms once capital was sunk; sometimes firms bid low, then demanded better terms.

54%

of transport concessions
renegotiated

74%

of water concessions
renegotiated

THE STAKES

The average concession was renegotiated just 2.2 years after signing. Weak commitment raised the cost of infrastructure and deterred the very investment these countries most needed.

14.5

Repeated Games and Cooperation

- Why finite repetition unravels
- Indefinite horizons sustain cooperation
- Grim trigger and tit-for-tat
- Tacit collusion and price wars

The horizon matters

■ Repeated games

Many situations recur: the same firms compete month after month, the same neighbors interact for years. Players can reward cooperation and punish defection over time.

The Folly of Finite Repetition

If a prisoner's dilemma is repeated a known, FINITE number of times, cooperation unravels. In the last round there is no future to protect, so both defect; knowing that, they defect in the second-to-last round too, and so on back to the first.

Indefinite repetition can sustain cooperation

INDEFINITE HORIZON

If the game is repeated indefinitely, players never know for sure when it will end, cooperation can be sustained. The key is a strategy that makes cheating unprofitable by threatening to withdraw future cooperation.

THE CONDITION

If players value the future enough, the loss of future cooperation outweighs the one-time gain from cheating, and cooperation holds.

Two punishment strategies



Grim trigger

Cooperate until the other defects even once, then defect forever after. A harsh, unforgiving punishment.



Tit-for-tat

Cooperate first, then simply copy whatever the other did last. Milder: it punishes, but forgives as soon as the other cooperates again.

WHY IT MATTERS

This is why ongoing business rivals can sustain high prices (tacit collusion), and why price-matching guarantees, a public promise to punish any rival's price cut by matching it, can keep prices high without any explicit agreement.

Keeping prices high without an agreement

■ Tacit collusion

Rival firms keep prices high without ever signing an illegal agreement. Two supermarkets facing each other week after week are playing a repeated pricing game: each could cut its price today, but the rival would match tomorrow, touching off a price war that leaves both worse off.

The Shadow of the Future

So each refrains, held high not by a contract but by the shadow of future punishment, exactly the grim-trigger and tit-for-tat logic. A few firms can behave almost like a monopoly even while competing fiercely on the surface.

Price-matching guarantees and price wars



Price-matching, paradox

A public promise to beat any rival's price can keep prices UP: it predicts that any cut will be instantly undone, removing the reward for cutting.



When it breaks down

A new entrant ignores the unwritten rules, or a firm in trouble breaks ranks, and the result is the price war the firms had been avoiding.

WHY REGULATORS CARE

Competition authorities watch for tacit collusion precisely because its effects can resemble those of an illegal cartel, even when no law has been broken.

14.6

Case Study: Entry Battles in the Airline Industry

The entry game of Figure 14.1, played for real.

14.6 CASE STUDY

American Airlines and the Dallas/Fort Worth hub

- In the 1990s, small low-cost carriers began serving routes out of American's Dallas/Fort Worth hub.
- American sharply cut fares and added flights on exactly those routes, Kansas City, Wichita, Colorado Springs, Long Beach.
- When the low-cost carriers withdrew, American raised fares again.

14.6 CASE STUDY

US v. AMR: predation or competition?

THE ALLEGATION

In 1999 the Department of Justice sued, alleging American had priced below cost to drive out entrants and “fight” in the sense of our game tree, planning to recoup losses later through higher fares once the threat of entry was gone.

- To be illegal predation, pricing had to be below American's own cost, with a realistic chance of recouping the losses.
- The courts ruled for American, finding the evidence of below-cost pricing insufficient.
- Whatever the verdict, the episode shows why incumbents work to build a reputation for fighting, a credible threat (Figure 14.2) can deter entry without a shot fired.

14.7

Empirical Evidence: Axelrod's Tournament and Tit-for-Tat

Can cooperation emerge among purely self-interested players?

14.7 EMPIRICAL EVIDENCE

A round-robin of computer strategies

- Political scientist Robert Axelrod invited scholars to submit computer strategies for a repeated prisoner's dilemma.
- Each pair played 200 rounds in a round-robin tournament.
- Strategies ranged from simple to fiendishly complex.

200

rounds per matchup

4

lines of code in the winner

THE RESULT

The winner, in both the original tournament and a larger rematch, was the simplest program of all: tit-for-tat, submitted by Anatol Rapoport.

RUN IT YOURSELF

Run Veconlab's repeated prisoner's-dilemma session and see whether your group drifts toward the tit-for-tat cooperation that won Axelrod's tournament.

veconlab.econ.virginia.edu/admin.htm

Why tit-for-tat succeeded

1

Nice

Never the first to defect.

2

Retaliatory

Punishes defection at once.

3

Forgiving

Returns to cooperation as soon as the other does.

4

Clear

Easy for the other to understand and adapt to.

THE CENTRAL LESSON

Greedy strategies that tried to exploit others did well in single encounters but poorly over the long run, as their victims learned to defect against them. When the same players interact repeatedly, reciprocity can sustain cooperation that one-shot self-interest would destroy.

Key takeaways

1

Game trees

Sequential moves need a tree, not a matrix, it shows who moves, the choices, and payoffs on each path.

2

Backward induction

Solve from the last move backward; the result is a subgame-perfect equilibrium.

3

Credible threats

Backward induction exposes non-credible threats; commitment can make a threat believable by tying your own hands.

4

Regulatory hold-up

Without credible commitment, firms will not sink investment; independent regulators are the cure.

5

Repeated games

Finite repetition unravels; indefinite horizons let grim-trigger and tit-for-tat sustain cooperation.

6

Evidence

Airline entry battles (US v. AMR) and Axelrod's tournament, where reciprocal tit-for-tat won.