EPBM-32 - CORE BUSINESS SKILLS - THE MASTER MERGE

Operational Excellence

The complete module in one document - all five sessions, 204 practice MCQs with answer keys, and the exam cheat codes

ABOUT THIS DOCUMENT

This is the master merge of the Operational Excellence module of EPBM-32: Session 1 (campus, Prof. Peeyush Mehta), Sessions 2-3 (live online, Prof. Balram Avittathur) and Sessions 4-5 (live online, Prof. Peeyush Mehta), compiled from the live transcripts and the professors' decks. It is written for a reader with zero prior background - every concept enters through a story or an everyday Indian business before any framework or formula appears. Each session ends with its own MCQ drill; the document closes with a mixed Grand Bank and a cheat-code section holding every formula, one-liner and classic trap. Read it start to finish once like a story; after that, it works as a lifetime reference and a night-before-the-exam weapon.

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01 HOW TO READ THIS DOCUMENT

This document assumes nothing. If you have never studied operations, an MBA, or even commerce, you can still read it cover to cover - every idea walks in through a kirana store, a chai stall, an airline queue or a delivery scooter before it wears its formal name. If you have twenty years of industry experience, the same pages work as a sharp consolidation: the frameworks, the numbers and the traps are all here, in the exact vocabulary our professors will use in the paper.

The three-pass method

Pass 1 - the story pass (one sitting, about 2-3 hours). Read the five sessions straight through like a book. Do not memorise anything; just follow the narrative - why Intel stumbled, why DMart wins, why your milk never runs out. The module is one continuous argument and it lands best in sequence.

Pass 2 - the framework pass. Go back through only the tables, the boxes and the worked numericals (collate-and-staple, the dumpers, the airport, EOQ, the newsvendor, the pooling formula, the queue formula). Redo each calculation once with your own pen. This pass builds the exam muscle.

Pass 3 - the drill pass. Attempt each session's MCQ set and then the Grand Bank at the end, without looking at the answers first. Every answer line tells you in one sentence why - and which trap the wrong options were laying. Finish with the cheat-code section on the morning of the exam.

What the boxes mean

KEY INSIGHT
The one idea a section exists to deliver. If you remember nothing else from the page, remember this.

MAKING IT REAL
The same idea retold through a business anyone can picture - a sweet shop, a tiffin service, a paowala. If a concept ever feels abstract, this box is the antidote.

EXAM TIP
Directly examinable material: formulas to memorise, question patterns the professors signalled in class, and ready-made answer structures.

CONCEPT TRAP
The classic wrong answer - the flip the paper loves to test. Read these twice; they are where marks are lost.

Words spoken by the professors, kept verbatim because they compress a whole lecture into a line.
IN CLASS

A note on depth

Nothing taught in class has been dropped. This master merge carries every framework, formula, worked number, named example, classroom exchange, quote and after-class exchange from all five sessions - the full knowledge of the module - with only the language simplified and the storytelling smoothed for reading speed. The five standalone session notes remain available, but everything in them lives here too; this is the one document you carry into the exam week - and, honestly, into every operations review meeting for the rest of your career.

02 THE MODULE'S STORY IN ONE PAGE

Every business on earth does the same thing: it takes an input, passes it through a process, and produces an output that somebody pays for. Operations is the discipline of designing and running that middle box well. For thirty years the world treated it as back-office plumbing whose only job was to be cheap. Then the shocks arrived - 2008, the pandemic, chip shortages, tariff wars - and every board discovered that the plumbing was the building. That is the story this module tells, in five acts.

Session	The big question	The crown jewels
1 - Strategy (Prof. Mehta, campus)	Where do operations decisions come from?	The strategy cascade; IndiGo decoded; the benchmarking curve; V = C x (A + P); why process moats (Zara, Toyota) outlast product moats (Apple, Nokia)
2 - Process (Prof. Avittathur)	How do you read any operation as a process?	Efficiency vs effectiveness; Lemon Tree; five process types; cycle time, bottleneck, Little's Law; the dumper and airport assignments
3 - Inventory (Prof. Avittathur)	How much to make, and when?	MTS vs MTO; the tyranny of utilisation; ABC analysis; EOQ; the newsvendor and the critical ratio; China's 100 days of oil
4 - Supply chain strategy (Prof. Mehta)	What to keep in-house, what variety to promise?	Intel vs Boeing (opposite blunders); the DMart flywheel; the product-process matrix; flexibility and the risk-pooling formula
5 - The finale (Prof. Mehta)	How do the greats actually play these levers?	Amazon un-pools, Netflix pools, FedEx re-pools; IndiGo's December; cognition as a variable cost; lean as philosophy; L = rho/(1-rho)

THE ONE THREAD THAT RUNS THROUGH ALL FIVE SESSIONS

Every operations choice must take its mandate from the business strategy - the answer to 'on what basis do we compete?'. Firms die not from choosing cost or speed or variety, but from running an operations design that contradicts the promise they made to the customer. Intel, Boeing, GM and Southwest's worst week are all the same failure; Zara, Toyota, DMart and Amazon are all the same success.

MAKING IT REAL

A dosa cart that promises 'hot, fast and Rs. 40' needs one batter, one tawa rhythm and no menu experiments. A fine-dining place that promises 'anything you dream of' needs a big flexible kitchen and must charge for it. Neither is wrong. The tragedy is the cart that adds a 40-item menu, or the fine-dining kitchen that tries to win on price. This module is five sessions of learning to spot that tragedy - and to design its opposite.

SESSION 1 OF 5 - Prof. Peeyush Mehta - Campus Immersion, 18 April 2026

Operations in the Boardroom: Strategy, Frontiers and Moats

Why operations stopped being back-office plumbing, how every operations choice flows down from the firm's differentiation, and why advantages built into the process (Zara, Toyota) outlast advantages built into the product (Apple, Nokia).

01 THE DECADE THAT DRAGGED OPERATIONS UPSTAIRS

For the last couple of years the people who run supply chains have not had a quiet moment - the world of supply chain, as Prof. Mehta put it, has been 'dancing to Trump's tune'. But the deeper truth is that operations has stopped being a back-office, field-level concern and become something CEOs and boards lose sleep over. Line up the big shocks of the last twenty-five years: the dot-com bust (~2000), the 2008 global financial crisis (financially triggered), COVID-19 in 2020 (biologically triggered - the shock that pushed resilience into every boardroom), and the tariff era that followed (politically triggered, and far more random than the others). Each one landed first and hardest on operations - the function whose whole job is to keep supply and demand in balance.

The professor's favourite dial for reading an economy's health is the retailers' **inventory-to-sales ratio**. Sales stands for demand; inventory stands for the supply decisions firms already made - and operations, in one line, is the business of matching the two. When a shock hits, demand falls faster than firms can stop producing, unsold stock piles up, and the ratio climbs; when it falls again, recovery has begun. On the 2008 chart the ratio peaks in the middle of the recession - which is why inventory is a **lagging indicator**: by the time stock has visibly piled up, you are already deep inside the trouble. The 2020 spike was unusually sharp because the shock itself was sudden.

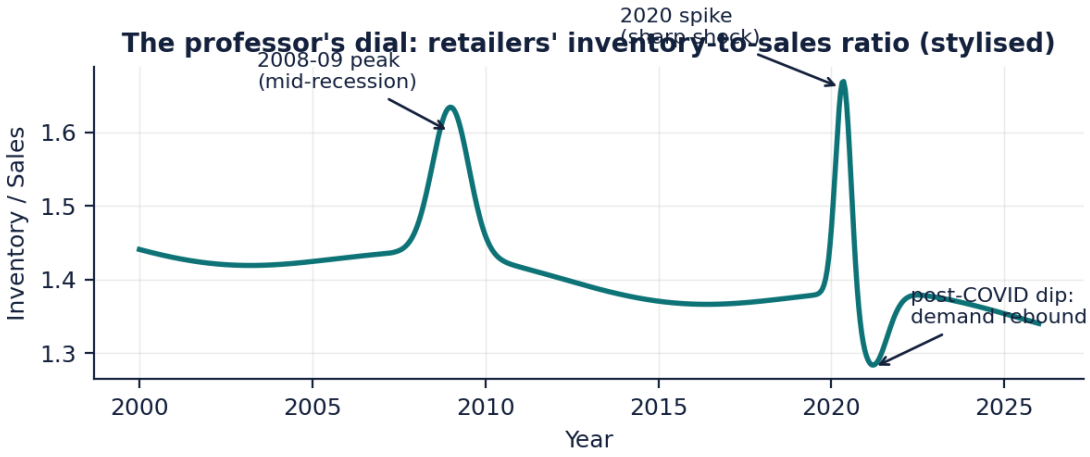


Fig 1.1 - The dial in action (stylised): the ratio peaks mid-recession in 2008-09, spikes sharply in 2020, then dips when demand rebounds before supply.

Dimension	2008 financial crisis	2020 pandemic
Trigger	Financial system	Biological / health
Supply side	Stable - factories and capacity kept running	Collapsed too, then could not restart fast enough
Demand side	Fell sharply - a demand-led recession	Fell first, then rebounded faster than supply could follow
The mismatch	No demand for the available supply	Demand returned (autos, tech) before supply was ready

Why was 2020's supply so slow to recover? Because the preceding decades were also a massive globalisation event: developed economies spread supply chains across the planet chasing labour arbitrage - India absorbed the bulk of

services, China the bulk of manufacturing. The result is a deeply connected world: efficient, but exposed, because the same connectivity becomes a transmission line for any shock. After 2020, **resilience** and **business continuity** stopped being annual-report boilerplate and became board-level commitments.

KEY INSIGHT

Rising ratio = demand falling relative to supply (a shock setting in). Falling ratio = recovery. Because inventory reacts slowly, the dial confirms a recession only after you are already inside it.

MAKING IT REAL

A small shop buys everything from one wholesaler because he is the cheapest. For years that is the smart choice - until the wholesaler shuts for a week and the shop has nothing to sell. The cheapest setup turned out to be the most fragile. That is the whole story of global supply chains in miniature - and why 'having a backup' went from nice-to-have to must-have.

02 FROM JUST-IN-TIME TO JUST-IN-CASE

For roughly thirty years, 'operational excellence' essentially meant cost minimisation - the **just-in-time** mindset: hold minimum inventory, squeeze every link, chase global labour arbitrage. Then the perennial shocks arrived and a new word entered the vocabulary: **risk**. Boards realised the relentless pursuit of low cost had quietly bought a large, hidden bill of risk - a lockdown in China, a blockage at one node, and the whole chain goes into chaos. Two new words now dominate boardrooms:

	DE-RISKING - diversify	DECOUPLING - rebuild at home
What it is	Spread the chain so no one geography holds you hostage. The famous version is China+1 (keep China, add India / Vietnam / Mexico / Brazil). Apple moving more value to India is textbook de-risking.	Pull entire capabilities back into your own domestic value chain - what the US and Europe attempt in chips, defence, pharma, batteries, renewables. The one-word mood: **control** - 'we lost it with too much offshoring; let's get it back.'
How hard	Relatively easy; almost nobody disputes it - it is simply building alternative supply chains, and it works.	Very hard - the lesson of recent years is that it is not plug-and-play.

Related jargon, all variations on bringing activity closer: **reshoring** (bring it all the way home), **nearshoring** (build near the home market), **friend-shoring** (source from politically friendly countries - India buying Russian oil, in this framing). Why is the U-turn so painful? Because two to three decades of outsourcing dilute your own **capabilities** - supply chains are not Lego bricks you can unplug from China and snap into the US. The US passed the CHIPS Act and discovered that money was never the constraint. Wall Street had spent those decades applauding 'asset-light' balance sheets - firms owning very few factories precisely because the capacity sat in low-cost countries - and those firms are now asked to recreate capacity they no longer know how to run. The bottleneck is capability, not cash.

Two live illustrations. **Rare earths**: the metals are not actually rare in the ground - China has abundant deposits, but so do others. The weapon is **refining capability**, which China dominates; restrict its chips and it can flex back with rare-earth exports - much of decoupling is geopolitics pulling operations around by chokepoints. **India** is ticking two boxes at once: self-reliance (a bigger slice of the value chain, backed by PLI - Production-Linked Incentives) and reduced import reliance in pharma and energy. But its semiconductor push hit the wall every latecomer hits: you cannot leapfrog to the frontier. NVIDIA is the most valuable firm on earth today precisely because of its access to 2-3 nanometre chips - and without those chips there is no modern AI. That capability is a slow, sequential climb, not one bold jump.

KEY INSIGHT

If the last forty years were about being as cheap as possible, the next forty will be about being safe and reliable. De-risking is the easy half; decoupling fails wherever the capability, not the cash, has been lost.

MAKING IT REAL

Picture a family that shopped for groceries just before each meal, keeping nothing in the cupboard because storing food felt wasteful. The moment the market shut unexpectedly, they were stuck - and after a scare like that, most families keep a little extra 'just in case'. Businesses did exactly the same after the shocks. Import taxes between countries solved none of this; they only made the planning harder.

03 THE STRATEGY CASCADE

Where do operations decisions come from? The class offered the usual words - a plan, choices, vision - but the professor wanted structure. Strategy arrives in a cascade of three connected levels, and operations sits at the bottom as a consequence of the two above it.

Level	The question	Who decides - and an example
Corporate strategy	Which game to play?	The board: which sectors and markets to enter, expand, diversify into or shut down. IndiGo entering Indian skies; Tata buying Air India.
Business strategy	How to play?	The CEO: on what basis will we compete and win - cost, quality, speed, variety, innovation, complexity? This is the differentiation. IndiGo choosing low cost. The mandate for everything below starts here.
Functional strategy	How to design and deliver it?	Functional heads, working concurrently and interactively: operations, marketing, finance, HR and R&D each design how they will deliver the chosen differentiation. Operations strategy lives here - what size, type and location of resources?

The arrows run strictly downward: you never design operations in a vacuum. And because all functional strategies are decided concurrently - marketing, finance and operations heads in the same room - a student's sharp question ('where does the signal to redesign come from?') has a clear answer: from all the functions together, never operations sitting alone in a silo.

THE ONE-LINE MAP

Corporate strategy = which game. Business strategy = how to play (your differentiation). Operations strategy = how to design the resources to deliver it. Change the goalpost at the business level and the entire operations design must change with it.

MAKING IT REAL

Opening a restaurant: choosing 'restaurant, not clothing shop' is corporate. Choosing 'fast and cheap, not fancy' is business. The small fixed menu, simple kitchen and no expensive chef then follow almost on their own - the kitchen design is decided by the promise made to customers. Never let how you run the place drift from the promise you chose to compete on.

04 DIFFERENTIATION - AND THE TRADE-OFFS IT FORCES

Business strategy answers one ruthless question the professor returned to all day: **what would the world miss about you if you disappeared tomorrow?** Pinpoint that and you have stated your business strategy. IndiGo - cost leadership in air travel. Amazon - variety ('no one beats my range') or speed ('fastest to your door'). Apple - leadership in innovation. L&T - differentiation by complexity: infrastructure projects no rival will touch. He pressed it with a deliberately hard case: what would the world miss if Harvard Business School vanished, when MIT and Wharton exist? Not 'brand' or 'quality' - rivals have those too. It is the **case-study method**: Harvard's own creation, refined and effectively owned by it ('95 percent of business education is on Harvard cases'). Real differentiation is whatever still stands once you strip away everything your rivals can equally claim.

