MANAGERIAL ECONOMICS · WEEK 6

Thinking strategically

How do we act when outcomes depend on others?

WHAT IS A DECISION PROBLEM?

Action determines the outcome

One person chooses an action from a set of alternatives to achieve their objective.

WHAT IS A STRATEGIC PROBLEM?

Actions determine the outcome

Two or more people, each with their own objective, choose actions. The outcome depends on what everyone chooses.

A GAME

Anatomy of a game

01 Players: who decides.

02 Strategies: what each can do.

03 Outcomes: what each combination of strategies leads to.

04 Payoffs: what each outcome is worth to each player.

05 Rules: who moves when, and who sees what.

PLAYERS' BEHAVIOR

What does rational mean?

Payoffs capture how a player ranks outcomes. Each player maximizes their payoff given what they know and what they conjecture about the others.

TIMING

Simultaneous or sequential

SIMULTANEOUS

No player sees the others' moves before choosing.

Payoff matrix

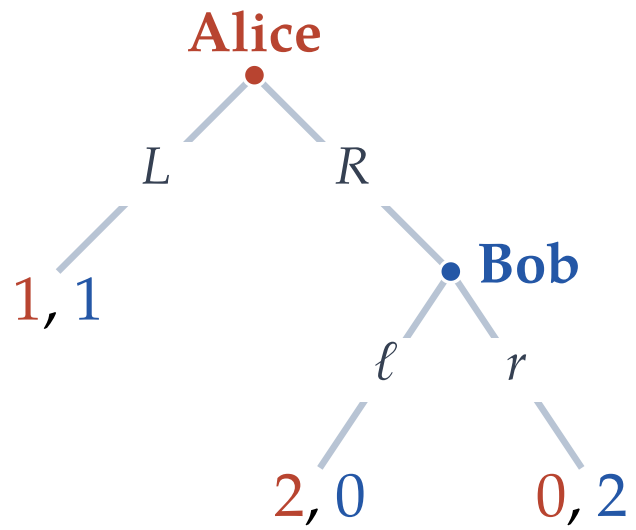
SEQUENTIAL

Later players see earlier moves.

Game tree

Simultaneous or sequential

Alice \ Bob	L	R
U	$1, 1$	$-1, 2$
D	$0, -1$	$3, 1$



INFORMATION

Complete or incomplete

COMPLETE

Every player knows the entire structure of the game.

INCOMPLETE

At least one player is uncertain about the ingredients of the game, such as a rival's payoffs.

TWO CAFÉS ACROSS THE STREET

$4 or $6 a cup?

100 price-sensitive customers a day go to the cheaper café. If the prices are equal, the cafés split the market equally.

If you ran Café A, how would you play?

TWO CAFÉS

Pricing game

Café A \ Café B	$6	$4
$6	300, 300	0, 400
$4	400, 0	200, 200

DOMINANT STRATEGY

Higher payoff against every action of the rival

No guessing needed. If you have one, play it.

> **Dominant strategy.** For a player, an action is dominant if it yields at least as high a payoff as any other action, regardless of what the other players do.

TWO CAFÉS, A VARIANT

Pricing game

Café A \ Café B	$6	$4
$6	300, 300	250, 400
$4	400, 0	200, 200

DOMINATED STRATEGY

What won't Player 1 play?

Player 1	Player 2: *Left*	Player 2: *Right*
Up	1, 2	4, 3
Middle	0, 1	3, 0
Down	3, 4	2, 2

DOMINATED STRATEGY

Another strategy does better against every action of the rival

A rational player never plays a dominated strategy, so we can delete it.

> **Dominated strategy.** For a player, an action is dominated if another action yields a higher payoff, regardless of what the other players do.

