LECTURE 17: STRATEGIC INTERACTION

Today's Topics: Oligopoly

1. **Two Sellers:** price takers versus a monopoly (cartel) versus ...
2. **A Cournot Duopoly:** payoff matrices, dominant strategies, Nash Equilibrium.
3. **The Prisoner's Dilemma:** Schelling's *n*-person game, the advertising game, repeated interactions.
4. **Others:** Chicken!, firms behaving badly? game trees.

1. TWO SELLERS

Sellers Jack and Jill face this market:

Quantity (litres/week) *Q*	Price ($/litre) *P*	Total Revenue *TR*	Marginal Revenue *MR* ($/l)	Price Elasticity $\|\eta\|$ (arc)	Price Elasticity $\|\eta\|$ (equation)
0	120	0			∞

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			70	3.8	
30	90	2700			3.0
			50	2.4	
40	80	3200			2.0
			30	1.67	
50	70	3500			1.4
			10	1.18	
60	60	3600			1.0
			−10	0.85	
70	50	3500			0.71
			−30	0.6	
80	40	3200			0.5
			−50	0.412	
90	30	2700			0.333
			−70	0.263	
100	20	2000			0.2
			−90	0.143	
110	10	1100			0.091
			−110	0.043	
120	0	0			0

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Note: *TR* is a maximum when *MR* = 0;
for arc, see Lecture 4, pp 9,10; for equation, see Lecture 4, pp 12,13.

MORE OR LESS

Assume that *MC* = 0 for all firm output *y*.

***Competition (price-taking)*:**

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choose output y^C to set Price $P^C = MC = 0$
y^C: $MC(y^C) = 0 = P^C$

$\therefore Q^C$ = 120 litres/week, $\pi^C = 0 \times 120 = 0$.

***Monopoly*:**

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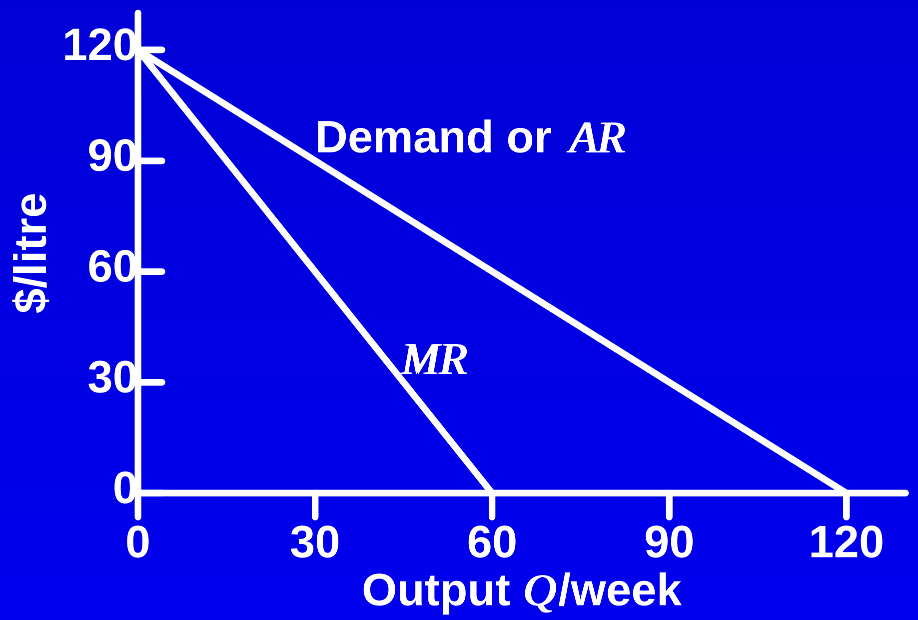
$\therefore Q^C = 120$ litres/week, $\pi^C = 0 \times 120 = 0$.

***Monopoly*:**
choose output y^M to set $MR = MC = 0$.
y^M: $MR(y^M) = MC(y^M) = 0$

$\therefore Q^M = 60$ litres/week, $P^M = \$60$/litre, and $\pi^M = 60 \times \$60 = \$3600$/week