The moment you pick your basis of competition, you accept **trade-offs** - business models are, at heart, captured trade-offs. High variety usually means high cost; low cost usually means low variety; you move along a frontier and rarely

escape it for free. Henry Ford in 1907 planted himself at low variety, low cost through mass production: one standardised car ('any colour so long as it is black'), enormous scale, low unit cost. He deliberately surrendered variety to win on cost - a business-strategy choice expressed directly as an operations design, and one that required scale to work.

MAKING IT REAL

Two coaching centres in one town: one promises the lowest fees, the other small premium batches with star teachers. The cheap one cannot also afford tiny batches; the premium one cannot also be the cheapest. Every choice of 'what we are best at' comes with a trade-off - trying to be best at everything usually means being best at nothing.

05 INDIGO, DECODED: ONE CHOICE, ENTIRE DESIGN

IndiGo is the cleanest worked example of the cascade. An airline's biggest controllable costs are not fuel (roughly the same for everyone, so no edge) but the **aircraft and its maintenance**, with manpower behind them. IndiGo's answer: essentially one aircraft type at high scale - and from that single choice a whole cost advantage cascades. One fleet type means high substitutability of parts, so spares, stocking and swaps are simpler and cheaper. One fleet type means one type of pilot and one type of simulator training - a major industry cost, collapsed. High scale means large single-type orders at lower unit and maintenance cost. And the lean, standardised model keeps working capital low, liquidity high and financing cheap - which feeds back into still-lower costs. You cannot run a low-cost airline without scale and standardisation.

Change the mandate and the design inverts. A pharma firm competing on **speed** of new-molecule launches needs **flexible** capacity - a platform that can produce molecule A, B or C as the science lands ('bring any science, I can apply it', the mRNA-style model) - and must accept that flexible capacity sits partly idle and costs real money: you buy agility with idle assets. A **cost** player builds large specialised lines, one per molecule, and accepts rigidity instead - a line built for A cannot make B. Tata Motors lived this: the newer Jaguar models come from the Solihull plant, retrofitted for flexibility precisely because the strategy changed to 'don't put all our innovation into one product on one rigid platform'.

And the vulnerability - the professor was careful not to leave IndiGo looking invincible. Because it runs one dominant fleet and engine type, a fault in that one component hits the whole fleet at once - exactly what happened when the Pratt & Whitney engines had to be replaced fleet-wide over three to four years, for IndiGo and every similar customer. (A whole configuration like the A321 failing is the rarest of rare; component failure is the real, live risk.) Its annual reports show substantial revenue from **supplier penalties** - compensation for groundings that were no fault of IndiGo's. Trade-offs always cut both ways: the standardisation that makes you efficient also concentrates your exposure.

MAKING IT REAL

A lunch-delivery service running one single scooter model is wonderfully efficient - one set of spares, one kind of repair, drivers who can swap scooters easily. The day that model shows a faulty brake, every scooter is grounded at once. Keeping everything the same saves money but concentrates the risk; build the efficiency, and keep a plan for the day the one common part fails.

06 THE BENCHMARKING CURVE: WHERE INEFFICIENCY HIDES

Plot **value** (whatever your differentiation delivers - speed, quality, variety) against the **cost** of creating it. The curve is the industry frontier: the most value currently achievable at each level of cost, with competitors scattered around it and an arrow labelled 'eliminate inefficiencies' pushing laggards toward the line. In mature industries the curve is well established; in highly innovative ones it is hard to estimate precisely - but you still know your rivals and your own capabilities well enough to place yourself roughly on the map.

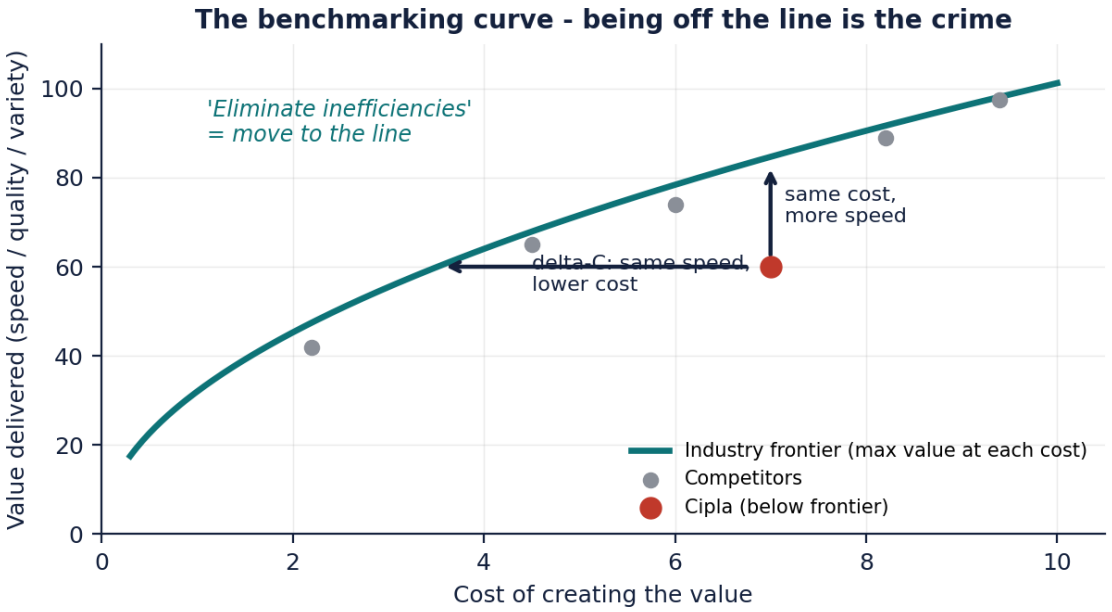


Fig 1.2 - The benchmarking curve. Cipla sits below the line; the two arrows are the two readings of the same crime - delta-C leftward, more value upward.

Now the Cipla thought experiment. Cipla competes on speed, and a consulting study plots it below the frontier. Bonus, or spotlight? The class landed on the right answer: under-performing - and the precise reasoning matters. Nobody questions how much value Cipla chose to offer; that level of speed is its prerogative. But if the same speed is achievable at lower cost - and the curve proves it is - then delivering it at higher cost is the failure: the gap to the frontier, the delta-C, is pure operational inefficiency, waste inside the system, not a strategy choice. Read the other way, if you can afford that cost, why not buy more speed? Either way, being off the line is the crime. One subtlety he insisted on: even the industry's lowest-cost producer can sit below the curve, because the frontier is defined by what is technologically possible, not by what today's best player happens to achieve.

KEY INSIGHT

Two ways to be off the frontier, both crimes: (a) delivering your chosen value at more cost than necessary, or (b) leaving value on the table your cost could already buy. The mandate is simple - get onto the curve. Once there - the 'first-bencher of the class' - the new question is endurance: how do you sustain it when rivals can see exactly what you did? That is what the case studies answer next.

07 V = C x (A + P): THE MAP OF OPERATIONS STRATEGY

Van Mieghem's schematic (2008) organises everything: **Value = Capabilities x (Assets + Processes)**. Capabilities are set by your business strategy - two questions: along which dimensions should we excel (the mandate), and along which do we actually excel today (the reality check)? Assets carry four resource questions: **sizing** (how much capacity), **timing** (when), **type** (specialised vs flexible), **location** (where). Processes are how value flows through the firm: supply, technology, demand, innovation and risk - the everyday decisions that turn assets into output. Not every box is relevant to every industry (retailing matters little for an energy firm; in services, capacity is often human capacity), but the underlying questions are universal. And operations itself, in one line: **input -> process -> output**, with value added in between. That middle box is deliberately enormous - it subsumes the supply chain, make-vs-buy, supplier choice, batch sizes, technology and distribution. Everything from a supplier to a consumer, done in the middle, is operations.

MAKING IT REAL

A neighbourhood bakery: Capabilities - be best at fresh bread every morning, and check what it is actually good at today. Assets - how many ovens, when to buy the next, big specialised or small flexible, and where to put the shop. Processes - buying flour, the baking method, guessing tomorrow's demand, trying new recipes, handling an oven breakdown. Input (flour) -> process (baking) -> output (loaves).

08 MASTERS OF OPERATIONS: ZARA, TOYOTA, INTEL vs NVIDIA

The professor grounded the theory in firms that turned operations into durable advantage, using the **Gartner Supply Chain Top 25 for 2025** as a conversation starter: Schneider Electric, NVIDIA, Cisco, AstraZeneca and J&J at the top, then L'Oreal, Colgate-Palmolive, Lenovo, Microsoft, Danone. He flagged it as a biased list - it favours conventional distribution-heavy chains and under-weights pure services - but useful to start; Walmart, he noted, would show up year after year on similar lists for the same reasons. He singled out two for a close look.

Zara competes on fast fashion - speed and constant variety are its order winners, with cost and quality kept competitive. The operations question is a classic risk trade-off: producing in small lots deliberately cuts **inventory risk** (no mountains of unsold stock) but takes on the other edge of the sword, **shortage risk** - reduce one and you take on the other; there is no free lunch. Zara counters the shortage risk it created with two linked moves: a **scarcity image** (customers learn a specific style and size is here today, gone tomorrow - so buy now; scarcity becomes a marketing asset) and **relentless replenishment**, refreshing stores sometimes twice a week, so even a disappointed customer returns to an effectively new store. Underneath runs a high-velocity, heavily **vertically integrated** chain - Zara owns and controls most steps itself: over half its suppliers in Spain, time-sensitive products in-house while predictable lines are offshored, **postponement of dyeing** (cloth kept un-coloured until the last moment, dyed to whatever is selling), small set-up times and small batches, centralised distribution to exploit risk pooling, frequent deliveries with short re-order lead times, an IT-enabled chain - all serving one objective: **reduce lead time**. The payoff is financial: roughly one-third the inventory of rivals and the industry's fastest inventory turnover - in fashion, where cash sits trapped in unsold stock, a massive advantage that has held for decades. The designs are unremarkable (often common designers); the speed of the supply chain is the moat.

Toyota competes on reliability - consistency above all. Post-war, with Japan short of land, labour and resources, Toyota engineers visited Ford and GM, learned what worked, and adapted it to scarcity - inventing, for instance, U-shaped assembly lines to save space. What emerged became the **Toyota Production System**, the original name for what the world now calls Lean; Six Sigma, Kanban, Kaizen, just-in-time and waste minimisation - in manufacturing or in services like healthcare and banking - all trace back here. Tellingly, the auto industry is generous with its practices (Toyota even let the world rename TPS as 'Lean'), whereas pharma hides its failures so rivals burn the same cash. The **GM bankruptcy puzzle** makes the deepest point: in the mid-1990s GM partnered with Toyota - shared facility, joint R&D, roughly fifteen years - and still went bankrupt in 2009, rescued with US government money (the government held GM shares long after), even as Toyota's US share kept climbing. Regulators asked the brutal question: how do you go bankrupt when the best operator in the world was your partner and teacher? Some operational advantages cannot be copied even by a partner sitting inside the same plant.

Culture eats strategy for breakfast, lunch and dinner. Toyota cannot fully replicate its own quality outside Japan - not because it can't transfer machines or suppliers, but because the missing ingredient is culture, and culture is part of the process.

THE LINE THAT EXPLAINS GM - FROM THE CLASS

Intel vs NVIDIA: same industry, same broad product, wildly different fortunes - NVIDIA remarkable, Intel ('once the darling of the chip industry') struggling. The divergence comes down to operations-strategy calls: how each designed capacity, how vertical or flexible to be, what to own versus outsource in a fast-moving, innovative industry - where you often cannot design capacity alone. Session 4 dissects this in full.

MAKING IT REAL

Zara and Toyota teach the same lesson: the advantages that last are built into how you work, not what you can buy. Think of a famous old sweet shop whose rivals can buy the very same sugar, milk and machines - yet cannot match the taste. The secret is in the method and the people, built up over years. The hardest thing for a rival to steal is the way you do things.

09 THE BIG IDEA: PRODUCT vs PROCESS INNOVATION

The framework the whole session was building toward. Every firm draws on both product and process innovation - both always matter - but in any given firm one dominates (think 60-40 or 70-30), and which one tells you how durable the advantage really is. In class he forced everyone to vote 'product or process' for Apple, Zara and Toyota - and the disagreement in the room was the point. First, a law: **disruption only happens when you kill a trade-off, at scale**. A niche player customising for a wealthy few is not a disruptor - that existed a century ago. Dell broke variety-vs-cost: a customised PC at low cost, at scale, by street-smart assembly - it makes nothing of its own, standardises everything up to the point the customer cares about, and exploits variety only at the very end. Asian Paints does the same in paint: millions of shades from three primaries, with the customisation pushed out to the retailer (in PCs the boundary sits at the factory). Tesla was a niche, aspirational EV - Musk 'overpromising, under-delivering' - until the low-price Model 3 and the Gigafactory gave it scale. And the AI parallel: what DeepSeek rattled markets by attempting - and what OpenAI and Anthropic do - is deliver most of the capability at far lower cost. The same Dell move, on a new curve.

THE TELL

Dell and Zara are doing the same thing. Dell gives you a customised product; Zara gives you fast fashion. In both, the value you consume is a product - but the innovation that delivers it lives in the process (the assembly model, the supply chain), not in any unique product design. That is the tell for which type of innovation dominates.

Firm	Dominant	Why - and how durable
Zara	Process	Designs are commoditised; the edge is doing it faster via the supply chain - hard to copy, hence durable.
Toyota	Process	German rivals lead on product engineering; Toyota wins on the production system and culture - which even Toyota cannot fully export.
Dell	Process	Makes nothing itself; the innovation is street-smart assembly delivering customisation at low cost.
Apple	Product	Its manufacturing ecosystem (Foxconn, Pegatron, now Tata) is the industry's shared asset, not Apple's own. The edge rests on launching new products - pause, and the market punishes it.

The Apple verdict is the session's punchline. Its products are brilliant, but whatever it launches can be replicated - a rival copies a new camera or face-unlock 'in no time'; that is the curse of product-led advantage. Its manufacturing ecosystem in China (and increasingly Vietnam and India) is world-class but not Apple's alone: Foxconn serves many customers, and when iPhone 17 succeeds it is Foxconn, not Apple, that ramps capacity. Apple can build second-generation AirPods in Vietnam, but the third generation still needs China - that ecosystem took forty years and is the industry's shared asset. Its surging services revenue is precisely an attempt to diversify away from a saturating hardware product. Why is process the stronger moat? Product innovations are low-hanging fruit - visible, therefore copyable. Process innovations are messy, slow and cultural - so complex that even the owner may not fully understand why they work, which is exactly why they endure; if process dominates your narrative you are, in his words, 'married' to a durable advantage (relative, not invincible - but the relativity runs in your favour). The cautionary coda: twenty years ago the class's dream operations firm would have been Nokia. Nokia and Kodak did not fail for lack of capability; they missed the **signal to redesign** - which comes from all functions reading the market together, never operations alone. Strength in today's process is no insurance against needing to redesign tomorrow.