Eliminating dominated strategies

Player 1 \ Player 2	*a*	*b*	*c*
a	15, 15	9, 5	2, 8
b	7, 5	3, 12	5, 6
c	20, 1	7, 3	10, 10

PRISONERS' DILEMMA

$4 is dominant for both

Café A \ Café B	$6	$4
$6	300, 300	0, **400**
$4	**400**, 0	**200**, **200**

PRISONER'S DILEMMA

Change the game, not the exhortation

01 Repetition: punish undercutting tomorrow.

02 Commitment: binding promise to match any price.

03 Changing the game: eliminate the prisoners' dilemma.

A NEW GAME

What to play now?

Player 1 \ Player 2	*a*	*b*	*c*
a	15, 15	9, 5	2, 8
b	25, 5	3, 12	5, 6
c	20, 1	7, 3	10, 10

NASH EQUILIBRIUM

Nobody wants to deviate

> **Nash equilibrium.** An action profile is a Nash equilibrium if no player has an incentive to make a unilateral deviation.

Label the best responses

Player 1 \ Player 2	*a*	*b*	*c*
a	15 , 15	9 , 5	2 , 8
b	25 , 5	3 , 12	5 , 6
c	20 , 1	7 , 3	10 , 10

Check | Show answer | Clear

Click a payoff to mark a best response: Player 1's in each column, Player 2's in each row. A cell with both payoffs marked is a Nash equilibrium.

How many equilibria?

Alice \ Bob	*Ballet*	*Opera*
Ballet	3 , 1	0 , 0
Opera	0 , 0	1 , 3

FOUR CLASSIC 2×2 GAMES

How many equilibria?

GAME	PURE EQUILIBRIA	THE PROBLEM
Prisoner's dilemma	One	Both would like to escape it
Pure coordination	Two, ranked the same	Beliefs: expect the same place
Chicken, battle of the sexes	Two, ranked differently	Who gets their way
Matching pennies	None	Don't be predictable

IN CLASS

Find the Nash equilibria

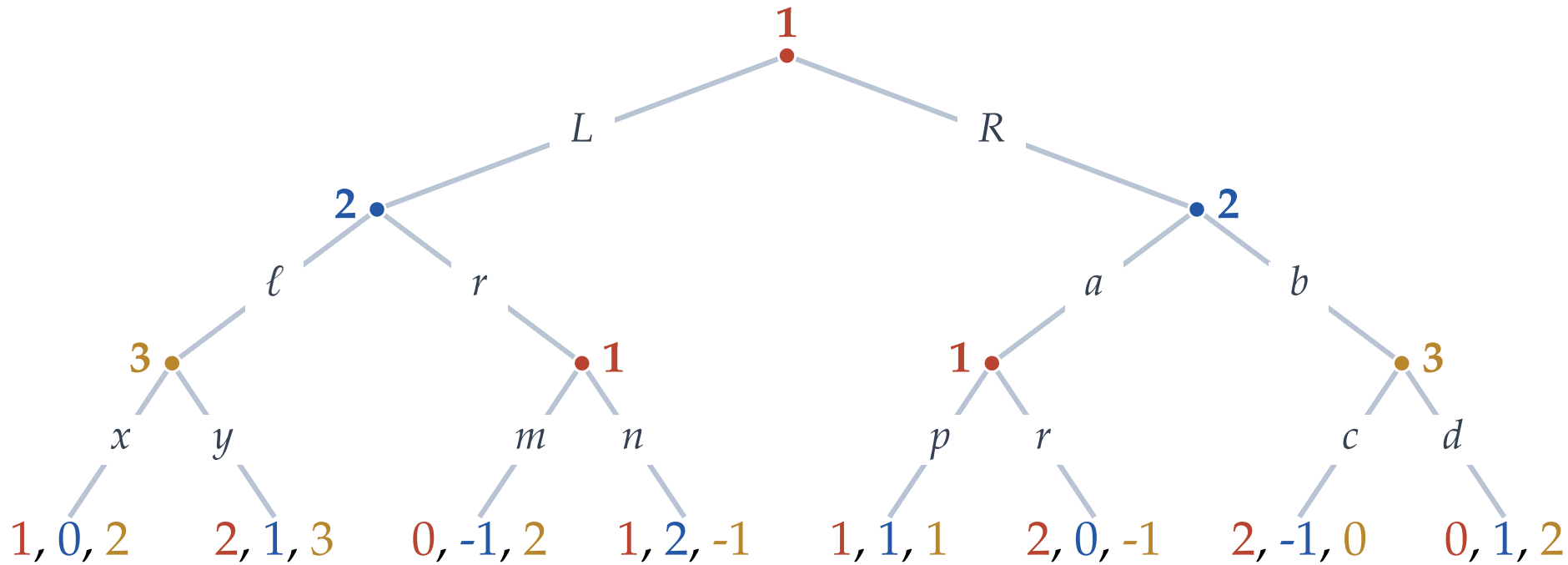
Alice \ Bob	a	b	c	d	e
w	2 , 2	1 , 3	0 , −2	−1 , 2	1 , 1
x	1 , 7	−2 , −1	0 , 0	1 , −2	10 , 9
y	3 , 5	−7 , 1	−4 , 6	8 , 1	−3 , 1
z	0 , 0	3 , 1	−2 , 0	10 , 7	8 , 4