GRAPHICALLY



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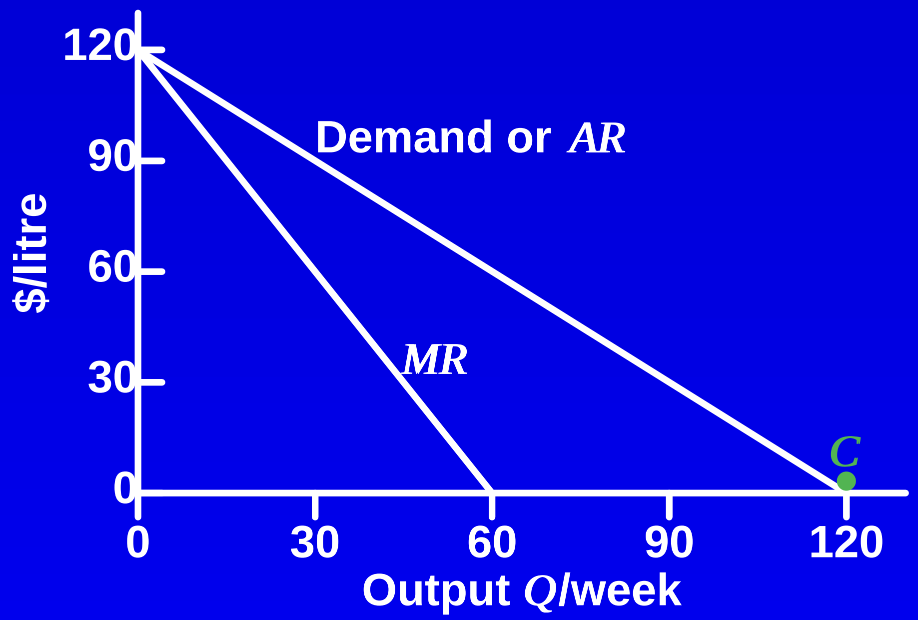

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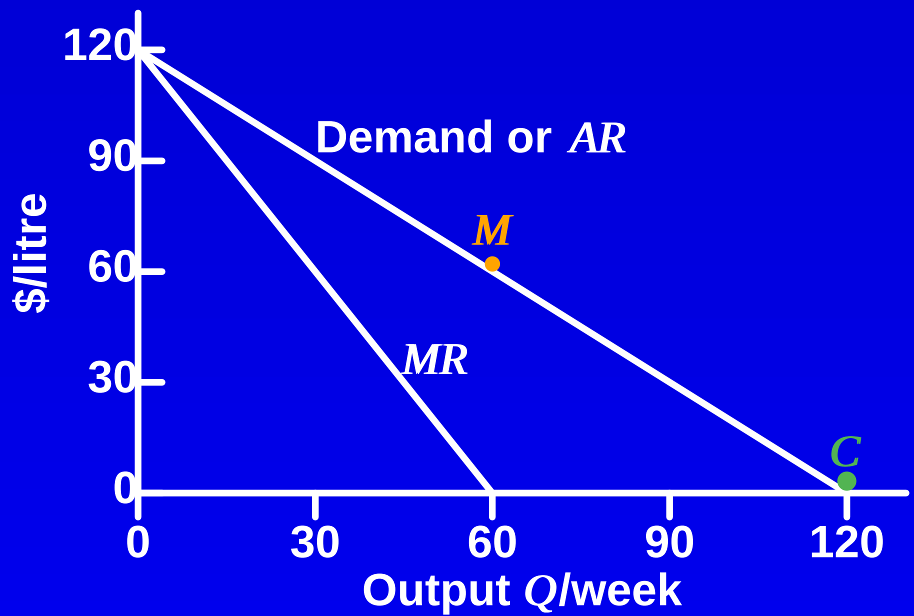

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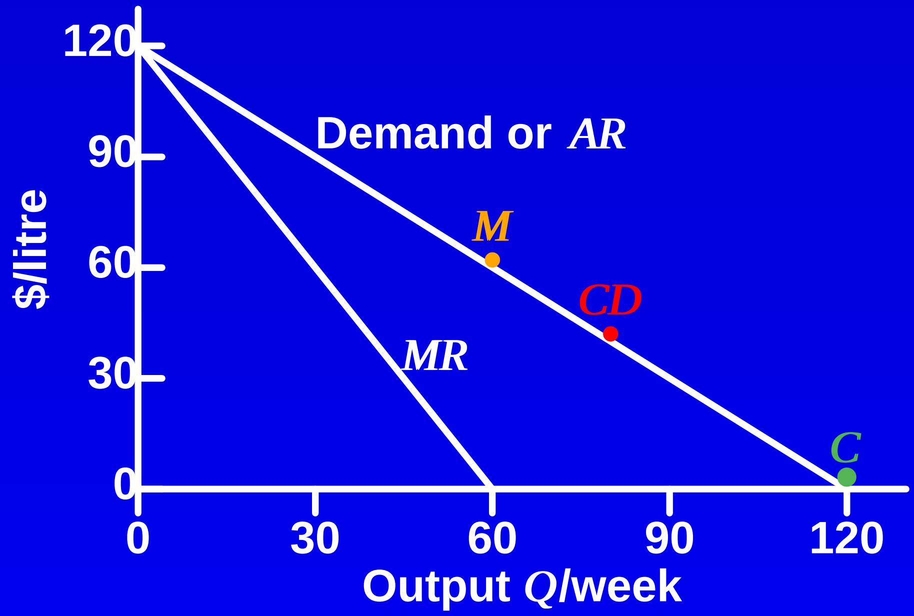