MAKING IT REAL

Build advantages into how you work, not just into what you sell. A clever new feature gets copied within months; the way you run the place - fast, smooth, reliable, with a team that cares - is far harder to copy. If your strength is your method, it lasts. If it rests only on the latest new thing, you are only as good as your next launch - and, like Nokia, you must keep watching for the moment even a winning method needs to change.

SESSION 1 IN ONE BREATH

Operations is a boardroom topic because disruption keeps testing it. Every operations choice flows down from the differentiation strategy - IndiGo shows one choice dictating the entire design, vulnerabilities included. The benchmarking curve tells you whether you run it efficiently; V = C x (A + P) organises the design; and the deepest durable advantage is process innovation - the Zara / Toyota kind that rivals, and even you, cannot easily copy.

MCQ SESSION 1 DRILL - 32 QUESTIONS

Q1. The retailers' inventory-to-sales ratio is called a lagging indicator because:

a) It rises before a recession begins
b) It peaks only in the middle of a recession, after trouble has set in
c) It measures demand, which always lags supply
d) Retail data is published late

Ans (b): Stock visibly piles up only after demand has already fallen - the dial confirms the recession from inside it.

Q2. The key operations difference between the 2008 and 2020 recessions was:

a) 2008 was supply-led; 2020 was demand-led
b) Both were supply-led
c) 2008 was demand-led with stable supply; in 2020 supply collapsed too and could not restart as fast as demand returned
d) 2020 had no supply chain impact

Ans (c): 2008: no demand for available supply. 2020: demand rebounded before supply was ready.

Q3. China+1 - keeping China but adding a second manufacturing base in India or Vietnam - is an example of:

a) Decoupling
b) De-risking
c) Reshoring
d) Vertical integration

Ans (b): De-risking = diversifying so no one geography holds you hostage; decoupling is rebuilding capability at home.

Q4. The US semiconductor push (CHIPS Act) discovered that the real constraint on decoupling is:

a) Capital
b) Tariff levels
c) Lost domestic capability
d) Consumer demand

Ans (c): Money was never the bottleneck; decades of offshoring diluted the capability itself.

Q5. Rare-earth metals give China leverage primarily because of its dominance in:

a) Deposits in the ground
b) Refining capability
c) Mining labour cost
d) Shipping routes

Ans (b): Rare earths are not rare; the chokepoint is refining, which China dominates.

Q6. IndiGo's decision to compete on low cost belongs to which level of the strategy cascade?

a) Corporate strategy
b) Business strategy
c) Operations strategy
d) Functional design

Ans (b): Business strategy answers 'how to play' - the basis of competition. Entering aviation at all was corporate.

Q7. The test of real differentiation, per the Harvard example, is:

a) Brand recall among customers
b) What still stands once you strip away everything rivals can equally claim
c) Market share leadership
d) Price premium

Ans (b): Harvard's answer is the case-study method - something rivals cannot equally say.

Q8. Ford's 'any colour so long as it is black' is a deliberate position of:

a) High variety, high cost
b) Low variety, low cost via mass production
c) High variety, low cost
d) Low variety, high cost

Ans (b): Ford surrendered variety to win on cost - a captured trade-off.

Q9. Which is NOT part of the cost cascade unlocked by IndiGo's single fleet type?

a) Substitutable spare parts
b) One pilot / simulator training pipeline
c) Lower unit cost from large single-type orders
d) Premium pricing power on trunk routes

Ans (d): The single fleet unlocks cost, not pricing power - IndiGo competes on price, not premiums.

Q10. IndiGo's engine groundings show that standardisation's hidden price is:

a) Higher fuel cost
b) Concentrated exposure when the one common component fails
c) Slower turnarounds
d) Weaker brand

Ans (b): One dominant engine type means one fault hits the whole fleet - hence supplier-penalty revenue in its accounts.

Q11. A firm sits below the industry benchmarking curve. The correct board reading is:

a) It chose too little value - raise the value target
b) It is operationally inefficient - the same value is achievable at lower cost
c) It is the industry cost leader
d) The curve does not apply to innovative industries

Ans (b): The value level is the firm's prerogative; delivering it above frontier cost is the crime.

Q12. In V = C x (A + P), the four questions carried by Assets are:

a) Supply, technology, demand, risk
b) Sizing, timing, type, location
c) Cost, quality, speed, variety
d) Plan, organise, lead, control

Ans (b): Assets = sizing, timing, type, location; supply/technology/demand/innovation/risk sit under Processes.

Q13. By producing in small lots, Zara deliberately trades:

a) Shortage risk for inventory risk
b) Inventory risk for shortage risk
c) Quality risk for cost risk
d) Speed for variety

Ans (b): Small lots cut unsold-stock risk but invite stockouts - which Zara converts into scarcity marketing plus rapid replenishment.

Q14. The deepest lesson of GM's 2009 bankruptcy despite a 15-year Toyota partnership is:

a) Toyota hid its methods
b) Lean does not work outside Japan
c) Culture is part of the process, and cannot be copied even from inside the same plant
d) GM lacked capital

Ans (c): The machines and checklists transferred; the culture did not - Toyota struggles to export it even to itself.

Q15. Per the first law of disruption, a disruptor must:

a) Launch a superior product
b) Kill an accepted trade-off, at scale
c) Patent its process
d) Vertically integrate

Ans (b): Dell (variety at low cost) and Tesla (post-Gigafactory scale) both broke a trade-off at scale; niches are not disruptions.

Q16. Apple is classified as product-innovation-led chiefly because:

a) Its supply chain is weak
b) Its manufacturing ecosystem is the industry's shared asset, not proprietary to Apple
c) It does no process improvement
d) It outsources design

Ans (b): Foxconn's ecosystem serves many customers; Apple's edge rests on the next launch - the fragile side of the moat.

Q17. Match the shock to its trigger, as taught in class:

a) Dot-com: political; 2008: biological; 2020: financial; tariffs: random natural events
b) Dot-com: tech bust (~2000); 2008: financial; 2020: biological; tariff era: political - and far more random than the others
c) All four were financially triggered
d) 2008: biological; 2020: financial

Ans (b): Each shock has a different trigger, but all landed first and hardest on operations - the function matching supply and demand.

Q18. Why did supply recover so slowly in 2020, per the class?

a) Factories were destroyed
b) Decades of globalisation chasing labour arbitrage built a deeply connected world - efficient, but the connectivity became a transmission line for the shock
c) Governments banned production
d) Demand never actually returned

Ans (b): India absorbed services, China manufacturing; the same links that made chains cheap made them fragile.

Q19. Wall Street's decades of applauding 'asset-light' balance sheets meant that when reshoring arrived, firms:

a) Had too much cash to deploy
b) Were asked to recreate capacity they no longer knew how to run - the bottleneck was capability, not cash
c) Could simply unplug supply chains from China and snap them into the US
d) Faced no difficulty at all

Ans (b): Supply chains are not Lego bricks; owning few factories for decades dilutes the very capabilities reshoring needs.

Q20. Friend-shoring, as defined in class, is:

a) Building factories near the home market
b) Bringing production all the way home
c) Sourcing from politically friendly countries - India buying Russian oil was the class framing
d) Outsourcing to the cheapest bidder

Ans (c): Reshoring = home; nearshoring = near the home market; friend-shoring = friendly geographies.

Q21. NVIDIA being the most valuable firm on earth was cited to prove that:

a) Marketing beats operations
b) Access to 2-3 nanometre chips is decisive - without them there is no modern AI, and that capability is a slow sequential climb no latecomer can leapfrog
c) Chip assembly is the highest-value stage
d) India should skip semiconductors

Ans (b): The frontier capability, not the brand, is the moat - which is exactly why India's fab push cannot jump the queue.

Q22. L&T;'s differentiation, per the class, is:

a) Lowest cost
b) Fastest delivery
c) Complexity - infrastructure projects no rival will touch
d) Widest variety

Ans (c): Differentiation is whatever would be missed if you vanished; for L&T; that is the projects nobody else attempts.

Q23. A pharma firm competing on SPEED of new-molecule launches must accept that:

a) Its lines must be rigidly specialised
b) Flexible, bring-any-science capacity sits partly idle - you buy agility with idle assets
c) It can run at 100% utilisation
d) Cost leadership comes automatically

Ans (b): The cost player builds one rigid line per molecule; the speed player pays for flexibility with idleness.

Q24. Tata's Jaguar plant at Solihull was retrofitted for flexibility because:

a) Regulators demanded it
b) The strategy changed - stop putting all innovation into one product on one rigid platform
c) Labour costs fell
d) The A321 failed

Ans (b): Change the mandate above and the asset design below must change with it - the cascade in action.

Q25. On fleet risk, the class distinguished:

a) Configuration failure is common; component failure is rare
b) Both are equally likely
c) A whole configuration (like the A321) failing is the rarest of rare; component failure - like the P&W; engines - is the real, live risk
d) Neither ever happens

Ans (c): Standardisation concentrates exposure at the component level - the exact failure IndiGo lived through.

Q26. Even the industry's LOWEST-COST producer can sit below the benchmarking curve because:

a) The curve is drawn wrong
b) The frontier is defined by what is technologically possible, not by what today's best player achieves
c) Low cost guarantees frontier position
d) Value cannot be measured

Ans (b): Being today's best is not the same as being at the technological frontier - the subtlety he insisted on.

Q27. The Gartner Supply Chain Top 25 was introduced WITH a caveat:

a) It is a perfect ranking
b) It is biased toward conventional distribution-heavy chains and under-weights pure services
c) It excludes American firms
d) It ranks only manufacturers by revenue

Ans (b): Useful conversation starter, biased instrument - Schneider Electric, NVIDIA and Cisco topped the 2025 list.

Q28. Zara keeping cloth un-dyed until the last moment (postponement) exists to:

a) Save dye costs
b) Delay commitment until real demand information arrives - dye to whatever is selling
c) Comply with regulation
d) Slow the supply chain down

Ans (b): Postponement converts forecasting risk into response speed - one of the levers serving the single objective: reduce lead time.

Q29. 'Culture eats strategy for breakfast, lunch and dinner' was used in class to explain:

a) Why strategy documents matter most
b) Why Toyota cannot fully replicate its own quality outside Japan - culture is part of the process
c) Why GM's culture saved it
d) Why breakfast meetings are effective

Ans (b): Machines and suppliers transfer; the cultural ingredient of a process moat does not - which is also why rivals cannot copy it.

Q30. THE TELL for which innovation type dominates: Dell and Zara are 'doing the same thing' because:

a) Both design unique products
b) In both, the value you consume is a product, but the innovation that delivers it lives in the process
c) Both are vertically integrated in Spain
d) Both compete on quality

Ans (b): Customised PC, fast fashion - the product is ordinary; the assembly model and supply chain are the moat.

Q31. Apple's surging services revenue was read in class as:

a) Proof of process dominance
b) An attempt to diversify away from a saturating hardware product - the curse of product-led advantage
c) A supply chain failure
d) Evidence Apple is leaving China

Ans (b): When advantage rests on the next launch, you hedge the launch - services is that hedge.

Q32. Second-generation AirPods can be built in Vietnam but the third generation still needs China because:

a) Vietnam lacks electricity
b) The manufacturing ecosystem took forty years to build and is the industry's shared asset - depth cannot be relocated quickly
c) Chinese tariffs are lower
d) Apple owns Chinese factories outright

Ans (b): Foxconn serves many customers; the ecosystem is world-class but not Apple's alone - and not portable on demand.

SESSION 2 OF 5 - Prof. Balram Avittathur - Live Online, 21 June 2026

Efficiency, Effectiveness - and Reading Any Operation as a Process

The distinction most managers blur every day - efficiency (doing things right) versus effectiveness (doing the right things) - with Lemon Tree Hotels as proof that excellence is the deliberate design that achieves both. Then the process-analysis toolkit: five process types, cycle time, bottlenecks, Little's Law, and two fully worked assignments that are prime exam material.

FROM 'SUPPLY CHAIN IS SOON DEAD' TO THE FOREIGN MINISTER'S SPEECH

In 1998, doctoral thesis freshly submitted at IIM Bangalore, the professor read a Harvard Business Review issue promising intelligent refrigerators ordering their own milk - and declared supply chain management would soon be dead. A rough week for a man who had left a job paying three times his stipend to spend four years on exactly that field; his guide talked him down. He joined IIM Calcutta in 1999 'for two or three years', stayed, took a Fulbright year in the US, later taught in Germany and Austria. In November 2025 he watched India's External Affairs Minister accept an honorary doctorate on this campus and deliver a speech that sounded, for long stretches, like a supply-chain briefing on trade and chokepoints. Fields written off as plumbing have a habit of becoming the headline. (He will not teach supply chain here, though - Prof. Peeyush Mehta covers it in the coming sessions; his own brief is process analysis and inventory.)

01 THE TRANSFORMATION LENS: INPUTS, RESOURCES, OUTPUTS

Operations management is the transformation process that converts **inputs** into **outputs** with the help of **resources**, adding value in between. An input need not be physical - an unmet need qualifies: standing in Calcutta while needing to be in Delhi is an input, and you rent an airline's resources to transform it (if we could all fly, airlines and railways would have nothing to transform). The trap question: people casually call manpower an input - so what separates an input from a resource, with a definition valid 100 percent of the time? The clean test: **once the transformation is over, the input no longer exists, while the resource is fully intact**. In steel-making the iron ore and limestone have vanished into the pig iron; the worker and the blast furnace are still standing - tired, perhaps, but intact. Manpower is a resource, never an input.

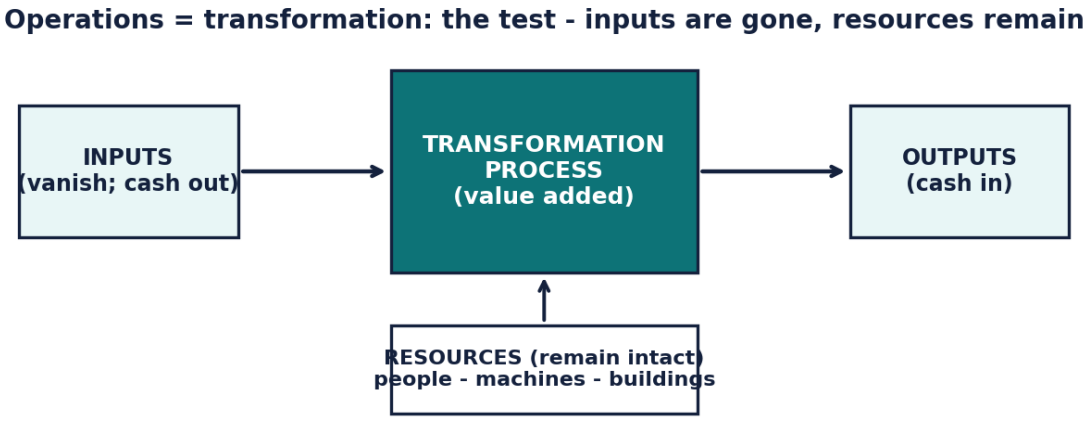


Fig 2.1 - The transformation lens. Inputs vanish into outputs, resources survive the transformation, and the cash flows map straight onto the picture.

Overlay finance and the mapping completes: inputs and resources are **cash outflows** (a building's outflow may have happened years ago, sitting on the balance sheet and reaching the P&L as depreciation), outputs are the **cash inflows** - unless you are paying customers to take your product, which sounds absurd and occasionally happens: in electricity markets, when supply swamps demand, the spot price can turn negative and buyers are literally paid to consume. Rare - but a useful reminder that even the cleanest mappings have exceptions.