SEQUENTIAL GAMES

Players move in sequence

What happens when the rival sees your moves?

Reading a game tree

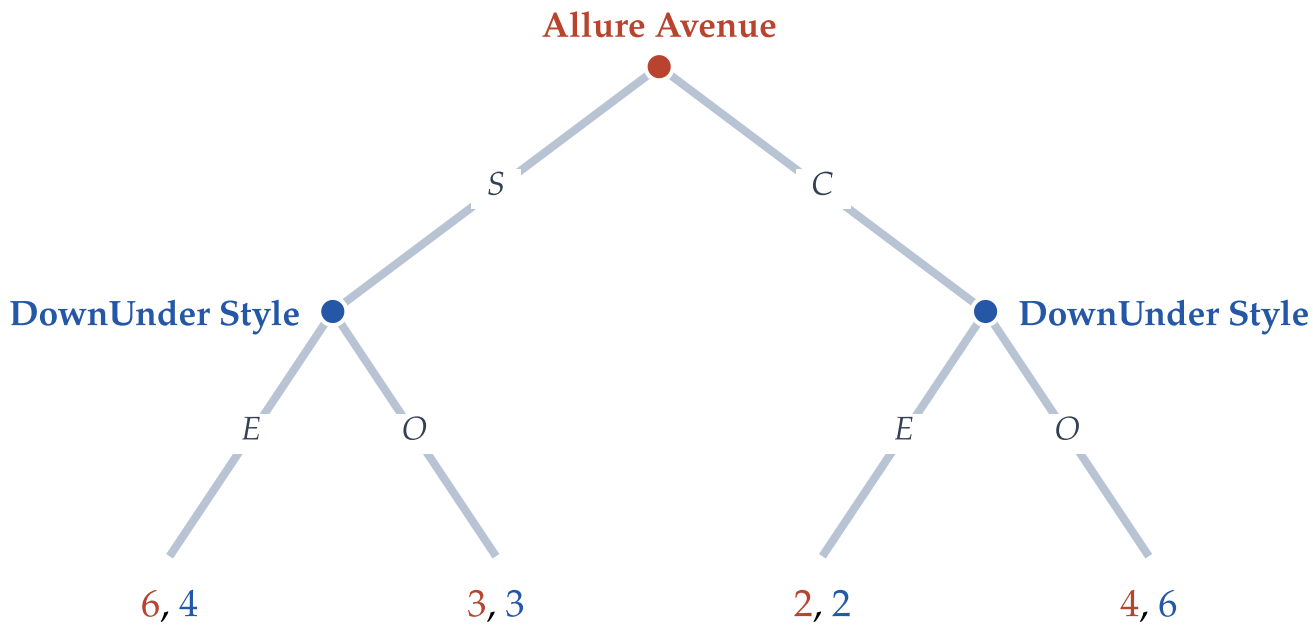


SEQUENTIAL GAMES

What is a strategy?

