Seminar 4 — Pricing and Game Theory

International Business and Finance, Warwick Summer School 2026

Dr. Ernil Sabaj

Companion to the Day 4 lecture — ANSWER KEY

Scope. Lecture material only: how firms actually set prices; price discrimination (first, second, third degree; behavioural; intertemporal; dynamic/algorithmic); pricing over the product lifecycle; transfer pricing; and game theory — dominant strategies, the prisoner's dilemma, sequential games and subgame-perfect equilibrium (backward induction), repeated games and tit-for-tat, and commitment vs flexibility.

Part 1. Multiple choice (10 questions)

Choose the single best answer.

1. Charging **each customer their maximum willingness to pay** is:

(a) first-degree (perfect) price discrimination
(b) second-degree
(c) third-degree
(d) not price discrimination

Answer. (a). First-degree extracts the entire consumer surplus; it is the theoretical benchmark, approximated by personalised pricing.

2. Offering **quantity discounts or versions** so customers self-select is:

(a) first-degree
(b) second-degree
(c) third-degree
(d) transfer pricing

Answer. (b). Second-degree: price varies with quantity/version chosen; the firm need not observe the customer's type — they reveal it.

3. Charging **different groups** (students, regions, seniors) different prices is:

(a) first-degree
(b) second-degree
(c) third-degree
(d) bundling

Answer. (c). Third-degree: prices differ by an observable group with different elasticities; requires preventing arbitrage between groups.

4. **Intertemporal** price discrimination occurs when firms:

(a) give bulk discounts

(b) set prices that vary over *time* to sort customers by willingness to pay (e.g. high launch price, later markdowns)

(c) charge every group the same

(d) personalise by individual data

Answer. (b). Sorting over time — early adopters pay more; patient buyers wait. Skimming is its lifecycle cousin.

5. In a one-shot game, a strategy that is best **regardless of what the rival does** is a:

(a) mixed strategy

(b) dominant strategy

(c) tit-for-tat

(d) focal point

Answer. (b). A dominant strategy is optimal against all rival choices; both playing dominant strategies can still be jointly bad (the dilemma).

6. The **prisoner's dilemma** captures situations where:

(a) cooperation is individually rational

(b) individually rational choices lead to a jointly worse outcome

(c) there is no equilibrium

(d) players always cooperate

Answer. (b). Each defects for private gain; both are worse off than under mutual cooperation — the logic of price wars.

7. In a **sequential** game solved by **backward induction**, the equilibrium concept is:

(a) Nash equilibrium in dominant strategies

(b) subgame-perfect equilibrium (SPE)

(c) mixed-strategy equilibrium

(d) constant-sum outcome

Answer. (b). Backward induction from the last mover yields the SPE, ruling out non-credible threats.

8. In **repeated** games, cooperation can be sustained by strategies such as **tit-for-tat** because:

(a) the game ends immediately

(b) the threat of future punishment makes defection unprofitable when the future matters enough

(c) there is only one player

(d) prices are fixed by law

Answer. (b). A credible "I cut if you cut" punishment can make cooperation self-enforcing if players value the future sufficiently (high discount factor).

9. Setting a **high launch price** for early adopters and lowering it later is **price skimming**, typically used in the product lifecycle's:

(a) decline stage

(b) introduction/growth stage

(c) maturity only

(d) never

Answer. (b). Introduction/early growth: few rivals, less elastic early demand; prices fall as competition and standardisation arrive in maturity.

10. **Transfer pricing** — the internal price on goods/services moved between units of the same MNE — matters for international business mainly because it:

(a) sets consumer prices

(b) shifts reported profit across tax jurisdictions and is a capital-structure/tax decision

(c) is set by the WTO

(d) only affects marketing

Answer. (b). Transfer prices allocate profit between countries, with tax and regulatory consequences — hence arm's-length rules.

Part 2. Discussion questions (10)

Short, open questions for the table; talking points follow each.