KEY INSIGHT

After the transformation: inputs are gone, resources remain. Inputs and resources are cash outflows; outputs are the inflows. This one test settles every 'is manpower an input?' debate.

MAKING IT REAL

Watch a tailor. The cloth (input) vanishes into the shirt (output). The sewing machine and the tailor (resources) are right there for the next customer. Run that test on a steel plant, a bank branch or a biryani kitchen and you have the operations lens.

02 EFFICIENCY: COST MINIMISATION IN POLITE CLOTHING

Peter Drucker's famous pairing - efficiency is doing things right, effectiveness is doing the right things - sounds like wordplay. The professor's promise for the afternoon: from an operations standpoint they are chalk and cheese, and firms that confuse them pay for it. Start with efficiency, through a class example: Sumit finishes a report in one hour, Biju takes three. Everyone agreed Sumit is 'efficient' - but why, precisely? Because a paid resource's time was minimised. And no, Sumit does not get two hours off; he gets the next task - same salary, double the work: the employer's resource cost per unit of output has fallen. (The professor's sly aside: on paper, Biju may be the street-smart one, deliberately pacing himself while the eager new joiner gets squeezed.) The definition, registered word by word: **for a given unit of output, efficiency is minimising the inputs and resources required, measured in currency terms**. Strip the politeness and it is cost minimisation - the operational route to profit maximisation.

Why does the polite word survive? Test three phrases in a boardroom: profit maximisation, cost minimisation, efficiency maximisation. The first two draw resentment - people suspect the profit is at their expense; only 'efficiency' passes as pure virtue, because nobody hears their own job inside it. Which is exactly why CEOs say it. The pressure is universal: asked whether anyone's cost pressures had eased over the last five years, the class produced vehement head-shakes and not a single hand. He was equally firm on the other face: this is not an anti-corporate lament. Firms exist to maximise the returns of the owners who risked their capital - that is the job, and India is fortunate to have ambitious builders of scale; look at most neighbouring economies to see what their absence costs. His cheeky peace formula for exhausted employees: if the efficiency drive grinds you down, buy the company's shares - when the squeezing is high, the profits usually are too. He held his old employer's stock for decades, partly nostalgia, mostly returns.

MAKING IT REAL

A chai stall that trims the milk in every cup is 'efficient'. The ledger calls it productivity; the recipe calls it cost-cutting. Both descriptions are true - and that double life is the whole reason the word is so popular.

03 THE HIDDEN BILL: WHO PAYS FOR PURE EFFICIENCY

If efficiency were free, the session could have ended there. Re-run the report example with one added fact: the job genuinely needed three hours, and Sumit compressed it under deadline pressure. Who received a thinner report? The customer - internal or external. The first casualty of squeezed inputs is usually quality, and quality always lands on somebody. The darker version, from an Economic Times article the professor recalled: residents around Patancheru on Hyderabad's outskirts - one of India's biggest antibiotic manufacturing clusters - show markedly higher antibiotic resistance than the average Indian. Making antibiotics generates waste; disposal has well-defined protocols; under cost pressure, protocols get followed 'to the extent convenient'. The effluent finds the water table, the water finds the residents, and the neighbourhood's antibiotics slowly stop working. On the plant's dashboard, this appears as efficiency - cost per unit, duly reduced. The roll of possible sufferers the class assembled - employees, customers, the local community, government and regulators, suppliers and partners - has a name: **stakeholders**. The shareholder is one of them; these are the others.

KEY INSIGHT

Aggressive cost-cutting rarely deletes a cost. It relocates the cost onto stakeholders who do not appear in your P&L. The bill is still paid - just not by you, and not yet.

MAKING IT REAL

A dhaba that re-uses its frying oil all week books a genuine saving. The cost has not vanished - it has moved into the customers' stomachs, and eventually into the dhaba's name. Efficiency without a second thought is often just cost transferred to someone who cannot see the invoice.

04 EFFECTIVENESS: EVERYONE ELSE'S WELFARE, MAXIMISED

The unusual definition, worth quoting exactly: **effectiveness is maximising the welfare of all stakeholders except the owner** - except, because efficiency already takes care of the shareholder; effectiveness need not repeat the favour. And economics gives 'welfare' a precise meaning: **value minus price**. A Rs. 20 water bottle on a rain-cooled Calcutta afternoon (the class met on one) might be worth Rs. 10 to you - no sale; ten days earlier at 37 degrees it was worth Rs. 30 or 40 - instant sale. Same product, same price; the value moved. You buy when your value exceeds the price, and the gap is your welfare. His own recent purchase made the point: a roughly Rs. 50,000 Google Pixel, bought under sustained pressure from his son ('like a gun to my head'), which he now privately values above Rs. 60,000 - a welfare of Rs. 10,000-plus, and a sheepish thank-you delivered to the boy. Employees price their jobs the same way: reckon your job worth Rs. 3 lakh a month while being paid Rs. 2 lakh and you praise the firm at every dinner - until someone offers Rs. 2.5 lakh, and twenty years of loyalty evaporates by lunchtime. Free evening chocolates are not employee welfare; the perceived gap is. The same construction extends to suppliers, partners, the community, the regulator - each has its own version of value minus price.

MAKING IT REAL

Why does one barber feel 'worth it' at Rs. 100 while another feels expensive at Rs. 80? Because welfare is the surplus you walk out with - what the haircut felt worth, minus what you paid. Firms that fatten that surplus for customers, staff and partners are being effective, whether or not they know the word.

05 CHALK AND CHEESE - OR TWO HANDS? THE QUIZ, ZARA, TOYOTA

Decision	Verdict	The reasoning
Open one more teller at a bank branch	Effectiveness	Costs more; cuts customer waiting and teller stress. (The corporate reflex, in his telling: propose cutting five tellers to four instead, and it is sanctioned overnight - with praise for your managerial skill.)
Sell only a single large pack size	Efficiency	Favours the producer's cost structure, not the customer's actual need.
Income-tax e-filing	Both	The department's running cost fell from about Rs. 3 to Rs. 0.5 per Rs. 100 collected (efficiency) - even before adjusting for inflation - while a citizen's filing collapsed to minutes (effectiveness). His own return that morning: about seven minutes of real work.
One 100-seater bus every 30 minutes	Efficiency	Flip it - 25-seaters every 15 minutes - and the same route becomes effectiveness.
Zara's fast, local supply chain	Effectiveness	Materials cost 15-20 percent more than rivals sourcing from Asia - on paper the opposite of efficient.

Zara deserves the pause, because it breaks the expected pattern: effective, not efficient - and more profitable than its efficient competitors. The explanation is **revenue quality**. Walk into the Marks & Spencer next door and you arrive hunting a bargain; walk into Zara and the same customer hunts novelty - what is new, what is scarce. Nobody asks Zara for a discount: higher costs, higher-quality revenue, better margins (Session 1's speed machine, seen through this lens).

Then the counter-example that dissolves the whole 'conflict': **Toyota** - efficient (lower cost than rivals) and effective (better stakeholder welfare), for decades. Efficiency and effectiveness are not natural enemies; treating them as a trade-off is a design failure. In the long run, efficient-and-effective beats efficiency-only on profitability itself - but effectiveness compounds slowly, and quarterly minds do not wait. His estimate: pick 100 firms today, and perhaps 95 are running on efficiency alone.

Operational excellence = efficiency + effectiveness. Be efficient and effective - be good to everyone, and be happy. You can run the same equation at home, too.
PROF. BALRAM AVITTATHUR - HIS SUMMARY, ONLY HALF IN JEST

MAKING IT REAL
Two tiffin services. One squeezes cost until the dal thins; one spends a little more and never misses a delivery, never shorts a portion. In year one the first is more profitable. By year three the second owns the neighbourhood - and the pricing power that comes with it.

06 EXCELLENCE BY DESIGN: LEMON TREE AND THE 95-IN-100 PROBLEM

How does a firm actually get both? His answer, repeated all afternoon: **design**. And his favourite proof is Lemon Tree Hotels. Patanjali (Patu) Keswani - IIM Calcutta PGP class of 1983, the day's most quotable alumnus - left a long career in the Tata fold's hotel business and, around 2004-05, went after a gap everyone could see but nobody served: India had five-star hotels above and lodges below, with almost nothing honest in between. One mid-market hotel became a chain. The turn came later: a government push around 2010-12 nudged firms to employ persons with disabilities, and Lemon Tree hired a few to comply. Some months on, a woman walked into Keswani's office, handed him a bouquet and burst into tears - the mother of a speech-and-hearing-impaired hire whose job had given him a livelihood, self-respect, even a marriage. Compliance became conviction: targets rose from 10 percent of staff to 20 to 30, and today roughly 40 percent are persons with disabilities or from severely disadvantaged backgrounds. Shareholders pushed back - you are chasing a Padma Shri at our cost. His answer: profitability has only improved since we began, and I never planned any of it ('for me, everything is serendipity'). The mechanism, articulated only in hindsight: a hotel guest's half-stated need is to be cared for, and a firm that visibly cares for its own people signals it will care for you - guests who could afford the Taj chose the caring house, because luxury is not the only need. A batchmate confirmed the pattern from the floor: a Mumbai restaurant where most servers are specially-abled is packed every evening - good food, and goodwill, compounding.

He set the counter-image beside it. The fastest way to lift a technology share price 10 percent this fortnight is not a better product - it is a layoff announcement; the class agreed the contagion has visibly reached Indian IT (a participant cited a fresh services-major announcement trimming hikes that rattled the whole sector). That is efficiency as theatre: the market applauds the cost signal long before any cost is actually saved. So what is 'design'? **Every stakeholder considered in every decision.** His test case: an electronics assembly plant running 6 am-2 pm and 2 pm-10 pm shifts with a largely women workforce - is their safe commute the government's headache (you pay taxes, after all), or part of your plant's design? A complete design answers for every stakeholder; a design that optimises for a subset is an incomplete design. Toyota spends 'extra' on employee and customer welfare because it wants the best employees and the best customers - and an extra cost of 10 that returns more than 10 is not a cost at all.

KEY INSIGHT
Effectiveness is not charity bolted onto strategy. Designed well, the 'extra' cost becomes extra revenue, because care is read by customers as reliability. Lemon Tree never ran the spreadsheet first - but the spreadsheet followed.

MAKING IT REAL
The sweet shop that pays for staff quarters and a safe late-night drop is not being sentimental. Rested, loyal staff are why the counter never has a bad day - and customers can taste it. The kindness and the profit are the same design decision.

07 WHY THE NITTY-GRITTY WINS: MAPS, AUDITS, TWO HOSPITALS

The bridge to the second half was a slide most managers would call boring: a cross-functional process map of a Jeep repair - customer, sales, repair shop, parts, purchasing and supplier, each in its own swim lane, with work orders and forms flowing between them. His question: do you really need this level of detail - 'list required parts', 'make up order for parts'? The room, mostly senior corporate hands, was emphatic: yes. The evidence came from the class itself: one participant had just migrated the firm from Oracle to SAP - the process maps WERE the migration; another ended months of cross-functional blame by drawing swim lanes and getting every team to agree on the handoffs; a third pointed at audits - ISO and SOC certifications are, at bottom, documented process. And without documentation you re-solve the same rare machine failure from scratch every eight months, because nobody wrote down the last rescue. One portfolio manager added the honest nuance: depth is role-dependent - as a project manager he lived inside solution-architecture detail; now, running ten-plus projects with 79 people, he needs the maps to exist without personally being the cartographer. Fair - the map is mandatory; your immersion in it is situational.

Then the story that separates process from reputation. The professor's own cataract operation happened at a small, 'inconsequential' hospital - which handed him a printed sheet listing every step of the procedure in sequence, almost with timestamps, and whose staff moved like clockwork. His mother-in-law's operation, at a far more reputed hospital, was chaos: what happens next? 'Wait, we will tell you.' He still wonders how the second place became the famous one. **Reputation is not process.**

> **MAKING IT REAL**
> Ask a good halwai how he trains a new boy. Not 'watch me' - a fixed sequence: syrup first, flame at this mark, stir till this colour. The recipe card is a process map. Places that have one survive the founder's day off; places that don't, don't.

08 THE MDP TURNAROUND: Rs. 1.5 LAKH, ~44% A YEAR

His flagship story is from inside this campus. Alongside long-duration programmes like yours, IIM Calcutta runs MDPs - Management Development Programmes, short open courses of a few days (M for management, he clarified, not medium). In 2016 he took charge of Executive Education - while managing a family health crisis at home - and within days an email landed in which he was only in CC: the HR head of a marquee engineering client (L&T) writing, in effect, we will not send anyone to IIM Calcutta again. 'A massive earthquake.' The process he inherited: a prospective participant downloads a PDF nomination form, prints it, fills it by hand, scans it, emails it; the programme office prints it again and files it. People endured this Himalayan trek - that was how much they wanted the training - but the paperwork was not the killer. The killer was **sequencing**. Wanting to be customer-friendly, the institute confirmed every nomination immediately on receipt; then, 7-10 days before the programme, it re-counted heads and cancelled under-subscribed programmes with a regret note - after participants had booked tickets. In the name of customer orientation, the design manufactured betrayal.

The repair began by making the problem loud - the Director himself attended the first emergency meeting ('sometimes you must make a situation look worse than it is, so everyone understands its significance'). Then came data, which upended the professor's own intuitions: he had assumed busy executives prefer short programmes, but 5- and 6-day programmes ran 100 percent of the time, every 2-day programme was cancelled, and more than half the 3-day ones died. Pricing behaved backwards too: in education, higher-priced programmes filled more reliably, because price is read as a signal of quality - 'a strange industry that we are in.' The redesign had three moves, none expensive. **Sequence**: faculty confirm a programme's viability before any participant is confirmed. **Communication**: nominations are acknowledged with an explicit 'we will confirm by such-and-such date - please book no travel until then.' **Digitisation**: the print-scan-email loop was replaced by a proper database-backed portal - the institute helped build the front end, the professor coded the back end himself, total spend about Rs. 1.5 lakh (procuring software formally would have taken a year or two). No consultants, no capital project.

Measure	2015-16 (before)	2017-18 (after)
Programmes offered	52	56

Measure	2015-16 (before)	2017-18 (after)
Programmes actually held	29	50 (only 6 cancelled)
Participants	~515	crossed 1,000
Participant-days	2,496	~4,000-4,400
Revenue	Rs. 331 lakh	~Rs. 700 lakh

KEY INSIGHT

Good intentions are not good design - the broken step was born of niceness; instant confirmations felt customer-friendly and were the single point of betrayal. The fix was sequencing plus Rs. 1.5 lakh of digitisation - not budget, not headcount. Roughly 44 percent growth in each of the next two years (a doubling in two), while the five-person team's workload fell. Opportunities like this sit unclaimed because everyone watches outcomes and nobody watches the process.

Hence his prescription, only half-joking: once a week, swap an hour of Netflix for an hour of process-wandering - 'is there some other way to do this?' The day job is boring, he said; process change is where the creativity lives. It is also, not incidentally, how careers get made.