Strategy. A player's behavior is described by a complete contingency plan indicating the action chosen at each decision node where the player is supposed to act. This is called a strategy.

What are the strategies?



Clear

Click a branch to color it. Click it again to clear it.

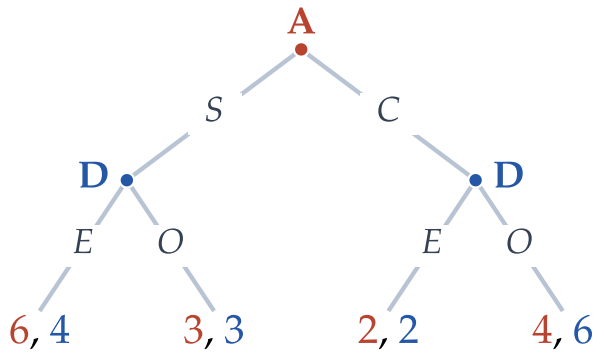
A STRATEGY IS A PLAN

DownUnder's four strategies

STRATEGY	AFTER SPORTY	AFTER CLASSICAL
EE	European	European
EO	European	Outback
OE	Outback	European
OO	Outback	Outback

AS A MATRIX

Three Nash equilibria



DownUnder

Allure	*EE*	*EO*	*OE*	*OO*
S				
C				

Next

(C, OO)

"Outback, whatever you launch"

If Allure launches Sporty anyway, DownUnder gets 3 from Outback and 4 from European.

Should Allure believe the threat?

CREDIBLE THREAT

One you'd want to carry out when the time comes

Stating a threat doesn't make it credible. The payoff from carrying it out does.