1. **Why prices are sticky.** Survey evidence (e.g. Bank of England) shows firms change prices infrequently and mostly cost-plus. Why, and what does this imply for how competition really works?

Answer. Firms report reviewing prices only a few times a year and setting them by marking up costs, because of *menu costs* (the effort/systems to re-price), *customer relationships* (frequent changes annoy buyers and invite retaliation), *contracts* that fix prices for a period, and *coordination fears* (moving first in a price war). Implication: real competition is less the smooth marginal-cost pricing of textbooks and more a strategic game of infrequent, watched moves — which is exactly why game theory, not just supply-and-demand, is needed to understand pricing.

2. **Degrees of price discrimination.** Distinguish first-, second- and third-degree price discrimination with an example each, and state what a firm needs to make discrimination work.

Answer. *First-degree*: charge each buyer their maximum willingness to pay (bespoke negotiation, some auctions) — rare because it needs perfect information. *Second-degree*: price varies by *quantity or version* and buyers self-select (bulk discounts, product tiers, damaged-goods versions). *Third-degree*: different *groups* pay different prices (student/senior fares, geographic pricing). To sustain any of them a firm needs: some market power, a way to *sort* buyers by willingness to pay, and — crucially — the ability to *prevent arbitrage* (resale from the cheap segment to the dear one).

3. **Intertemporal price discrimination.** Explain pricing the same product differently over time (new releases, then discounts). What can undermine it?

Answer. Firms launch high to skim impatient, high-value buyers, then cut price to reach the patient, price-sensitive ones — sorting buyers by *willingness to wait* (hardbacks then paperbacks; new-release films; new gadgets). It is undermined by *rational expectations*: if buyers learn the discount is coming, they wait, collapsing the early high-price sales — the durable-goods/Coase problem. Firms counter with credible commitment: limited editions, "no discount" reputations, refreshes that reset the cycle, or leasing rather than selling.

4. **Transfer pricing.** What is the transfer price, why does it matter for tax as well as internal incentives, and what disciplines it?

   Answer. The transfer price is the internal price one unit of an MNE charges another for goods, services or IP. It matters twice: for *incentives/performance* (it allocates profit across divisions and shapes their decisions) and for *tax* (it shifts reported profit between jurisdictions with different rates). Left unchecked, firms set prices to book profit in low-tax locations. The discipline is the *arm's-length principle* — the price must match what unrelated parties would charge — policed by tax authorities and OECD rules; deviations invite adjustments, penalties and double taxation. So the transfer price sits between a genuine management tool and a tax-avoidance lever.

5. **The pricing prisoner's dilemma.** Why do two rational rivals often end up in a price war that hurts both, and how do real firms escape it?

   Answer. If undercutting is each firm's best response *whatever* the rival does (a dominant strategy), both cut, reaching a low-price Nash equilibrium that is worse for both than jointly holding prices high — the prisoner's dilemma. Firms escape not by promising (talk is cheap) but by changing the game: *repetition* with credible punishment (tit-for-tat), price-matching guarantees that remove the gain from undercutting, product *differentiation* that softens the substitution, or reading price leadership. Escape requires making cooperation individually rational, not merely collectively desirable.

6. **Repeated games and tacit collusion.** How does repetition sustain cooperation without an illegal agreement, and what conditions make it break down?

   Answer. In a repeated game, a firm will hold price high if the discounted future profit from continued cooperation exceeds the one-off gain from undercutting minus the future punishment (a "grim" or tit-for-tat trigger). No communication is needed — the *threat of future price war* enforces it, which is why stable oligopolies can look collusive while never meeting. It breaks down when: the future is discounted heavily (high interest rates, firms in trouble), demand is volatile so cheating is hard to detect, there are many firms or asymmetric costs, or entry/innovation disrupts the pattern. Detection lags and impatience are the enemies of tacit cooperation.

7. **Commitment and credible threats.** Why can *limiting your own options* make you better off? Give a business example of a credible commitment.