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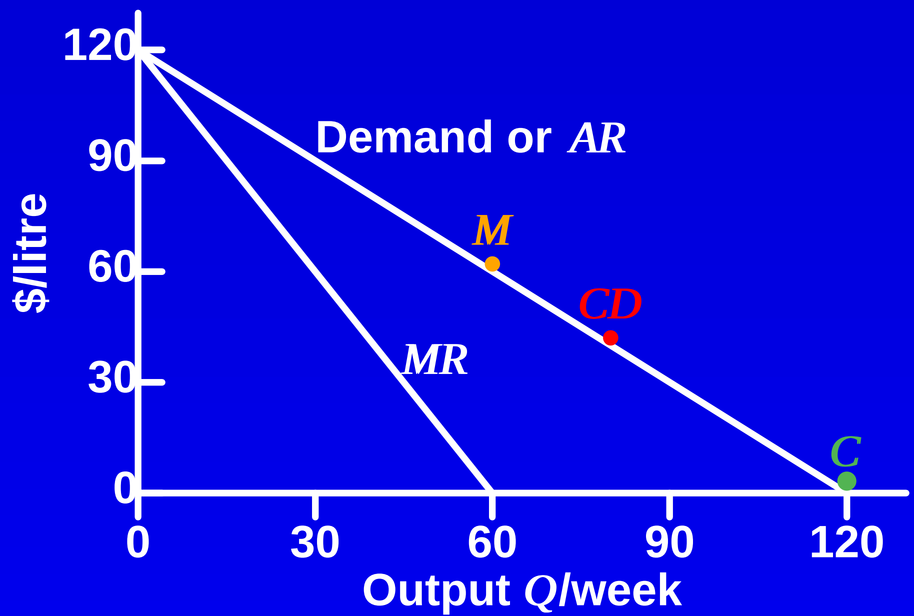

Competitive: P_C **= $0,** Q^C **= 120.**

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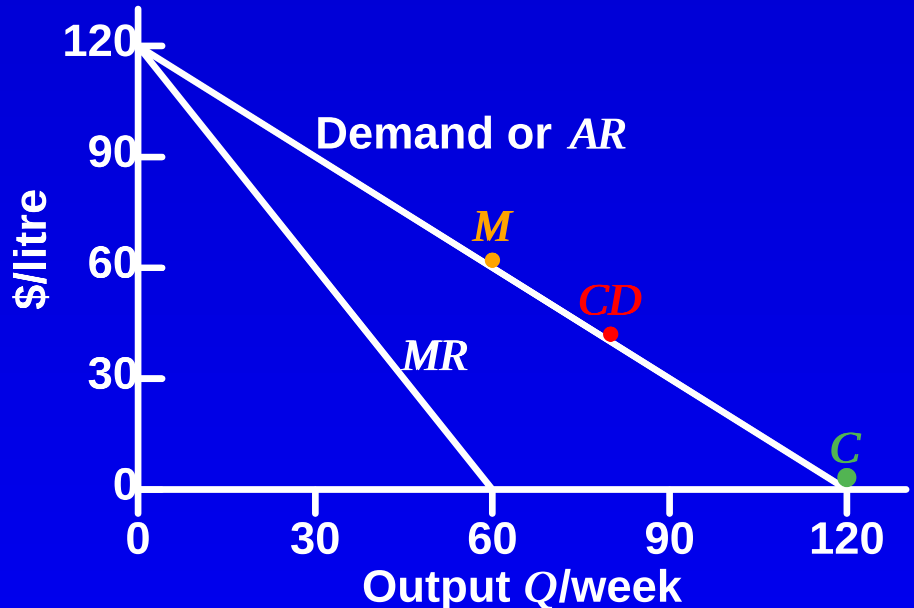

Competitive: P_C = \$0, Q^C = 120.