BACKWARD INDUCTION

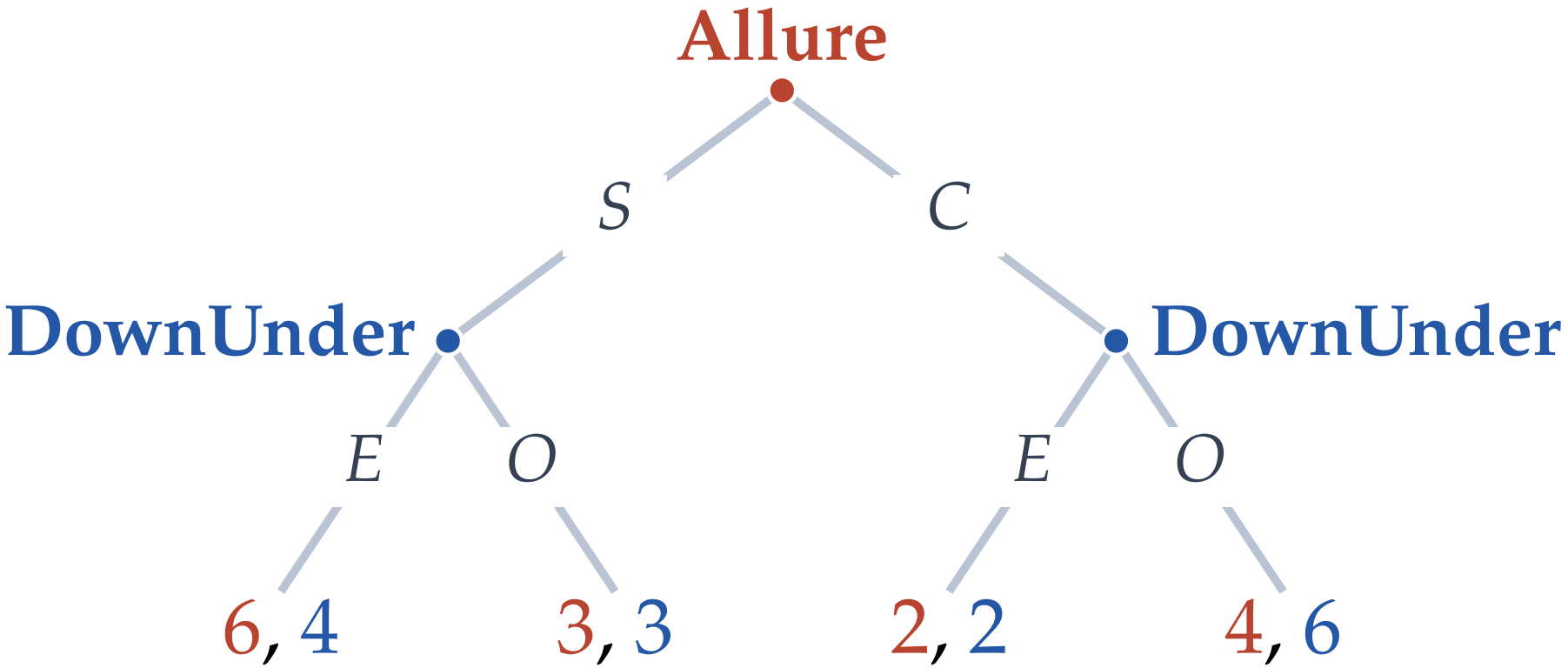
Solve from the end

01 At each last decision, find the best action.

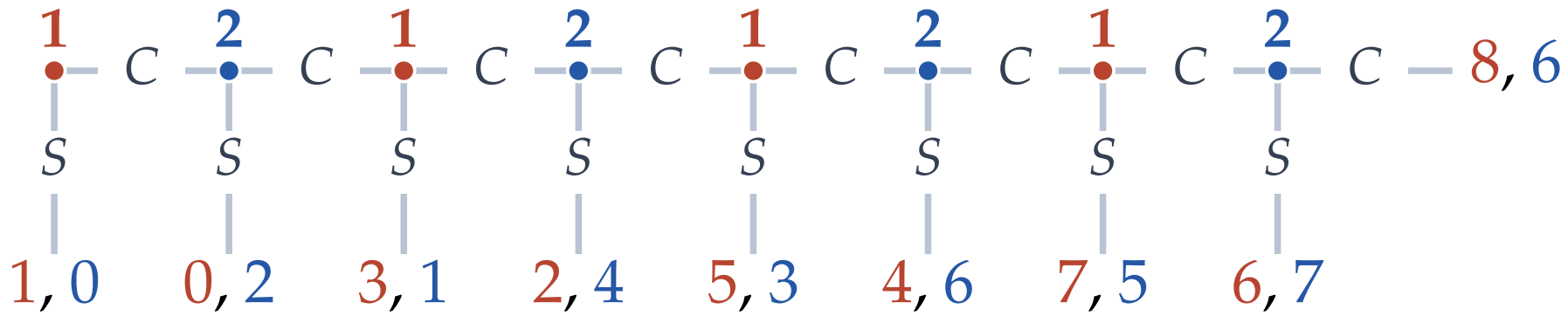
02 Replace the decision with its outcome.

03 Repeat until the first move.

Solve the catwalk game



Stop or continue?



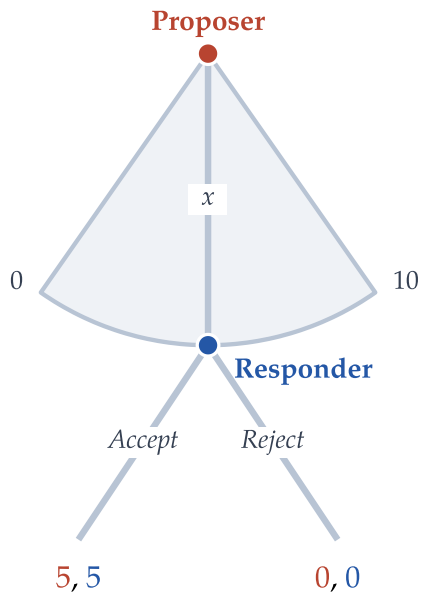
ULTIMATUM GAME

Split $10

The proposer offers a share. If the responder rejects, both get nothing.