   Answer. A threat or promise only changes a rival's behaviour if the rival believes you will carry it out; an option you would *not* rationally use after the fact is pruned by backward induction (a non-credible threat). By making an action *irreversible* — sinking cost — you change your own future best response and thus the rival's calculation. Examples: building excess capacity so a price war is credibly cheap for you (deterring entry), signing take-or-pay supply contracts, or publicly committing to a most-favoured-customer clause. The paradox is that *removing* your flexibility can be strategically valuable because it makes your threat believable.

8. **Behavioural and dynamic pricing.** Algorithmic/surge pricing and personalised offers exploit behavioural patterns. What are the efficiency and fairness tensions, and why does backlash arise?

   Answer. Dynamic pricing can improve efficiency — clearing markets in real time (ride-hailing surge), filling perishable capacity (airlines, hotels) — and approaches richer price discrimination using behavioural data (defaults, framing, urgency cues). Tensions: it edges toward first-degree discrimination that transfers surplus from consumers to firms, can feel *unfair* (same seat, different price; higher prices in emergencies), and risks discrimination or manipulation. Backlash and regulation arise when pricing is opaque or exploits vulnerability, because perceived fairness — not just efficiency — governs whether customers accept it; firms trade short-run yield against long-run trust and legal risk.

9. **First-mover advantage.** When is moving first a genuine advantage, and when is it a disadvantage? Relate to commitment and entry deterrence.

   Answer. Moving first helps when early commitment is *credible and valuable*: pre-empting scarce assets or locations, setting a standard, building switching costs and an installed base, or sinking capacity that deters entry (the commitment logic). It hurts when the mover bears high pioneering costs while *followers free-ride* on proven demand, technology and consumer education, or when the market/technology is still uncertain and flexibility beats commitment. So first-mover advantage is conditional — it pays when the first move locks in an advantage rivals cannot cheaply replicate, and backfires when being second is cheaper and better informed.

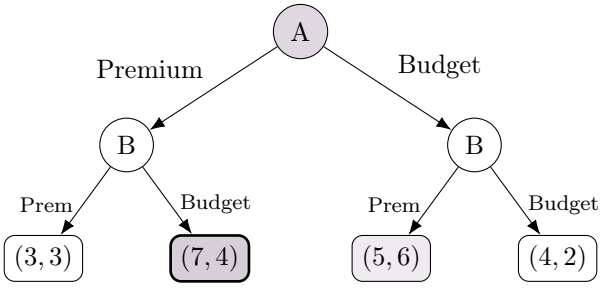
10. **Coca-Cola vs Pepsi.** A stable duopoly that avoids ruinous price war. What sustains the cooperation, using the game-theory tools of the week?

    Answer. The two have played a *repeated* game for over a century, so the threat of mutual price war makes holding prices individually rational (tacit cooperation without agreement). Heavy *differentiation* through branding softens substitution, so competition is diverted into advertising and product variety rather than price. Both have deep pockets and symmetric costs, making any punishment credible and detection easy, and both know a price war would destroy the category's profitability. It is a textbook case of escaping the pricing prisoner's dilemma through repetition, differentiation and credible mutual deterrence — reaction functions that respond to advertising, not price cuts.

Part 3. Analytical questions (5)

Structured, exam-style problems with diagrams and calculations. Full model answers follow.

1. **A sequential entry game (game tree).** Firm A chooses its positioning first — *Premium* or *Budget* — then Firm B, observing A, chooses its own. Payoffs are (π_A, π_B). Solve by backward induction, state the subgame-perfect equilibrium, and explain the first-mover advantage.



   Answer. Solve from the bottom (B's choice, given A):

   - If A played *Premium*, B compares Premium ($\pi_B = 3$) vs Budget ($\pi_B = 4$) $\Rightarrow$ B plays **Budget**, outcome $(7, 4)$.
   - If A played *Budget*, B compares Premium ($\pi_B = 6$) vs Budget ($\pi_B = 2$) $\Rightarrow$ B plays **Premium**, outcome $(5, 6)$.