Monopoly: P^M = \$60, Q^M = 60.

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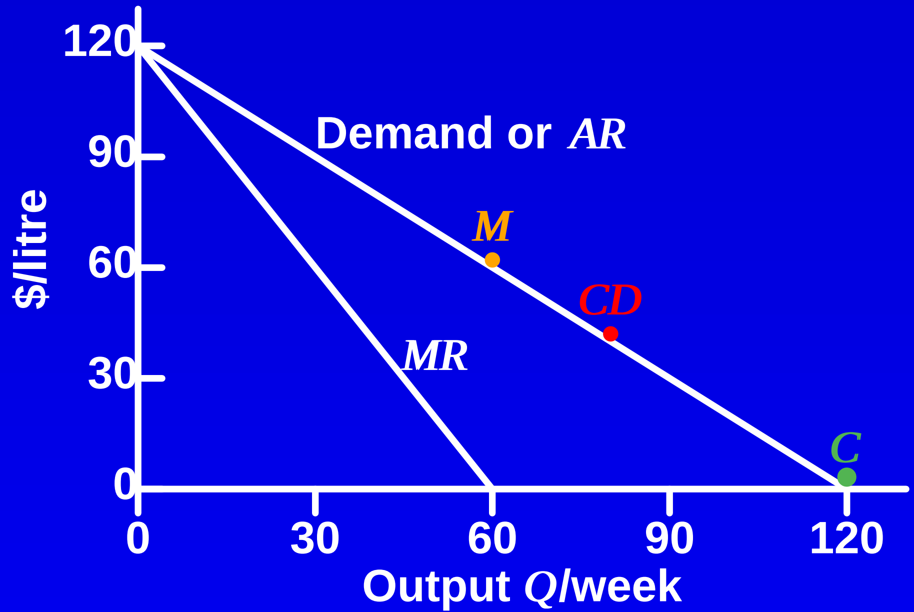

Competitive: P_C **= $0,** Q^C **= 120.**

Monopoly: P^M **= $60,** Q^M **= 60.**

Cournot duopoly: P^{CD} **= $40,** Q^{CD} **= 80.**

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How to split production and profits between them?

If equally, then each produces 30 litres and makes $1800/week.

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- **Produce 40 litres and make ... what?**
  Q **= 30 + 40 = 70 litres** $\rightarrow$ P **= \$50/litre.**
  Jack's profit = 40 $\times$ **\$50 = \$2000 > \$1800/week.**
  Looks good.

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  At 30 litres, Jill's profit falls to 30 $\times$ 50 = $1500/week.

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  At 30 litres, Jill's profit falls to $30 \times 50 =$ $1500/week.

But if Jill thinks like Jack, then $Q = 40 + 40 = 80 \rightarrow$ $P = \$40$, and the profit of each = $1600/week.

PAYOFF MATRIX 1

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		Jill 40	30
Jack	40	1600, 1600	2000, 1500
	30	1500, 2000	1800, 1800

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Jack	40	1600, 1600	2000, 1500
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Each player has two actions to choose from: produce 30 litres or produce 40 litres.

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Jack	40	1600, 1600	2000, 1500
Jack	30	1500, 2000	1800, 1800

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		40	**30**
Jack	**40**	**1600, 1600**	**2000, 1500**
	30	**1500, 2000**	**1800, 1800**

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Each player has two actions to choose from: produce 30 litres or produce 40 litres.

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		40	**30**
Jack	**40**	**1600, 1600**	**2000, 1500**
	30	**1500, 2000**	**1800, 1800**

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Each player has two actions to choose from: produce 30 litres or produce 40 litres.

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		Jill 40	30
Jack	40	1600, 1600	2000, 1500
	30	1500, 2000	1800, 1800

The payoff matrix (Jack, Jill).

What will Jack do? What will Jill do?

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But this is frustrating: if they could collude or cooperate, they'd make $1800 each, instead of $1600. What is best collectively is not attainable individually. This is an example of the *Prisoner's Dilemma*.

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$y^{Jack} = y^{Jill}$ = 40 litres is a *Nash Equilibrium*: a situation in which each actor chooses her best strategy, given that the others have chosen their best strategies.