What's the smallest offer you'd accept?

Offer, then accept or reject



◀ Prev Step 0 of 2 Next ▶

The game tree. Press Next to solve it by backward induction, from the bottom up.

Splitting 10

Offer x 5.00

Responder's envy α 0.00

The Proposer offers x out of 10. The Responder accepts or rejects; rejection leaves both with nothing. Press Next to solve.

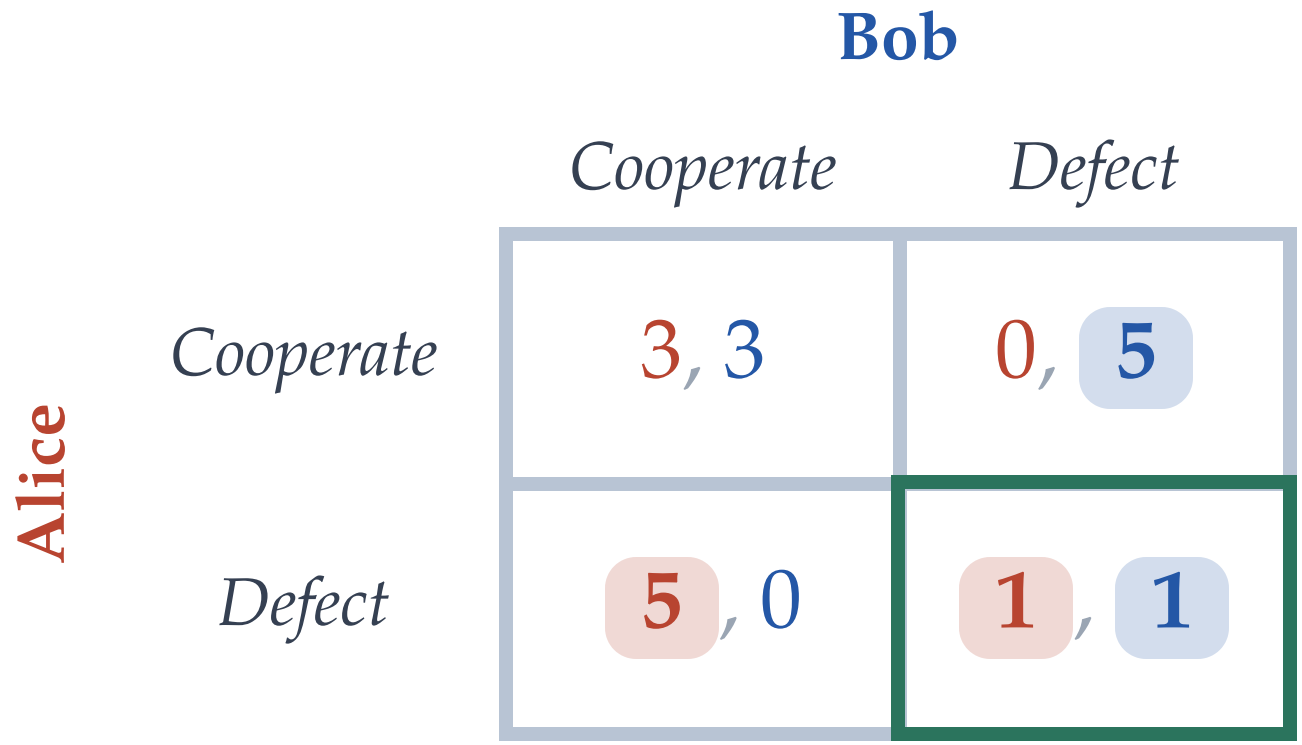
Raise α and the Responder dislikes getting less than the Proposer. Offers below 0 are rejected.