   Now A looks ahead: Premium leads to $\pi_A = 7$, Budget leads to $\pi_A = 5$. A therefore plays **Premium**.

   Subgame-perfect equilibrium: A = Premium; B = Budget if A is Premium, Premium if A is Budget. **Outcome** $= (7, 4)$ (shaded, dark).

   First-mover advantage: by committing to Premium first, A forces B into the budget slot and captures its best payoff (7). If B could move first it would seize the better position and the payoffs would flip in B's favour — so the advantage comes from *credible commitment*, and only because B observes A's move before choosing. The lighter-shaded $(5, 6)$ is B's best response off the equilibrium path (if A had chosen Budget); it is what makes A's forward reasoning work.

2. **Pricing prisoner's dilemma (payoff matrix).** Two firms simultaneously set a *High* or *Low* price. Profits (π_1, π_2):

		Firm 2	
		High	Low
Firm 1	High	$(10, 10)$	$(4, 12)$
	Low	$(12, 4)$	$(6, 6)$

(i) Find each firm's dominant strategy. (ii) State the Nash equilibrium and why it is inefficient. (iii) How could repetition change the outcome?

Answer. (i) *Firm 1*: if 2 plays High, 1 gets 12 (Low) vs 10 (High) $\Rightarrow$ Low; if 2 plays Low, 1 gets 6 (Low) vs 4 (High) $\Rightarrow$ Low. **Low is dominant** for Firm 1; by symmetry, for Firm 2 too. (ii) The unique Nash equilibrium is **(Low, Low)** $= (6, 6)$. It is *inefficient* because both firms would earn more at (High, High) $= (10, 10)$ — individual incentives to undercut destroy the jointly better outcome (the essence of a price war). (iii) In a *repeated* game, each firm can support (High, High) with a trigger strategy — cooperate while the rival does, revert to Low forever (or tit-for-tat) if it cheats. Cooperation holds if the discounted future loss from triggering the war exceeds the one-shot gain from undercutting ($12 - 10 = 2$ today vs a permanent drop from 10 to 6 later). So patient firms who can detect cheating can sustain high prices without any explicit — and illegal — agreement.

3. **Third-degree price discrimination (a calculation).** A firm with marginal cost £10 sells in two separable markets with constant demand elasticities $\varepsilon_A = -2$ and $\varepsilon_B = -4$. Using the inverse-elasticity (Lerner) rule, compute the profit-maximising price in each market, and state the conditions the strategy requires.

Answer. The Lerner rule: $\dfrac{P - MC}{P} = \dfrac{1}{|\varepsilon|} \;\Rightarrow\; P = MC \cdot \dfrac{|\varepsilon|}{|\varepsilon| - 1}$.

Market A ($|\varepsilon| = 2$): $P_A = 10 \times \dfrac{2}{2-1} = 10 \times 2 = \mathbf{£20}$ (margin 50%).

Market B ($|\varepsilon| = 4$): $P_B = 10 \times \dfrac{4}{4-1} = 10 \times \dfrac{4}{3} \approx \mathbf{£13.33}$ (margin 25%).

The *less elastic* market (A — customers less price-sensitive) bears the *higher* price; the more elastic market gets the lower price. This is optimal only if the firm can (i) *separate* the two groups, (ii) *identify* who belongs to which, and (iii) *prevent arbitrage* — if buyers in A could purchase at B's price and resell, the two prices would collapse to one. Geographic borders, versioning, or eligibility rules (student/senior) are the usual arbitrage barriers.