PAYOFF MATRIX 2

		Jill 50	*Jill* 40
Jack	50	1000, 1000	1500, 1200
Jack	40	1200, 1500	1600, 1600

PAYOFF MATRIX 2

Jill

		50	40
Jack	50	1000, 1000	1500, 1200
	40	1200, 1500	1600, 1600

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		Jill 50	40
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PAYOFF MATRIX 2

		Jill 50	*Jill* 40
Jack	50	1000, 1000	1500, 1200
Jack	40	1200, 1500	1600, 1600

The Nash Equilibrium at quantities (40,40) (and *P* = $40/litre) is shown by the arrows: any cell with no arrows leaving and only arrows into it is a Nash Equilibrium,

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	40	1200, 1500	1600, 1600

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There may be one, several, or no Nash Equilibria.

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Jack	50	1000, 1000	1500, 1200
Jack	40	1200, 1500	1600, 1600

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This is not a Prisoner's Dilemma. Why?

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	40	1200, 1500	1600, 1600

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This is not a Prisoner’s Dilemma. Why? Because what is best individually is also best if they acted together.

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Their total profits ($3200/week) are less than monopolistic ($3600), but greater than competitive ($0).

A *Cournot duopoly* because the firms set the quantity, and the market (demand) determines the price; in a *Bertrand duopoly* the firms set the price and the market determines the quantity.

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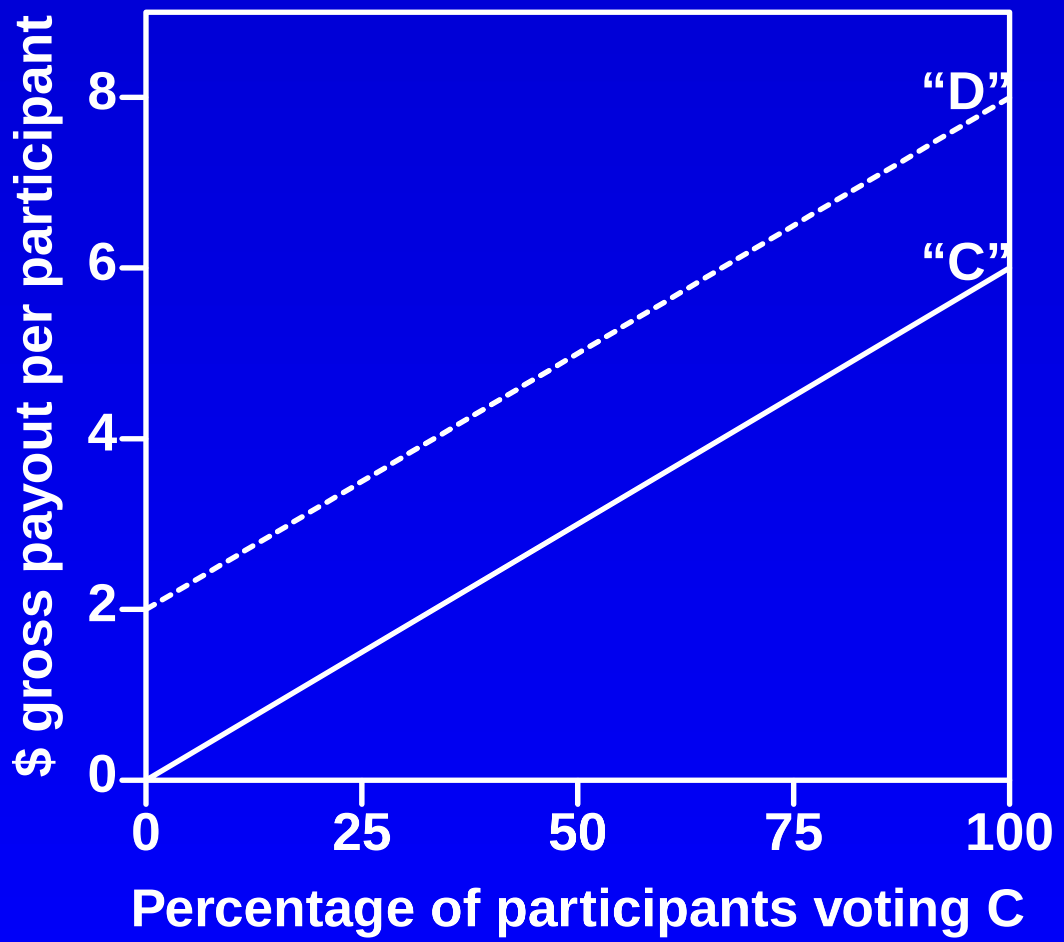
- ➢ **Or: You needn't play at all.**

SCHELLING'S GAME 2



Note: the game costs $4 to join.