REPEATED GAMES

Playing repeatedly

The same rivals, every period.

A prisoner's dilemma, every period



REPEATED GAME

The stage game, every period

01 In every period t, players play the stage game.

02 The outcome of the stage game in period t determines each player's stage payoffs.

03 Stage payoffs arrive every period. The payoff of the repeated game aggregates them.

INFINITELY REPEATED GAMES

No last period

There's no well-defined final period, so backward induction has no natural point to start.

DISCOUNTING

A stream of $1 in every period

$$1 + \delta + \delta^2 + \cdots = \frac{1}{1 - \delta}$$

With $\delta = 0.9$, a dollar every period is worth 10 today.

GRIM TRIGGER

Consider the following strategy

01 In period 1, I play C.

02 In period $t = 2, 3, \ldots$, I play C if my opponent has always played C. Otherwise, I switch to D forever.

GRIM TRIGGER

Cooperate until anyone defects, then defect forever

Deviating earns 5 in period t, then 1 a period. Cooperating earns 3 a period.

How patient must Alice be to keep cooperating?

GRIM TRIGGER

What does Alice gain by deviating?

Bob plays grim trigger.

ALICE	OUTCOMES	PAYOFF
Cooperates	(C, C), (C, C), (C, C), …	$V_C = 3 + 3\delta + 3\delta^2 + \cdots = \frac{3}{1-\delta}$
Deviates	(D, C), (D, D), (D, D), …	$V_D = 5 + \delta + \delta^2 + \cdots = 5 + \frac{\delta}{1-\delta}$

ALICE'S COMPARISON

Cooperate or deviate?

$$\frac{3}{1-\delta} \geq 5 + \frac{\delta}{1-\delta}$$

$$3 \geq 5(1-\delta) + \delta$$

$$3 \geq 5 - 4\delta$$

$$\delta \geq \frac{1}{2}$$

TIT-FOR-TAT

Consider the following strategy

01 In period 1, I play C.

02 In period $t = 2, 3, \ldots$, I play whatever my opponent played in period $t - 1$.

TIT-FOR-TAT

What does Alice gain by deviating?

Bob plays tit-for-tat.

ALICE	OUTCOMES	PAYOFF
Cooperates	(C, C), (C, C), (C, C), …	$V_C = 3 + 3\delta + 3\delta^2 + \cdots$
Deviates once	(D, C), (C, D), (C, C), …	$V_1 = 5 + 0 \cdot \delta + 3\delta^2 + \cdots$
Deviates forever	(D, C), (D, D), (D, D), …	$V_D = 5 + \delta + \delta^2 + \cdots = 5 + \frac{\delta}{1-\delta}$

ALICE'S COMPARISON

Cooperate or deviate once?

$$3 + 3\delta \geq 5 + 0 \cdot \delta$$

$$3\delta \geq 2$$

$$\delta \geq \frac{2}{3}$$

Deviating forever needs $\delta \geq \frac{1}{2}$, as under grim trigger. Both must hold.

GRIM TRIGGER AND TIT-FOR-TAT

How much patience?

STRATEGY	PUNISHMENT	COOPERATION NEEDS
Grim trigger	Defect forever	$\delta \geq \frac{1}{2}$
Tit-for-tat	Defect for one period	$\delta \geq \frac{2}{3}$

A milder punishment never needs less patience.

THE SHADOW OF THE FUTURE

Cooperation needs a future that matters

Frequent interaction, a lasting relationship and no known last period.

ASSIGNMENT FOR QUIZ 7

Hats

Akubra and Barmah set prices, first at the same time, then with a promise to match.