MAKING IT REAL

A tiffin service that instantly confirms every order, then cancels at 11 am when the count falls short, teaches customers to distrust it within a month. Confirm only what the kitchen has confirmed. Most 'service problems' are sequencing problems wearing a disguise.

09 FIVE WAYS TO ORGANISE WORK - THE VOLUME-VARIETY DIAGONAL

He opened with a photograph: Karan Johar on his own show in an outfit you will never see repeated - quite possibly the only unit ever made. Cloth worth perhaps Rs. 10,000, resources another Rs. 5,000, priced around Rs. 1 lakh - and it sells, on design, brand and the buyer's actual need: to be unmissable on camera. That is a **job shop**. The five types:

Process type	Signature	From the class
Job shop	Low volume, high variety; general-purpose equipment, skilled hands; process layout; no learning curve, no scale	Karan Johar's one-of-one suit
Batch shop	Job shop's cousin: bigger lots, less variety; shared resources with setups between batches	A heat-treatment furnace (a participant's example)
Assembly line	Repetitive processing of near-identical units; specialised equipment; product layout	Subway's counter; high-volume cataract surgery
Continuous flow	Variety of one; dedicated facility running 24x7 for weeks	A blast furnace making pig iron
Project	A defined sequence of activities; the end of all activities is the end; a one-shot affair	INS Vikrant at Cochin Shipyard

Two clarifications mattered. First, 'assembly line' means any repetitive near-identical process - Subway qualifies (veggie delight or chicken, the sequence is cut bread, fill, wrap), so does a hospital doing a hundred cataracts a day. Second - and he was emphatic - it is not a derogatory term: India's medical entrepreneurs turned process discipline into affordable, high-quality care at scale. Aravind Eye Care is the canonical case, where executive director Thulasiraj Ravilla (IIM Calcutta, 1973) has driven a goal of releasing every OPD patient within two hours - with staff literally checking that you are still in your seat so your file keeps moving. The world now flies in for Indian healthcare: his own UK toothache met a 28-day NHS wait or a 900-pound private quote, and the arithmetic where a heart patient flies business class to India and still spends a third of UK private cost is now routine. **Quality is not the casualty of process; it is the product of it.**

Where does a batch shop sit? Between the poles: more than one unit, some standardisation, but shared resources and a setup between batches. His thought experiment: if, purely hypothetically, the cataract procedure differed for men and

women, the hospital would run a women's batch, change over, then a men's batch - the moment resource-sharing forces changeovers between dissimilar lots, you are batching. All five sit on one continuum - the volume-variety paradox: job shop, volume of one and enormous variety; continuous flow, variety of one and enormous volume. The product-process matrix (Fig. 4.4 in the deck) draws the consequence - customised furniture, heavy equipment, automobile assembly and a sugar refinery sit on a diagonal, and the off-diagonal corners are labelled NONE: a continuous-flow plant for one-of-a-kind products, or a job shop for commodity volume, is a mismatch, not a strategy. An after-class question sharpened it: can one value chain mix types stage by stage? Yes, routinely - Asian Paints runs continuous flow at the factory (the white base and pigments) and near-job-shop tinting at the dealer's mixing machine for your exact mood of pink; a ready-made trouser runs down an assembly line to the store, where a tailor hems the length to you - a job-shop tail on an assembly-line body.

CONCEPT TRAP

'Assembly line' is a generic term for repetitive, near-identical processing - Subway sandwiches and cataract surgery both qualify. Do not reserve it for automobile plants in the exam, and do not treat it as an insult in discussion.

MAKING IT REAL

You have seen all five this month: the wedding tailor (job shop), the local bakery firing trays of biscuits between batches of bread (batch shop), the momo cart's cut-fill-fold rhythm (assembly line), the flour mill that never stops (continuous flow), and the metro station rising down the road (project).

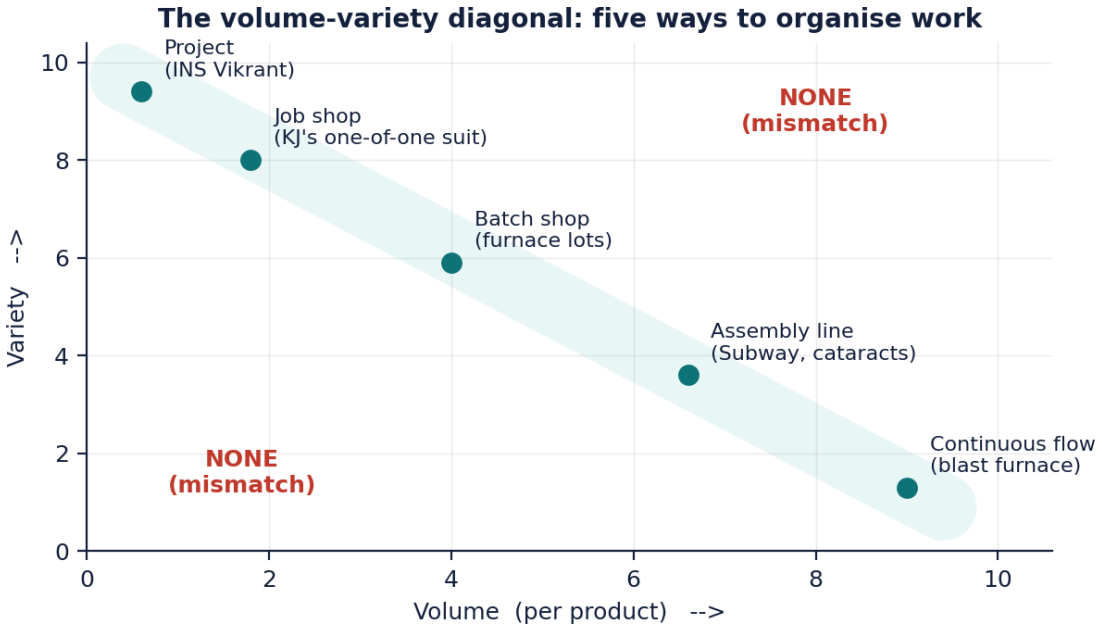


Fig 2.2 - The volume-variety diagonal: from a one-of-one project to continuous flow, with the off-diagonal corners marked NONE - a mismatch, not a strategy.

10 THE NUMBERS TOOLKIT - AND BOTH ASSIGNMENTS, SOLVED

The last hour turned quantitative - in his view the most important stretch for anyone within reach of operations. He also issued a warning worth recording before the assignments:

The more ChatGPT you use for these type of things, the less will be there in your own system. Solve them with your own head first.
PROF. BALRAM AVITTATHUR - BEFORE THE ASSIGNMENTS

Term	This course's definition
Cycle time	The interval between two consecutive units coming out of the process - set by the slowest stage
Bottleneck	The stage that governs the output rate of the whole process
Setup time	Preparing a resource for the next item (necessary, but no value work)
Operation time	Setup time + run time for a batch of parts
Waiting time	Queuing for a resource, with nothing happening to the unit
Throughput time	Operation + waiting - the average time one unit takes end to end
Capacity	The maximum a system can produce in a given time period
Capacity utilisation	Actual output / capacity
Productivity	Output / input

CONCEPT TRAP

The slide's wording - cycle time is 'time required to produce one unit' - invites the wrong reading. Cycle time is NOT how long one unit spends inside the process (that is throughput time). Stand at the end of the line: the interval at which finished units appear is the cycle time. Ten shops give ten definitions; in this course and this exam, use this one.

Collate and staple: the two-minute drumbeat. Two stages: collate a five-page set (2 minutes), staple it (1 minute), one person each, start 4:00 pm. The first set leaves collation at 4:02 and is stapled by 4:03; the second at 4:04, stapled by 4:05; then 4:07, 4:09... Finished sets appear every two minutes: **cycle time = 2 minutes**, set by collation - the bottleneck. Throughput time = 2 + 1 = 3 minutes (no waiting here). Hourly output = 30 sets, though the stapler could do 60 - the bottleneck's capacity is the system's capacity, and the stapler idles half the time. Add a second collator and cycle time falls to 1 minute; the stapler is finally busy.

The airline test for the taxonomy. An aircraft's 30-40 minutes at the gate - deplaning, cleaning, boarding - is setup time: readying for the next flight, exactly like scrubbing the kadai between two dishes. The queue of five aircraft ahead at the runway is waiting time: nothing is happening to you. The five-minute taxi from gate to runway is operation time. Throughput time is the sum of all three - which is why his 4:30 am ride from campus to the airport takes 45 minutes door to door (pure operation), and the same ride at 4:30 pm takes two hours plus: operation, plus waiting, plus even a mid-ride switch of cabs - a setup inside the journey.

Little's Law: counting the crowd without counting. Throughput time = WIP / throughput rate, or rearranged, **WIP = throughput time x throughput rate**. His eye-hospital OPD: a cycle time of one minute means 60 patients an hour flow through; each visit takes one hour end to end. Walk in at 8:00 am, after the system has warmed up, and you will find exactly 60 patients inside - the 7:00 arrival is just leaving as the 8:00 arrival enters. No faith in the formula required; count them. It is also why queues explode when rates dip: rain cutting an intersection from 100 vehicles a minute to 80 can freeze a corridor - one centimetre of rain can cripple Delhi or Bengaluru, and the maths, not the traffic police, is the villain. (An after-class exchange added the industry footnote: car plants speak of takt time - the conveyor's pace - against each station's cycle time, and matching the two is line balancing; his reading tip for anyone in that industry, Arthur Hailey's novel Wheels.)

Assignment 1, solved: the dumper fleet

One shovel loads waste; dumpers carry it to the dump. Loading 7.5 minutes; travel 9; dumping 2; return 7 (round trip 25.5). Shovel with operator Rs. 200/hour; each dumper with driver Rs. 800/hour. How many dumpers to hire? One dumper first: loaded 8:00 to 8:07:30 (the shovel active, the dumper standing there), travels, dumps, returns - back at the shovel at 8:25:30. Cycle time = max(7.5, 25.5) = 25.5 minutes; the shovel works 7.5 of those and idles 18. The general move: **cycle time with n dumpers = max(7.5, 25.5 / n)**. The arms cross at 25.5 / 7.5 = 3.4, so only n = 3 and n = 4 are worth examining - with four, each dumper returning at 8:25:30 finds the fourth still loading until 8:30, a built-in 4.5-minute breather per cycle.

Performance measure	1 dumper	3 dumpers	4 dumpers
Cycle time	25.5 mins	8.5 mins	7.5 mins
Shovel utilisation	29.4%	88.2%	100%
Dumper utilisation	100%	100%	85%
Process capacity (loads/hour)	2.35	7.05	8.0
Total cost per load	Rs. 425.50	Rs. 368.79	Rs. 425.00

Costs settle the two questions differently. Cost per hour = Rs. 200 + Rs. 800n, divided by loads per hour. **Finish the work earliest: hire four** (capacity 8 loads/hour). **Minimise cost per load: hire three** (Rs. 2,600 / 7.05 = Rs. 368.79). The two objectives disagree - which is precisely the question's point.

EXAM TIP

Memorise the move, not the numbers: CT(n) = max(loading time, round-trip / n). Find the crossover n* = round-trip / loading time; evaluate the whole numbers on either side; then utilisation = busy time / CT, capacity = 60 / CT, cost per load = hourly cost / hourly capacity.

Assignment 2, solved: the departure terminal

A not-so-modern airport: identity check (1 min, 2 entrances), checked-baggage scanning (3 min, 3 machines), check-in with boarding pass (4 min, 5 counters), security (2 min, 3 counters). One airline; only half the passengers carry checked baggage. (First answers of 50 and 15 in class came from missing the multiplication by counters - or the baggage line.)

Stage	Time x servers	Capacity per hour
Identity check	1 min x 2	120 passengers
Baggage scanning	3 min x 3	60 bags = 120 passengers (half carry bags)
Check-in	4 min x 5	75 passengers - THE BOTTLENECK
Security	2 min x 3	90 passengers

System capacity = **75 passengers/hour**, set by check-in. To process 120/hour: check-in needs 120 / 15 = 8 counters (add 3); security needs 120 / 30 = 4 (add 1); the other two stages already stand at 120. And a closing thought from after class: the deepest capacity lever is often process redesign, not more counters - at Istanbul's airport, security is a walk-through with nothing removed, no belts, no laptops out; the same change here, he reckoned, could roughly double a security lane's capacity without adding a single counter.

CONCEPT TRAP

Read the fine print: 'only half the passengers carry checked baggage' turns 60 bags/hour into 120 passengers/hour of support. And in this module the constraint is a BOTTLENECK - 'critical path' belongs to project management ('use it in Prof. Megha Sharma's class,' he joked, 'not in mine').

AFTER CLASS: THE ZUDIO QUESTION

A participant from lifestyle retail asked his read on Zudio, Trent's runaway value-fashion format. His answer was a confession: he had assumed another patient Tata bet and found instead a highly profitable business - Westside struck him as 'the Indian Zara', and the numbers floored him: roughly a 47-day inventory cover, barely any discounting, an end-of-season sale of about a fortnight. The student added the puzzle: Zudio's average price point (around Rs. 1,500) sits far below Zara's Rs. 4,500-6,000, so it cannot be a copy-paste of Zara's economics - yet the fingerprints of small lots and frequent replenishment are all over it, with the supply chain kept deliberately opaque. A live Indian case for Session 1's thesis: the advantage is in the process, and the process is exactly what outsiders cannot see.

SESSION 2 IN ONE BREATH

Operations is transformation: inputs vanish into outputs while resources remain. Efficiency minimises the rupee cost per unit and serves the owner; effectiveness maximises every other stakeholder's welfare, value minus price. Toyota proves the conflict is a design failure, and Lemon Tree shows effectiveness quietly producing efficiency's prize. The route to both runs through process: map it (the MDP turnaround paid ~44% a year on a Rs. 1.5 lakh fix), classify it (job shop to continuous flow along the volume-variety diagonal), and measure it (cycle time set by the bottleneck; throughput = setup + operation + waiting; WIP = throughput time x rate).

MCQ SESSION 2 DRILL - 41 QUESTIONS

Q1. By the 100-percent-valid test, manpower is a resource and not an input because:

a) It appears on the balance sheet
b) It is paid monthly
c) After the transformation it is fully intact, while inputs no longer exist
d) It cannot be outsourced

Ans (c): Iron ore vanishes into pig iron; the worker and furnace remain - the vanishing test settles every debate.

Q2. In the cash-flow reading of a process:

a) Inputs are inflows, outputs are outflows
b) Inputs and resources are outflows; outputs are inflows
c) Only resources are outflows
d) Depreciation is an inflow

Ans (b): A resource's outflow may be years old (depreciation), but it is an outflow all the same.

Q3. The course definition of efficiency is:

a) Maximising output at any cost
b) For a given unit of output, minimising the inputs and resources required, in currency terms
c) Doing the right things for all stakeholders
d) Maximising customer surplus

Ans (b): Efficiency is cost minimisation in polite clothing - the operational route to profit maximisation.

Q4. Patancheru's antibiotic-resistance story illustrates that:

a) Efficiency always improves quality
b) Cost-cutting deletes costs permanently
c) Aggressive efficiency relocates costs onto stakeholders outside your P&L
d) Regulation has no role in operations

Ans (c): The saving showed as efficiency on the plant dashboard; the bill moved to the community's health.