SCHELLING'S GAME 3

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- **previous years?**

Dilemma: { coöperate for the common good *or*
defect for oneself

Public/private information

SCHELLING'S *n*-PERSON PD

Examples?

- — cooperative pricing v. price wars
- — tax compliance
- — individual negotiation
- — coal exports
- — market development
- — common property issues
- — others?

THE PRISONER'S DILEMMA

		Kelly Spill	*Kelly* Mum
Ned	Spill	8, 8	0, 20
Ned	Mum	20, 0	1, 1

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Years of prison (Ned, Kelly).

The choices: Spill the beans to the cops, or keep Mum.

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Nash Equilibrium = Spill, Spill, despite the longer sentences.

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Nash Equilibrium = Spill, Spill, despite the longer sentences.

See also the *Tragedy of the Commons* in the Marks on-line reading.

THE ADVERTISING PD

		B & H	
		Don't Advertise	Advertise
Philip Morris	Don't Advertise	$4bn, $4bn	$2bn, $5bn
	Advertise	$5bn, $2bn	$3bn, $3bn

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In a *repeated PD*, so long as the discount rate is not too high, repetition will support cooperation.

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FIRMS BEHAVING BADLY?

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Laws can hinder competition, as well as help it. Behaviour that seems to reduce competition may be legitimate.

Price-fixing

Resale price maintenance

Predatory pricing

Tying or bundling

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See *Strategic Game Theory for Managers* in Term 3.

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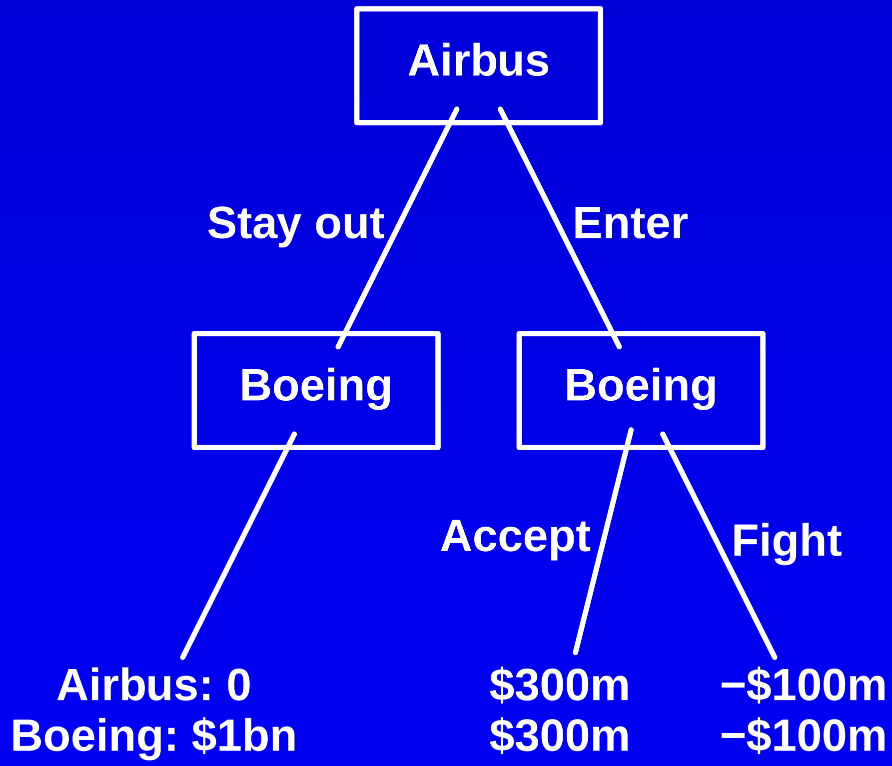
With peace, each firm will make a profit of $300 m. With a price war, each will lose $100 m.