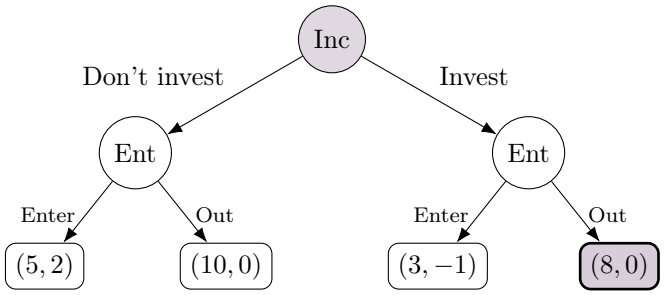
4. **Transfer pricing and tax (a calculation).** An MNE makes a component in country L (corporate tax 10%) at a cost of £40 and its subsidiary sells the finished good in country H (tax 30%) for £100. The internal *transfer price* TP splits the £60 profit between the two units. (i) Write total tax as a function of TP. (ii) Which direction minimises tax, and how much is saved by moving TP from £50 to the arm's-length ceiling of £70? (iii) What limits the shifting?

Answer. (i) L's profit $= TP - 40$ (taxed at 10%); H's profit $= 100 - TP$ (taxed at 30%). Total tax $T(TP) = 0.10(TP - 40) + 0.30(100 - TP) = 0.10\,TP - 4 + 30 - 0.30\,TP = \mathbf{26 - 0.20\,TP}$.

(ii) T *falls* as TP rises, so the firm shifts profit to low-tax L by charging a *high* transfer price. Each extra £1 of TP saves £0.20 in tax — exactly the rate gap (30% − 10%). Moving TP from £50 to £70 (shifting £20 of profit from H to L) saves $0.20 \times 20 = \mathbf{£4}$: tax falls from $26 - 0.20(50) = £16$ to $26 - 0.20(70) = £12$, so after-tax profit rises from £44 to £48 (effective tax 26.7% $\to$ 20%).

(iii) The **arm's-length principle** caps TP at a defensible market-comparable price; tax authorities (and OECD transfer-pricing rules) challenge prices outside the comparable range, imposing adjustments, penalties and the risk of double taxation. So the profitable shift is bounded by what the firm can *justify* as an arm's-length price, not by the rate gap alone.

5. **Entry deterrence through commitment (game tree).** An incumbent decides whether to sink cost in extra capacity (*Invest* or *Not*); then a potential entrant decides *Enter* or *Stay out*. Payoffs $(\pi_{\text{Inc}}, \pi_{\text{Ent}})$. Solve, and explain why irreversibility matters.



Answer. Backward induction on the entrant:

- After *Don't invest*: entrant compares Enter (2) vs Out (0) ⇒ **Enter**, outcome $(5, 2)$.
- After *Invest*: the sunk capacity means a post-entry price war, so the entrant compares Enter (-1) vs Out (0) ⇒ **Stay out**, outcome $(8, 0)$.

The incumbent compares 5 (don't invest, entry happens) with 8 (invest, entry deterred) and therefore **Invests**. **SPE:** Invest → entrant Stays out → $(8, 0)$ (shaded).

Why irreversibility matters: the threat "I will fight if you enter" is only credible because the capacity is *already sunk* — fighting is now the incumbent's rational post-entry choice. Without the irreversible investment, the same threat is empty: after entry the incumbent would prefer to accommodate, backward induction prunes the threat, and the entrant comes in. Commitment converts a non-credible threat into a credible one, and the incumbent pays 2 (10 monopoly → 8) to keep the entrant out — worth it versus the 5 it would earn once entry occurs.

Part 4. Case studies

Case A — OPEC+: the cartel as a repeated prisoner's dilemma

OPEC and its partners ("**OPEC+**", including Russia) coordinate crude-oil output to influence prices. The arrangement has the structure of a **prisoner's dilemma**: the group is collectively better off restraining output to keep prices high, but each member is individually tempted to pump a little more and sell into the high price others are supporting. If everyone yields, output floods the market and prices collapse. Because members interact **repeatedly**, cooperation can be sustained: quotas are agreed, output is monitored, and cheating is deterred by the threat that others retaliate by opening their taps (a price war). In early **2020** cooperation broke down — a Saudi–Russia disagreement triggered a price war, each raising output, and (with pandemic demand collapsing) prices fell to historic lows, briefly negative in one US futures contract — before members reversed course with record coordinated cuts.

Questions.