Q5. Effectiveness is defined in this course as maximising the welfare of:

a) All stakeholders including the owner
b) All stakeholders except the owner
c) Customers only
d) Employees only

Ans (b): Efficiency already serves the shareholder; effectiveness need not repeat the favour.

Q6. Customer welfare, precisely, equals:

a) Price minus cost
b) Value minus price
c) Revenue minus discount
d) Quality minus defects

Ans (b): The Rs. 20 bottle worth Rs. 40 on a hot day gives Rs. 20 of welfare; on a rainy day, none - the value moved.

Q7. Income-tax e-filing was classified as:

a) Pure efficiency
b) Pure effectiveness
c) Both - department cost fell from ~Rs. 3 to ~Rs. 0.5 per Rs. 100 collected while citizen filing collapsed to minutes
d) Neither

Ans (c): One redesign served the owner (cost) and the stakeholder (time) simultaneously.

Q8. Zara is MORE profitable than efficient rivals despite 15-20% costlier materials because:

a) It pays suppliers late
b) Its revenue quality is higher - customers hunt novelty and scarcity, and nobody asks for a discount
c) It advertises more
d) It has lower rents

Ans (b): Higher costs, higher-quality revenue, better margins - effectiveness producing efficiency's prize.

Q9. The Lemon Tree mechanism, articulated in hindsight, is:

a) Disability hiring qualifies for tax breaks
b) A firm that visibly cares for its own people signals to guests that it will care for them
c) Lower wages reduced cost
d) Awards drove bookings

Ans (b): Care is read by customers as reliability - the 'extra' cost became extra revenue.

Q10. A layoff announcement lifting a share price is best described as:

a) Effectiveness
b) Efficiency as theatre - the market applauds the cost signal before any cost is saved
c) Operational excellence
d) Process innovation

Ans (b): The signal, not the saving, moves the price - the opposite of the Lemon Tree design.

Q11. The single point of betrayal in the old MDP process was:

a) The PDF nomination form
b) Slow email replies
c) Confirming every nomination instantly, then cancelling under-subscribed programmes after participants had booked travel
d) High programme fees

Ans (c): Sequencing, not paperwork, was the killer: faculty viability now precedes any participant confirmation.

Q12. A hospital doing one hundred identical cataract surgeries a day is best classified as:

a) Job shop
b) Batch shop
c) Assembly line
d) Project

Ans (c): Repetitive, near-identical processing is an assembly line - and quality is the product of that process, not its casualty.

Q13. Collate (2 min) then staple (1 min), one person each. Cycle time, throughput time and hourly output are:

a) 1 min, 3 min, 60 sets
b) 2 min, 3 min, 30 sets
c) 3 min, 2 min, 20 sets
d) 2 min, 2 min, 30 sets

Ans (b): The slowest stage (collation) sets CT = 2; TP = 2 + 1 = 3; output = 60/2 = 30, while the stapler idles half the time.

Q14. An aircraft's 30-40 minutes at the gate (deplaning, cleaning, boarding) is:

a) Waiting time
b) Operation time
c) Setup time
d) Throughput time

Ans (c): It is preparation for the next flight - like scrubbing the kadai between dishes. The runway queue is the waiting time.

Q15. An OPD has a 1-minute cycle time and a 1-hour visit. Average patients inside the system:

a) 1
b) 30
c) 60
d) 3,600

Ans (c): Little's Law: WIP = throughput time x rate = 1 hour x 60/hour = 60.

Q16. Dumper problem (load 7.5, round trip 25.5, shovel Rs. 200/hr, dumper Rs. 800/hr): to minimise cost per load, hire:

a) 2 dumpers
b) 3 dumpers (Rs. 368.79/load)
c) 4 dumpers (Rs. 425/load)
d) 5 dumpers

Ans (b): Crossover n* = 25.5/7.5 = 3.4; three dumpers minimise cost per load, four merely finish fastest.

Q17. In the departure terminal, the bottleneck and system capacity are:

a) Baggage scanning, 60/hour
b) Identity check, 120/hour
c) Check-in, 75 passengers/hour
d) Security, 90/hour

Ans (c): Check-in: 5 counters x 15/hour = 75, the lowest stage capacity - the system's capacity.

Q18. To lift that terminal to 120 passengers/hour you must:

a) Add 3 check-in counters and 1 security counter
b) Add 2 baggage scanners
c) Add 1 identity entrance
d) Add 3 security counters only

Ans (a): Check-in needs 120/15 = 8 counters (+3); security 120/30 = 4 (+1); the other stages already stand at 120.

Q19. Negative electricity prices - buyers paid to consume - were cited to show:

a) Outputs are always cash inflows, no exceptions
b) Even the cleanest mapping (outputs = inflows) has exceptions when supply swamps demand
c) Electricity is not an output
d) Power firms are inefficient

Ans (b): Rare, but a useful reminder: in spot markets, oversupply can flip the sign of the inflow.

Q20. Standing in Calcutta while needing to be in Delhi is, in the transformation lens:

a) A resource
b) An output
c) An input - an unmet need qualifies; you rent the airline's resources to transform it
d) Waste

Ans (c): Inputs need not be physical; if we could all fly, airlines would have nothing to transform.

Q21. Why does the word 'efficiency' survive in boardrooms while 'cost minimisation' draws resentment?

a) They mean different things
b) Only 'efficiency' passes as pure virtue - nobody hears their own job inside it
c) Cost minimisation is illegal
d) Efficiency excludes labour costs

Ans (b): Test the three phrases: profit maximisation and cost minimisation sound like someone pays; efficiency sounds like everyone wins.

Q22. Sumit finishes in one hour what takes Biju three. Sumit's reward is:

a) Two hours off
b) The next task - same salary, more output; the employer's resource cost per unit falls
c) A share of the savings
d) Nothing changes

Ans (b): That is exactly why it counts as efficiency: a paid resource's time per unit of output was minimised.

Q23. The professor's cheeky 'peace formula' for employees ground down by efficiency drives:

a) Change jobs annually
b) Work less
c) Buy the company's shares - when the squeezing is high, the profits usually are too
d) File a complaint

Ans (c): He held his old employer's stock for decades - partly nostalgia, mostly returns.

Q24. His Rs. 50,000 Google Pixel, privately valued above Rs. 60,000, illustrates:

a) Impulse buying
b) Welfare = value minus price: a surplus of Rs. 10,000-plus - and a sheepish thank-you to his son
c) Price equals value
d) Phones are A items

Ans (b): You buy when your value exceeds the price; the gap is your welfare.

Q25. An employee valuing the job at Rs. 3 lakh while paid Rs. 2 lakh praises the firm - until a Rs. 2.5 lakh offer arrives. Lesson:

a) Loyalty is permanent
b) Employee welfare is the perceived value-minus-price gap, not the evening chocolates
c) Salary does not matter
d) Counter-offers always work

Ans (b): Shrink the surplus below an outside option and twenty years of loyalty evaporates by lunchtime.

Q26. Selling only a single large pack size was classified as:

a) Effectiveness - it serves customers
b) Efficiency - it favours the producer's cost structure, not the customer's actual need
c) Both
d) Neither

Ans (b): Flip it - smaller packs, more often - and the same product line moves toward effectiveness.

Q27. One 100-seater bus every 30 minutes versus 25-seaters every 15 minutes:

a) Both are efficiency
b) The first is efficiency (producer's cost per seat); the flip to smaller-more-frequent is effectiveness
c) The first is effectiveness
d) Bus size is irrelevant

Ans (b): Same route, same total seats - the design choice decides whose welfare is being optimised.

Q28. 'Design', in the effectiveness discussion, means:

a) Product styling
b) Every stakeholder considered in every decision - the women-workforce safe commute is part of the plant's design, not the government's headache
c) Outsourcing HR
d) Annual CSR budgets

Ans (b): A design that optimises for a subset of stakeholders is an incomplete design.

Q29. Toyota spending 'extra' on employee and customer welfare is defended because:

a) Regulation requires it
b) An extra cost of 10 that returns more than 10 is not a cost at all
c) Toyota cannot control spending
d) It reduces taxes

Ans (b): It wants the best employees and best customers - effectiveness quietly producing efficiency's prize.

Q30. The class evidence for process maps included all of these EXCEPT:

a) An Oracle-to-SAP migration where the maps WERE the migration
b) Swim lanes ending months of cross-functional blame
c) ISO and SOC audits being documented process at bottom
d) Maps eliminating the need for any digitisation

Ans (d): Maps enable migration, accountability and audit; the MDP story still needed its Rs. 1.5 lakh portal.

Q31. The professor's two-hospitals story (his cataract vs his mother-in-law's) teaches:

a) Famous hospitals have better processes
b) Reputation is not process - the small hospital ran like clockwork with a printed step-sheet; the reputed one ran on 'wait, we will tell you'
c) Surgery quality depends on size
d) Process sheets are bureaucracy

Ans (b): He still wonders how the second place became the famous one.

Q32. The MDP data upended intuition on programme length:

a) Short programmes filled best
b) 5-6 day programmes ran 100% of the time; every 2-day was cancelled and more than half the 3-day ones died
c) Length made no difference
d) Only 1-day events survived

Ans (b): He had assumed busy executives prefer short programmes; the data said the opposite - and higher price filled MORE reliably ('a strange industry').

Q33. The MDP repair cost about Rs. 1.5 lakh because:

a) Consultants were hired
b) The institute helped build the front end and the professor coded the back end himself - formal procurement would have taken a year or two
c) Software was pirated
d) Only stationery was needed

Ans (b): Sequencing + communication + digitisation - not budget, not headcount - bought ~44% growth a year.

Q34. The professor's half-joking weekly prescription:

a) An hour more email
b) Swap an hour of Netflix for an hour of process-wandering - 'is there some other way to do this?'
c) Attend two more meetings
d) Memorise formulas

Ans (b): The day job is boring; process change is where the creativity lives - and how careers get made.

Q35. If cataract procedures hypothetically differed for men and women, the hospital would run women's and men's batches with a changeover - because:

a) Assembly lines forbid variety
b) The moment resource-sharing forces changeovers between dissimilar lots, you are batching
c) Projects require batches
d) Continuous flow demands it

Ans (b): That is the precise trigger separating a batch shop from a pure assembly line.

Q36. His 4:30 am airport ride takes 45 minutes; the 4:30 pm ride takes two hours plus. The extra time decomposes into:

a) Pure operation time
b) Operation plus waiting - plus even a mid-ride switch of cabs, which is a setup inside the journey
c) Setup only
d) Cycle time

Ans (b): Throughput time = setup + operation + waiting; the clock does not care which one is eating you.

Q37. Rain cutting an intersection from 100 to 80 vehicles a minute can freeze a corridor because:

a) Drivers panic
b) Little's Law: with arrivals steady, a lower throughput rate makes the accumulating queue explode - the maths, not the traffic police, is the villain
c) Roads shrink in rain
d) Signals fail

Ans (b): One centimetre of rain can cripple Delhi or Bengaluru - queueing arithmetic at city scale.

Q38. Takt time (from the after-class exchange) is:

a) The bottleneck's cycle time
b) The conveyor's pace that each station's cycle time must match - aligning the two is line balancing
c) Total throughput time
d) Setup time per batch

Ans (b): Car-industry vocabulary; his reading tip for that world was Arthur Hailey's novel Wheels.

Q39. With four dumpers, each returning dumper waits 4.5 minutes while the fourth loads. The measures read:

a) Shovel 88.2%, dumpers 100%
b) Shovel 100%, dumpers 85% - capacity 8 loads/hour, the fastest but not the cheapest configuration
c) Both at 100%
d) Shovel idle

Ans (b): Four maximises capacity (finish earliest); three minimises cost per load - the objectives disagree, which is the point.

Q40. Istanbul airport's walk-through security (nothing removed, no belts, no laptops out) shows:

a) More counters is the only lever
b) The deepest capacity lever is often process redesign - roughly doubling a lane's capacity without adding a counter
c) Security must be slow
d) Bottlenecks cannot move

Ans (b): Before buying capacity, redesign the work the capacity does.

Q41. The Zudio numbers that floored the professor:

a) 300-day inventory and deep discounting
b) Roughly a 47-day inventory cover, barely any discounting, a fortnight's end-of-season sale - at a Rs. 1,500 price point far below Zara's
c) Zara-level prices in India
d) A fully transparent supply chain

Ans (b): Not a copy-paste of Zara's economics, yet the fingerprints of small lots and frequent replenishment everywhere - with the chain kept deliberately opaque.

SESSION 3 OF 5 - Prof. Balram Avittathur - Live Online, 28 June 2026

MTS, MTO and the Mathematics of Inventory

Why 95-97 percent of everything you consume is made to stock, why the make-to-order revolution never came, and the two formulas - EOQ and the newsvendor's critical ratio - that run procurement everywhere from Maruti to the paowala.

01 THE CHINGRIGHATA LESSON: THEORY IS OLD, USAGE IS RARE

The session opened with a confession from the professor's own Saturday. His son had a 6:55 pm flight to Indore; at 2:30 pm Google Maps quoted 1 hour 26 minutes from campus to the airport (about 35 km), with no red anywhere. They left at 3:05 with a professor-of-operations buffer - on a Saturday afternoon when state government offices were shut and, it being the fourth Saturday, banks too - and reached after 5:30, the flight saved only by the padding. The cause, discovered later: the Chingrighata crossing had been closed from Friday evening to Monday morning to place three flyover beams - news that had not reached even Google Maps. One intersection's closure cascaded until, by his estimate, every journey above ten kilometres in the city ran an hour late. Next morning, for his wife's flight, they left at 5:00 and reached by 6:00 - absurdly early, and gladly so.

Why tell it? Because everything in Session 2 has sat in textbooks for fifty or sixty years - open a 1960s operations text and cycle time is there - and its usage is still this thin, in firms and in cities. He confessed he nearly retired the process-analysis lecture around 2013-14 as too obvious to teach. Then 2014 happened: Amazon's rise (and later quick commerce) put cycle time, throughput time and bottleneck back into boardroom vocabulary - one firm, miles ahead of everyone, on the strength of simple operations arguments coded into software. He sketched the longer arc: into the early 1980s, operations sat at the centre of the firm and everything else was a support function. From the mid-80s the narrative was captured - by marketing ('package it well and you can sell anything'), by strategy (Porter's frameworks, the BCG two-by-twos), by finance - to the point where operations management actually fell out of several American MBA syllabi. 'Luckily, that did not happen in India.' Walmart, Dell and Amazon dragged the subject back. His counsel: treat operations, statistics and operations research as career-critical equipment, not background plumbing - the machinery humming behind everything from Google Maps to your grocery app.

KEY INSIGHT

The gap between operations theory (settled for half a century) and operations practice (thin everywhere) is precisely the career opportunity. Amazon's edge was not new theory; it was old theory finally taken seriously - and coded into software.

MAKING IT REAL

Even the best navigation app is only a process model: one closure missing from the data, and the model fails city-wide. Your firm's ERP is no different. The map is only as good as what the process feeds it - and someone has to own the feeding.