A GAME TREE


Airbus
Stay out
Enter
Boeing
Boeing
Accept
Fight
Airbus: 0
Boeing: $1bn
$300m
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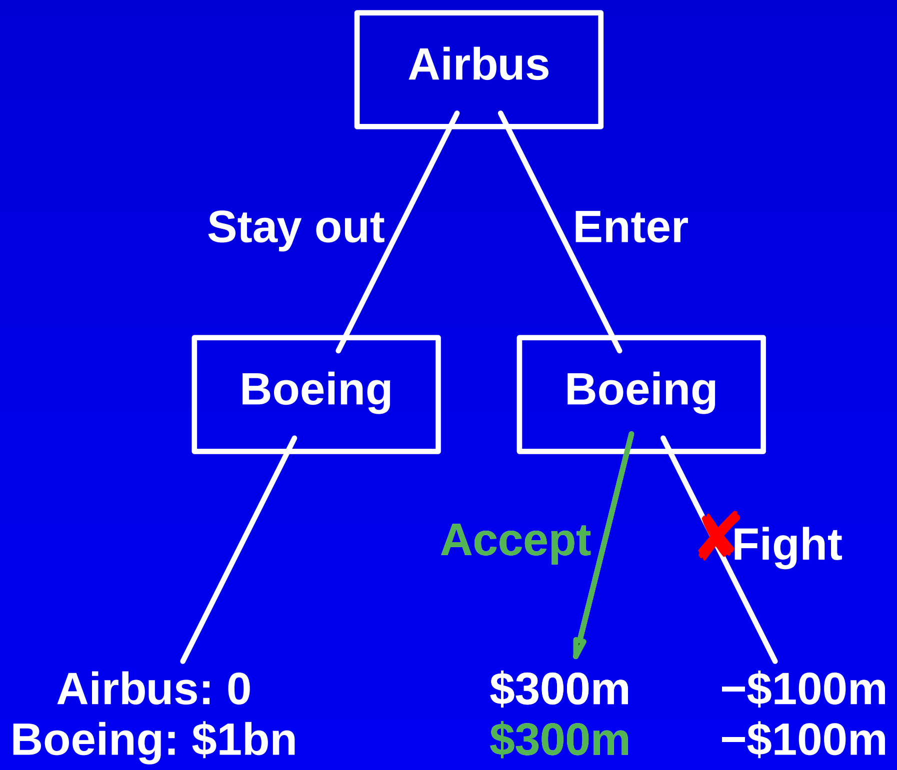
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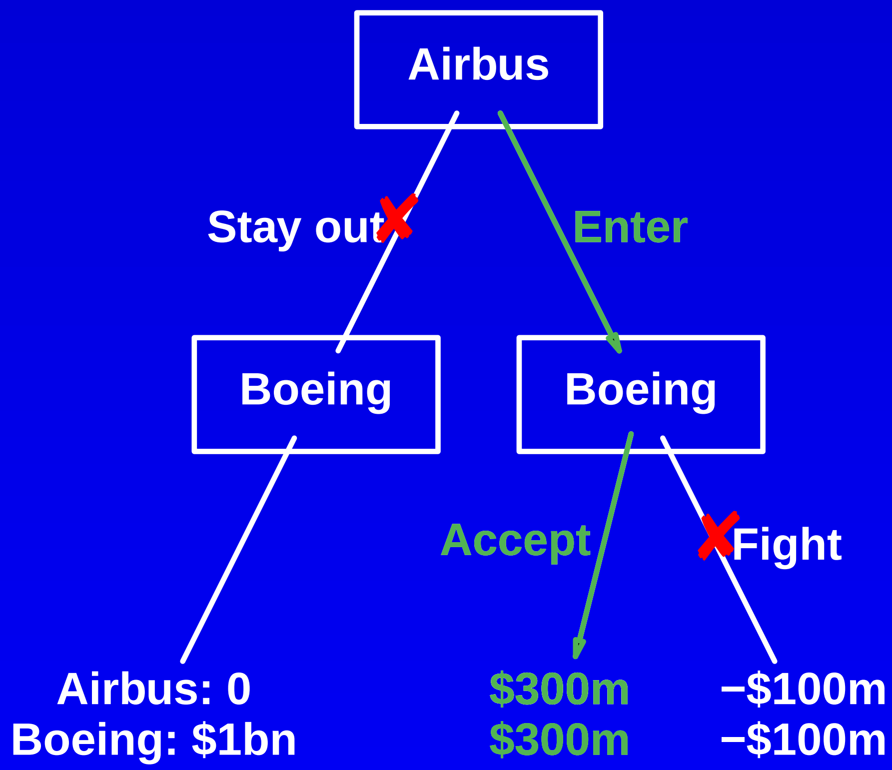
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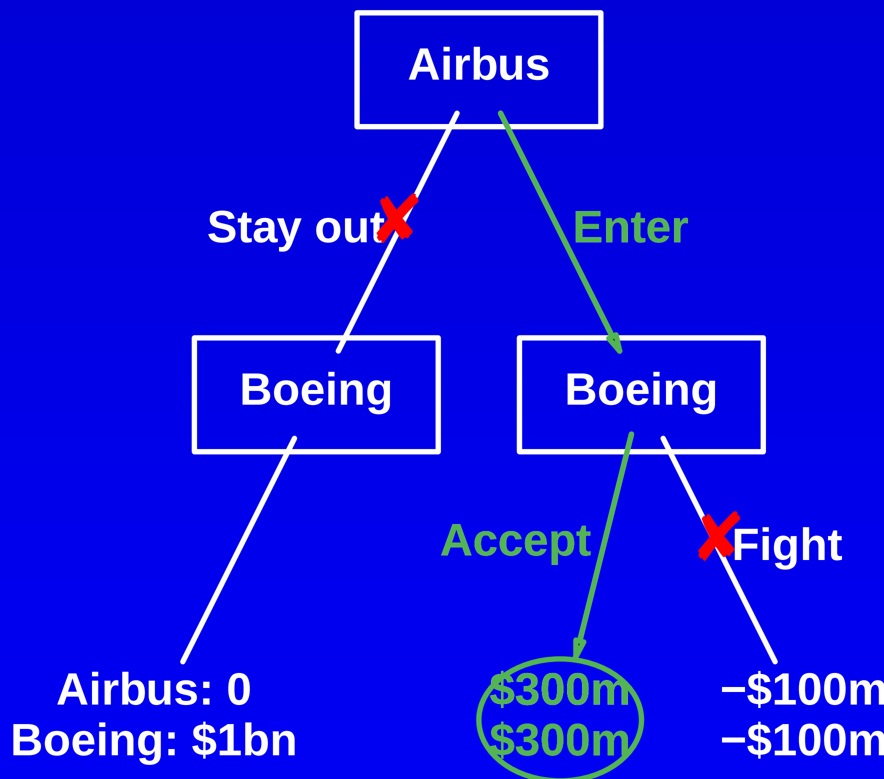