1. Set out the **prisoner's dilemma** facing two representative producers ("restrain" vs "overproduce"). Why is mutual overproduction the one-shot equilibrium, and why is it collectively bad?

   Answer. Whatever the rival does, a producer earns more by overproducing (sell extra barrels into a high price, or avoid being the only one cutting) — so "overproduce" is a dominant strategy. Both overproducing is the one-shot Nash equilibrium, yet it floods the market and crashes the price: each acted rationally, both ended up worse off than under mutual restraint. That gap between individual and collective rationality is the dilemma.

2. Explain how **repetition** lets OPEC+ sustain cooperation the one-shot game cannot. What role do monitoring and the price-war threat play?

   Answer. Repetition allows trigger/tit-for-tat strategies: "I restrain while you do; if you cheat, I open my taps and we both suffer." If members value future revenue enough (high discount factor), the discounted loss from punishment exceeds the one-off gain from cheating, so restraint is self-enforcing. Monitoring makes cheating detectable (else punishment cannot be triggered); the credible price-war threat is the enforcement mechanism. Cooperation is an equilibrium of the *repeated*, not the one-shot, game.

3. Interpret the **2020** breakdown as a failure of the repeated-game conditions. Which condition(s) failed, and how did the outcome resemble the dilemma's bad equilibrium?

   Answer. The price war is the punishment/breakdown phase: a dispute over burden-sharing, plus collapsing demand lowering the value of future cooperation, cut the incentive to restrain — so a member defected and others retaliated, i.e. mutual overproduction and crashing prices, exactly the dilemma's bad equilibrium. It shows cooperation is fragile: when the future is discounted heavily or the split is disputed, the punishment threat is triggered and the group falls to the non-cooperative outcome until it re-coordinates.

Case B — One pill, many prices: pharmaceuticals across borders

The same patented medicine often sells at very different prices across countries — high in the United States, lower in much of Europe, and lower still in many emerging markets. This is textbook **third-degree price discrimination** by national market, reflecting different willingness to pay, incomes and regulation (many countries negotiate or cap prices; the US historically does less). Firms defend it as funding the large fixed cost of R&D while enabling access in poorer markets; critics call the high prices unfair. The structure survives only if the markets stay separate: **parallel trade** (buying where the drug is cheap and reselling where it is dear) is the arbitrage threat, which firms and regulators limit through supply controls, differentiated packaging, contracts and legal restrictions on reimportation.

Questions.

1. Identify the type of price discrimination and the single condition that makes it sustainable across countries.

   Answer. **Third-degree** price discrimination — different prices to different national groups by elasticity and regulation. It is sustainable only if **arbitrage between markets is prevented**: parallel imports would otherwise flow from cheap to dear markets and collapse the price gap. Market separation is the necessary condition.

2. Give the firm's welfare/access argument for cross-country price discrimination, and the main criticism.

   Answer. For: it lets the firm serve low-income markets at low prices it could not profitably charge under one global price, expanding access, while high-price markets fund the fixed R&D cost — total output and access can rise. Against: it transfers surplus from high-price consumers to the firm, can look like gouging (US prices), and access gains depend on the firm choosing to serve poor markets. The welfare verdict hinges on whether output/access actually rises.

3. Explain how **parallel trade** works and one mechanism used to limit it — and connect this to why arbitrage is the enemy of third-degree discrimination.

   Answer. Parallel trade: buy where the drug is cheap, ship it to where it is dear, undercutting the high price — arbitrage equalises prices and destroys the segmentation. Firms/regulators limit it via supply quotas to low-price markets, differentiated packaging or formulations, territorial contracts, and legal barriers on reimportation. Third-degree discrimination requires *separable* markets; anything

that lets goods flow between them undermines it — the same "arbitrage police" logic as the lecture's world-scale pricing.

Note. Case adapted from the instructor's seminar handouts and public reporting on OPEC+; items follow the Warwick Summer School written-exam format. Answer key — set `\answersfalse` for the student sheet.