02 MAKE-TO-STOCK, MAKE-TO-ORDER - AND THE HYBRID BETWEEN

The formal frame. **Make-to-Stock (MTS)** produces standard products ahead of demand and serves the customer from inventory - the natural partner of the assembly line. **Make-to-Order (MTO)** activates production only in response to an actual order - the job shop's world. And the **hybrid** makes and stocks a generic product, finishing it only against real orders. The class sorted examples quickly: automobile plants, MTS; a readymade coat, MTS; Raymond fabric stitched for you, MTO; Karan Johar's one-of-one suit, pure MTO. His childhood school uniform captured both in one purchase: the fabric came from the school's designated shop (make-to-stock), then a tailor sat on it for a month before stitching it (make-to-order) - with a small boy's rising panic as reopening day approached. A custom-printed t-shirt today is roughly 90 percent MTS (the shirt) and 10 percent MTO (the print). When he polled the class on their own consumption, most

guessed a 90:10 split; his estimate of reality is harsher - **95-97 percent of what we consume is make-to-stock**. The 1990s prophecy that everything would migrate to MTO (revived by 3D printing, which has since gone quiet) simply never happened; if anything, old MTO like uniform tailoring has migrated to MTS.

Characteristics	Make-to-Stock	Make-to-Order
Product	Producer-specified; low variety; inexpensive	Customer-specified; high variety; expensive
Objectives	Balance inventory, capacity and service	Manage delivery lead times and capacity
Main operations problems	Forecasting; planning production; control of inventory	Delivery promises; delivery time

One distinction he slowed down for: the two systems carry **different clocks**. Total lead time - source to consumption - is usually longer in MTS: the packet of chips you eat in June was manufactured in April and slept in three warehouses on the way (only milk and bread escape this). What MTS compresses is the customer's order-to-delivery time, because the stock already sits near you. MTO's lead time is almost all processing with little waiting - but the clock starts only when you order, so the customer feels it in full.

CONCEPT TRAP

'Which system has the longer lead time?' depends on which lead time. Total, source-to-consumption: MTS. Perceived, order-to-delivery: MTO. An exam answer must name the clock it is using.

MAKING IT REAL

One sweet-shop counter runs all three systems at once. The barfi in the display case is make-to-stock. The five-kilo wedding order prepared fresh tonight is make-to-order. And the khoya base made every morning, flavoured only when you choose, is the hybrid.

03 WHY THE MTO REVOLUTION NEVER CAME: THE TYRANNY OF UTILISATION

Two reasons are visible from the surface: customisation is costly (the scale effect evaporates), and lead times stretch beyond what customers tolerate. But his deeper reason is **capacity utilisation**. Any capacity is an investment, and every investing brain is coded to one statistic - run a factory and your boss asks for your utilisation weekly if not daily. Make-to-stock lets you run near 100 percent against a forecast. A pure make-to-order system running near 100 percent makes customers queue forever - so MTO structurally cannot give capital the busy-ness it demands. The proof is on your phone: quick commerce delivers in 15-20 minutes only because dark stores keep armies of riders standing by - deliberately low human utilisation. Staff a dark store to average demand and the ten-minute promise dies the same day. His own evidence: a large retailer's store near the campus now doubles as an online fulfilment node, its parking permanently colonised by delivery motorbikes; and no Domino's outlet anywhere is without idle blue scooters at the kerb. That idleness is not waste - it is the product.

The counter-current proves the rule. Southwest Airlines squeezes its aircraft - 13-14 flying hours out of an 18-hour operating day, 20-minute turnarounds - but that is a standardised, MTS-style service chasing utilisation, not customisation. Pure MTO survives at the value-over-volume fringe: Ferrari's famously tiny volumes, Rolls-Royce, Rolex - profitable niches, not disruptions (and even Europe's luxury houses, he noted, now feel China at their backs). Dell owned the MTO middle from about 1996 to 2005-06; then the PC commoditised, the glamour moved to smartphones, and even that industry drifted back toward make-to-stock. He closed the half with the same scale-obsession loose in education - an Economist piece on universities chasing enrolment while rigour dilutes, test scores falling decade on decade. His barb, with the honest caveat that his own institute rides the same wave: 'When an MBA programme throws out operations management, I have no hesitation saying the rigour is gone. You have become friendlier to the student - and you are selling an inferior product.'

KEY INSIGHT

MTS dominates because capital demands utilisation and MTO cannot deliver it. Every ten-minute delivery you enjoy is bought with someone's deliberately idle capacity - you are consuming low utilisation as a service.

MAKING IT REAL

The pizza counter keeps more riders than the average hour needs; on a slow Tuesday they lean on their scooters. That 'waste' is exactly what the 30-minute promise costs. Whenever a business promises speed, ask whose idleness is paying for it.

04 ASSEMBLE-TO-ORDER: THE ASIAN PAINTS TRICK

Between the poles sits the formalised hybrid - **Assemble-to-Order (ATO)**: make and stock a generic base, finish it only against a real order. The national example is Asian Paints. The factory runs continuous flow on the white base and the pigments - make-to-stock all the way to the dealer. The store's computerised tinting machine then mixes your exact mood of pink on demand - the make-to-order tail. Thousands of shades served in minutes from a handful of stocked components, depending, as he put it, entirely on the mood of the day - pink today, blue day after tomorrow, and they are ready for either. The slide's scorecard: less inventory and faster service than pure MTO, at the price of some work-in-process inventory; the measures that matter are speed of service, inventory levels, and quality. The design question is **where to put the customisation boundary**. Dell held it at the factory - standardise everything up to the point the customer cares about, then assemble to the order. Asian Paints pushes it all the way out to the retailer. Everything before the boundary enjoys scale and forecasting; everything after it delivers the customer's whim. (The ready-made trouser from Session 2 - assembly line to the store, tailor's hemming at the store - is the same idea in cloth.)

MAKING IT REAL

A juice corner stocks cut fruit on forecast and blends your glass on order. Momos are steamed ahead; the plate is assembled when you point. Half the street-food economy is assemble-to-order without ever hearing the term - the base is a bet, the finish is a response.

05 THE QUICK-COMMERCE DEBATE - WHAT THE CLASS CONCLUDED

Mid-session he polled the room: everything considered, has quick commerce made your life better? The obvious yes - rain outside, an uninvited guest, no milk at home, no parking wars - met his contrarian audit. Until 2020 his household ran on one weekly trip to one well-stocked store, everything in one place, requests passed to the manager. Post-COVID, that single trip has splintered into five or six app orders a week, because no single app stocks everything: **variety at dark stores is shrinking, not growing**, since a store close to you can only hold so many items. He mourned Big Basket's old hub-and-spoke model - a city hub with nearly everything, feeding the spokes - now being competed away; you buy 500 g of bhindi because that is the pack, and the 200 g you wanted is not an option.

The batch's contributions, kept honest on both sides. **For**: zero planning needed, instant rescue when the guest arrives, you pick exactly what you want without a cart of temptations, easy comparison across brands, and returns that actually work (Big Basket's photo-and-refund earned specific praise). **Against**: handling and delivery fees stack up, flash offers manufacture impulse buys ('MRP 120 at 70 - you buy what you never needed'), broken milk packets, vegetable quality you cannot inspect, fresh frustration when the promised slot slips, and the quiet death of the monthly-ration discipline that once ran a household. His sociology: penetration is still only about 1 percent - price-sensitive India has not converted, and the kirana is still crowded on Sunday evening. And the thread back to theory: quick commerce is not make-to-order at all. It is **make-to-stock pushed to your doorstep**, with all of MTS's constraints - limited variety held near you - hidden behind the ten-minute thrill. He even cheered the regulator's nudge that stopped the '10 minutes' advertising: the delivery boys' faces have smiles again, he said, and driving past a dark store is safer.

MAKING IT REAL

The kirana asks 'usual?' and packs your month in one bag - that is a forecast. The app asks nothing and sells to you six times a week - that is a funnel. Convenience and control are different products; know which one you are buying.

06 ABC ANALYSIS: NOT EVERY ITEM DESERVES YOUR ATTENTION

The pivot to inventory began with a discipline question: should everything you buy get equal management attention? No - and the tool is **ABC analysis**. Take every item you purchased last year, compute its annual Consumption Value (CV = annual demand x unit cost), and rank the list in descending order. Pareto's shape appears every time: **A items** - the top ~10 percent of items, carrying about 70 percent of total CV; **B items** - the next 20 percent, about 20 percent of CV; **C items** - the bottom 70 percent of items, worth only ~10 percent of CV (the slide's ten-item example walks the cumulative-usage column and assigns the classes). If your raw-material bill is Rs. 100 crore, roughly Rs. 70 crore rides on that top sliver. Policy then follows the class - twice over, and the two halves trip everyone. **Ordering**: A items are bought in small, very frequent lots - daily, against a standing contract - while C items are bought rarely, in bulk (salt for the whole year in one shot); the transaction cost of an order is roughly the same whatever the item, but holding cost scales with value. **Safety stock**: the intuition reverses. A items carry MORE days of safety stock, not fewer - not because of cost, but because of **supply risk**: an A item is often specialised, with one or two capable suppliers who cannot be replaced in five days; a C item (nuts and bolts) has a bazaar full of substitutes. Hence long-term contracts, relationship investment and physical proximity for A suppliers - Maruti's A-class vendors famously sit within an hour of the plant - while a C supplier can be anywhere, even overseas.

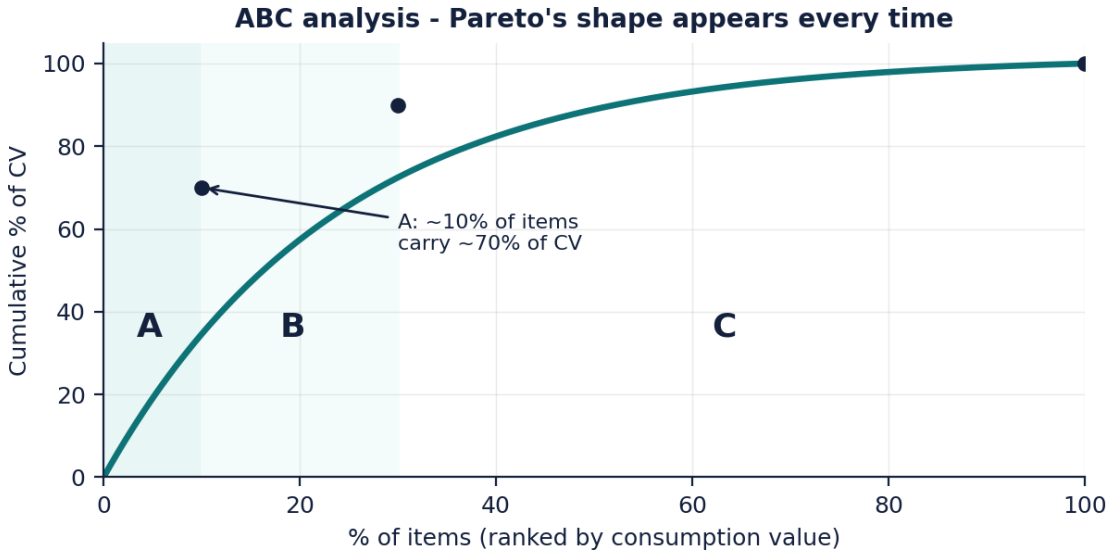


Fig 3.1 - Pareto's shape: rank items by consumption value and the cumulative curve bends the same way every time - A carries ~70%, C barely 10%.

Class	Items / CV	Order pattern	Cyclic stock	Safety stock	Supplier strategy
A	~10% / ~70%	Small lots, very frequent	Low (days)	Highest (days)	Few, contracted, nearby, relationship-heavy
B	~20% / ~20%	Intermediate (weekly-ish)	Medium	Medium	In between
C	~70% / ~10%	Bulk, infrequent	High	Least	Many substitutes; location immaterial

Your kitchen already runs ABC: fruit (valuable, perishable) every few days, rice monthly, salt once a year. A participant's question sharpened the tool's limit: a car's chip is a C item by value, yet - as the shortage years proved - it can halt the whole industry. His answer: ABC is the vanilla cut; the **Kraljic** view crosses value with supply risk. A low-value, high-risk

part is a **bottleneck** item; high-value, high-risk is **strategic** (crude oil); high-value, low-risk is **leverage** (the bargaining power is yours); the rest are non-critical routine buys. Which item wears which label keeps rotating - COVID's chip crunch has become AI's - and no formula rescues you. This, he said plainly, is exactly where managers get to be stars or failures; just beware hindsight, because every bold inventory call looks like grand strategy only after it pays.

EXAM TIP

A items: order OFTEN in SMALL lots - but hold MORE safety-stock days. C items: order rarely in bulk, minimal safety stock. The exam loves flipping exactly one of these four. Anchor the logic: lot size follows holding cost; safety stock follows supply risk.

MAKING IT REAL

A caterer guards his saffron (costly, one trusted supplier, an extra tin always in reserve) very differently from his salt (any shop, one sack a season). Same shelf, two policies - that is ABC without a spreadsheet.

07 THREE COSTS, TWO TRADE-OFFS - AND CHINA'S 100 DAYS OF OIL

Every inventory decision trades between exactly three costs. **Ordering cost** - the transaction burden of each order placed. **Holding (carrying) cost** - capital locked, warehousing, preservation. And **shortage cost** - which is not an expense at all but a lost profit: the shop that does not have your milk loses the sale to the next shop; the mango-seller who stocked 50 against a likely demand of 100 forfeited the margin on every unserved customer. It looks like a cost; it is really revenue that never arrived. And there are only **two** trade-offs, not three - a batchmate nailed it, crediting Prof. Manju Jaiswal's costing sessions. Ordering versus holding: resolved by **cyclic stock** - the EOQ question of how often to buy. Holding versus shortage: resolved by **safety stock** - the cushion question. There is no meaningful ordering-shortage trade-off; the two barely touch. Any inventory, anywhere, decomposes into those two components - cyclic stock is Q/2 (half your order quantity), and whatever average inventory exceeds Q/2 is your safety stock. Give him your order data, he offered, and he will split the two on the spot.

Then the trick question: open any manufacturer's P&L - where is the line called 'inventory cost'? Nowhere. The COGS arithmetic (opening 100 + purchases 500 - closing 150 = 450) is a flow computation, not an inventory cost. The true cost arrives in disguises - working-capital interest, warehouse rent, preservation, security, handling labour, depreciation - 'like Vishnu,' in his image, 'inventory has many incarnations.' Which is why silo owners each optimise their own sliver and the total stays unmanaged; he insisted many firms still cannot state their true carrying cost - and invited anyone to disagree. Even country-level logistics league tables mislead: the same Rs. 5 of carrying cost is a fat percentage on India's Rs. 60 butter and a slim one on Switzerland's Rs. 150 butter, so low-price economies look inefficient by construction. He admitted he does not fully trust anyone's number, including his own.

Safety stock, meanwhile, deserves respect at civilisational scale. His recent LinkedIn post (about ten thousand impressions) was on China's strategic petroleum reserve - on the order of 1.1-1.2 billion barrels, roughly a hundred days of consumption. When war closed around the Strait of Hormuz and forecasts screamed 150-200 dollar oil, prices touched roughly 110-120 once and were back near 70 within about three months - partly, in his telling, because China simply stopped buying some three million barrels a day and lived off the reserve, flattening the spike for everyone (including, he smiled, an India that dislikes thanking China). By any inventory-cost yardstick, a hundred billion dollars sleeping in tanks is madness - which is exactly why such stock is called **strategic**. Safety stock is the price of the uncertainties you refuse to be hostage to.