How should Boeing respond?

ROLLBACK

1. From the end (final payoffs), go up the tree to the first parent decision nodes.
2. Identify the best decision for the deciding player at each node.
3. “Prune” all branches from the decision node in 2. Put payoffs at new end = best decision’s payoffs
4. Do higher decision nodes remain? If “no”, then finish.
5. If “yes”, then go to step 1.
6. For each player, the collection of best decisions at each decision node of that player → best strategies of that player.

QUESTIONS

1. **Draw the tree for this game. Use *rollback* (or backwards induction) to find the equilibrium.**
2. **Why is Boeing unlikely to be happy about the equilibrium? What would it have preferred? Could it have made a credible threat to get Airbus to behave as it wanted?**
3. **What if Boeing had moved first? Would there still have been a credibility problem with Price War? Explain.**

SUMMARY

1. Oligopoly is a market structure between Perfect Competition and Monopoly, in which firms behave strategically.
2. In a Cournot duopoly the two sellers of a homogeneous product choose quantities, and the market demand determines the price.
3. Cooperation would lead to higher profits, but the logic of the once-off game is to cheat on agreed quotas $\rightarrow$ lower profits.
4. Use Payoff Matrices for a simultaneous-move game and Game Trees for a sequential-move game.

5. **Use arrows in the Payoff Matrix to determine whether and where the Nash Equilibrium (in which each player does the best for herself, given that the other players are doing the best for themelves) is.**
6. **A dominant strategy is an action that is best for you, no matter what the other player does.**
7. **The Prisoner’s Dilemma occurs when individual choices lead to a lower payoff than cooperative actions would.**
8. **But repetition can overcome the once-off logic and result in cooperation.**

9. **Not all interactions have a single N.E. — some have none, some have several.**
10. **Can have 3×3 or larger payoff matrices.**
11. **Some market behaviours are illegal.**
12. **Rollback: look forward and reason back — to find the equilibrium of the game.**

APPENDIX: CARTEL v. OLIGOPOLY

The cartel chooses $Q = y_1 + y_2$ **to maximise its profit** $\pi = \pi(y_1, y_2)$**.**

When production shares are equal $(y_1 = y_2)$**, then calculus (**$\frac{\partial \pi}{\partial Q} = 0$**) reveals that in this case with** $P = 120 - Q$ **and zero costs** $y_1^* = y_2^* = 30$**.**

Each oligopolist chooses its output y_1 **(or** y_2**) to maximise its profit** $\pi_1 = \pi_1(y_1, y_2)$**, but it has no control over the other firm's output** y_2**.**

Since the problem is symmetrical, assume $y_1 = y_2$**, and calculus (**$\frac{\partial \pi_1}{\partial y_1} = 0$**) reveals that** $y_1^* = y_2^* = 40$**.**