KEY INSIGHT

Cyclic stock answers 'how often to buy' (ordering vs holding). Safety stock answers 'how much cushion' (holding vs shortage). And shortage cost is invisible in the accounts - profit that never arrived - which is why efficiency dashboards systematically under-weigh it.

MAKING IT REAL

A shaadi caterer holds extra paneer he will probably waste. The one night the baraat doubles, that 'waste' saves his name. His account book records only the discarded trays; the saved reputation appears nowhere - which is why safety stock is the first thing a cost-cutter kills and the first thing a crisis exposes.

08 EOQ: THE SQUARE ROOT THAT RUNS PROCUREMENT

Now the cyclic-stock trade-off, formalised. Order Q at a time and your average cyclic inventory is Q/2; annual demand D means D/Q orders a year. Total cost TC = S x (D/Q) + H x (Q/2), where S is the cost per order and H the holding cost per unit per year (**H = I x C**: carrying rate times unit cost). As Q grows, the ordering term falls - steeply at first, then flat - while the holding term rises in a straight line; their sum is a U-shaped curve with one minimum. Differentiate, set to zero, and the classic result drops out: **Q* = sqrt(2DS / H)** - the Economic Order Quantity. At the optimum, annual ordering cost exactly equals annual holding cost; the minimum total is sqrt(2DSH), and the reorder point is R = D x L (demand during the lead time).

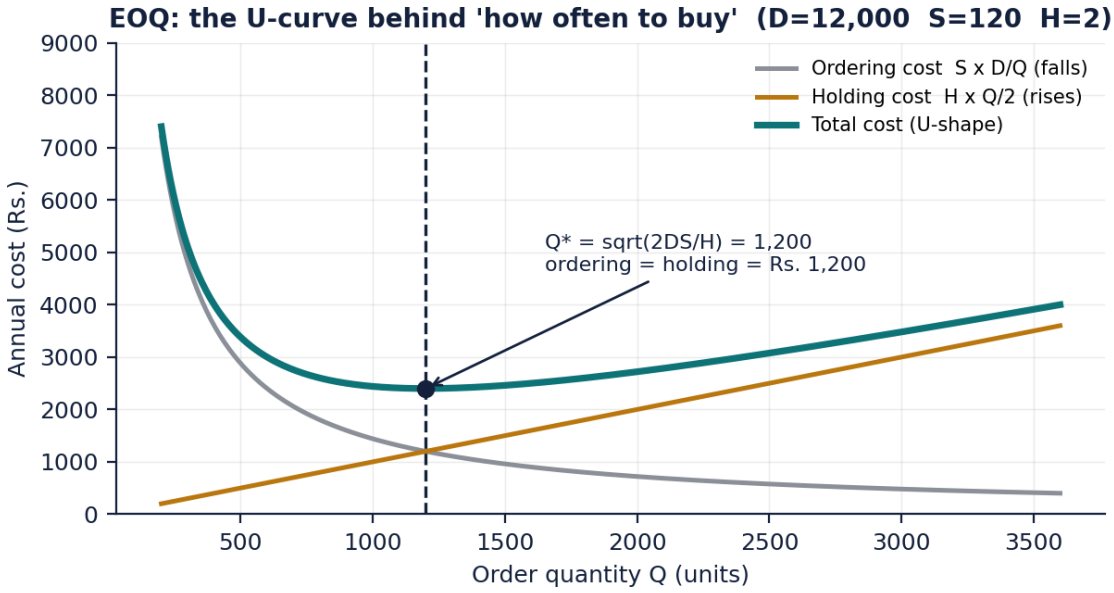


Fig 3.2 - The EOQ U-curve for the worked problem: ordering cost falls, holding cost rises, and the minimum sits exactly where the two are equal - Q = 1,200.*

The worked problem, to reproduce cold: D = 12,000 units; S = Rs. 120; unit cost C = Rs. 10; carrying rate I = 0.2, so H = Rs. 2. EOQ = sqrt(2 x 12,000 x 120 / 2) = sqrt(1,440,000) = **1,200 units** - ten orders a year, average cyclic stock 600. Read the formula like a manager and Section 06's rule falls out of the algebra: H sits in the denominator, so costly items get small lots and cheap items big ones. The model's assumptions are the textbook world - constant uniform demand, constant lead time, constant price, constant ordering cost, all demand met - and reality's uncertainty is precisely the next model's job. One firm turned this dry parameter into strategy: the American thumb rule put H at roughly double the financing cost - about 20 percent a year in the high-interest 1980s and 90s. **Dell alone declared 30 percent** - not better measurement, but intent: a bigger H drives Q down, and tiny lots pushed Dell into just-in-time and the made-to-order machine that ruled PCs for a decade. One number, chosen with intent, became a business model. And yet - his amused close - industry people still phone him asking how to compute Q, for mathematics that is a century old.

EXAM TIP

EOQ = sqrt(2DS/H), with H = I x C. At Q*, ordering cost = holding cost. Drill: D 12,000, S 120, I 0.2, C 10 gives 1,200. And his exact words: 'If I buy once in 30 days, what is my cyclic stock?' Answer: Q/2 = 15 days of demand. Given average inventory of 25 days and Q/2 of 15, safety stock = 10 days.

MAKING IT REAL

Why does the chaiwala buy milk twice a day but sugar once a month? He has never seen the formula - but milk is his A item (costly to hold, perishable) and sugar his C. EOQ is the algebra underneath a street instinct.

09 THE NEWSVENDOR: STOCKING FOR A ONE-SHOT DAY

The safety-stock trade-off got the session's longest worked example - the single-period inventory model, better known as the **newsvendor problem**. The setting: demand for the period is uncertain; the entire stock must be ready before the period starts and cannot be replenished mid-period; stock too little and you forfeit profit; stock too much and the leftovers clear at a loss. Nobody buys the 25th's newspaper on the 28th - he tried the joke on the class - and milk and bread live under the same clock. (When his warm-up question on expected value met a long silence, he turned it into feedback: tell your Programme Directors you want a statistics and probability module - 'can you survive as a manager today without it?') The numbers, from the pre-circulated assignment: demand can be 10, 20, ... 90, each with probability 0.1 except 50, which has 0.2 - expected demand 50. Profit per unit sold Rs. 7.5 (sold at Rs. 30); each unsold unit clears at a Rs. 2.5 loss. Sales = the smaller of demand and starting stock. Grinding through the grid cell by cell - he apologised for the manual labour before revealing the shortcut - produces the payoff table:

Starting inventory	Expected sales	Expected leftover	Expected net profit
50	40	10	Rs. 275
60	44	16	Rs. 290
70	47	23	Rs. 295 - THE OPTIMUM
80	49	31	Rs. 290
90	50	40	Rs. 275

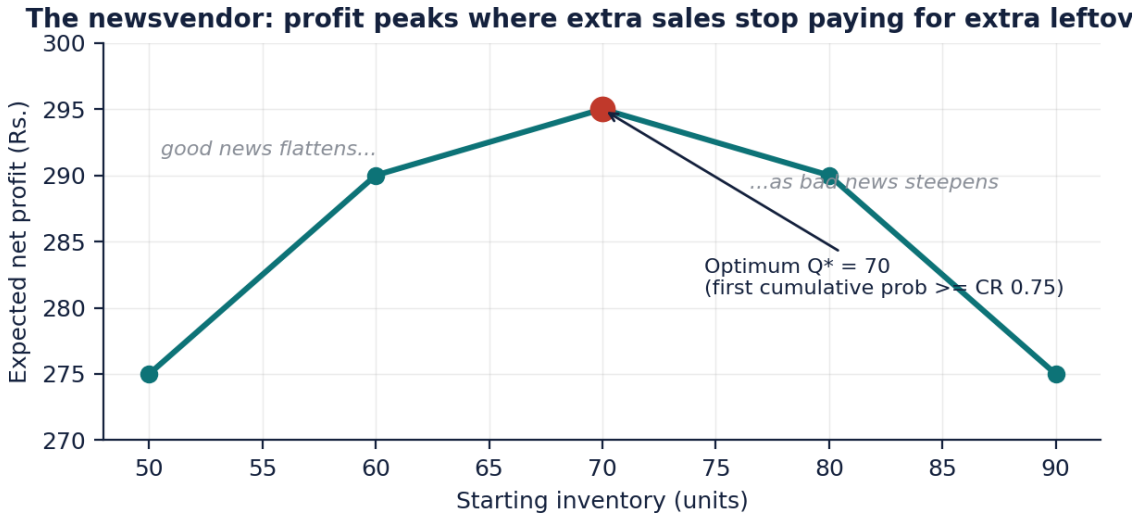


Fig 3.3 - The newsvendor payoff: expected profit peaks at 70 units, exactly where the cumulative probability first reaches the critical ratio of 0.75.

Why an interior optimum? Expected sales climb at a decreasing rate (each extra unit is less likely to be needed) while leftovers climb at an increasing rate - the good news flattens exactly as the bad news steepens, so profit peaks at 70 and falls away on both sides. The safety stock hiding inside: starting stock minus expected demand, about 20 units (more precisely, 70 - 47 = 23 above expected sales). Too much cushion is as costly as too little - even China's hundred days would look foolish only in a world of year-long wars. Then the shortcut that replaces the whole grid: the **critical ratio**. Let Cu be the unit cost of understocking - the forgone profit, Rs. 7.5 - and Co the cost of overstocking, Rs. 2.5. Choose the smallest Q whose cumulative probability Prob(D <= Q) reaches **Cu / (Co + Cu) = 7.5 / 10 = 0.75**. The cumulative column reads 0.6 at 50, 0.7 at 60, 0.8 at 70 - first crossing at 70. Same answer, one line. That cumulative probability has a name

you already use: the **service level** - the proportion of periods in which you meet demand in full.

The model's quiet empire is wider than newspapers. Airline seat buckets and hotel rooms run on it - how many seats at Rs. 1,000 versus Rs. 2,000, now fully dynamic. And it explains the two products he calls India's best-run supply chains: **milk and bread** - in twenty-plus years he has almost never faced a stockout, never been sold anything more than a day or two old, and the system throws away almost nothing. Perishability forced mastery; supply chains without that whip tolerate sloppiness. (His one modern complaint: the apps ration his milk packets, and the campus doorstep vendor gave up the trade with no replacement - home delivery of milk no longer pays.) The mirror image closes the logic: aged wine or whisky is worth holding only while each year's price appreciation beats that year's carrying cost - sell the moment it does not - and on gold as an investment he remains a confessed sceptic, open to being wrong.

EXAM TIP

Newsvendor recipe: critical ratio = Cu / (Cu + Co). With discrete demand, pick the smallest Q whose cumulative probability is at least the ratio (with continuous demand, set them equal). Here 0.75 leads to the first cumulative of 0.8, so Q* = 70. Be ready to define service level, and to identify Cu (lost profit) and Co (clearance loss) from a word problem.

MAKING IT REAL

The paowala who bakes 100 when average demand is 80 looks wasteful - until you price the customer who walks away. His nose has computed a critical ratio: margin per sold pao against the paisa lost per stale one. Newsvendor thinking is older than its name.

10 AFTER CLASS: CONTRACTS, INCARNATIONS, THE EXAM MAP

The post-class huddle tied loose ends. **Contracting for A items**: frequent small orders do not mean spot-market chaos - you lock a long-term (often annual) contract for assurance, then transact daily against it; without that commitment the supplier hedges elsewhere and stops taking you seriously. **Inventory changes form**: once an engine sits inside a finished car, it is car inventory - the engine's identity is absorbed (raw material, WIP, finished goods, exactly as the accounting sessions taught); ask a plant how many engines it holds and the answer counts only the loose ones. **The reading question**: asked for a book, he offered - with a bias disclaimer he insisted on recording - his own Excellence in Supply Chain Management, noting these two sessions barely touch it; for quick references, he conceded, even the AI tools now assemble decent reading lists - 'but for these fundamentals, use your own head first.'

THE BALRAM EXAM MAP - SIX ZONES TO DRILL

(1) Cycle time vs throughput time, and bottleneck arithmetic. (2) Classifying process types. (3) MTS vs MTO - which clock, which problems. (4) ABC - ordering pattern vs safety-stock logic. (5) EOQ mechanics and Q/2. (6) The critical ratio and service level.

His sign-off was pure Balram Avittathur. He compared his own teaching to Krishnamachari Srikkanth's batting - storytelling with no control over the shots - apologised to anyone who wanted a straighter lecture, and defended the method: if a formula intimidates you, you drop the subject, and with it the opportunity. Management, he reflected, has served him better than engineering - it is the more philosophical degree, the one that refuses a single right answer - and a programme is wasted on anyone who absorbs only the 10 percent that looks immediately useful. Then he left the batch with the line that bookends both his sessions: **be efficient and effective - be good to everyone, and be happy.** His email sits in the slides; he answers.

SESSION 3 IN ONE BREATH

The world makes to stock - 95-97 percent of everything you consume - because capital demands utilisation and make-to-order cannot supply it; the customisation that survives is a luxury niche or a hybrid that stocks a generic base and finishes to order. Quick commerce is MTS at your doorstep, paying for its ten minutes with deliberately idle riders. Inventory splits into two questions: cyclic stock (how often to buy - EOQ = sqrt(2DS/H)) and safety stock (how much cushion - the critical ratio Cu/(Cu+Co) and the service level it buys).

MCQ SESSION 3 DRILL - 38 QUESTIONS

Q1. The professor's estimate of how much of what we consume is make-to-stock:

a) 50-60%
b) 70-75%
c) 80-85%
d) 95-97%

Ans (d): The MTO revolution never came; if anything, old MTO (uniform tailoring) migrated to MTS.

Q2. Total source-to-consumption lead time is usually longer in MTS because:

a) MTS factories are slower
b) The product is made months ahead and sleeps in warehouses en route
c) MTO has no processing time
d) Customers order earlier in MTS

Ans (b): The June packet of chips was made in April. What MTS compresses is the customer's order-to-delivery clock.

Q3. The DEEP reason the make-to-order revolution never arrived:

a) 3D printing failed technically
b) Customers dislike customisation
c) Capital demands utilisation, and MTO structurally cannot run near 100% without endless queues
d) Governments favour mass production

Ans (c): MTS runs hot against a forecast; MTO running hot makes customers wait forever.

Q4. Quick commerce's 15-minute promise is paid for by:

a) Higher rider salaries
b) Deliberately low utilisation - idle riders and dark-store slack
c) Faster scooters
d) AI routing alone

Ans (b): Staff a dark store to average demand and the promise dies the same day - you consume low utilisation as a service.

Q5. Asian Paints' base-plus-tint model places the customisation boundary:

a) At the factory
b) At the distributor's warehouse
c) At the retailer's tinting machine
d) At the customer's home

Ans (c): Dell held the boundary at the factory; Asian Paints pushes it all the way to the dealer.

Q6. Quick commerce, classified correctly, is:

a) Make-to-order
b) Assemble-to-order
c) Make-to-stock pushed to your doorstep
d) A job shop

Ans (c): Limited variety held near you, behind a ten-minute thrill - all of MTS's constraints intact.

Q7. In ABC analysis, A items are approximately:

a) 70% of items, 10% of consumption value
b) 10% of items, 70% of consumption value
c) 20% of items, 20% of value
d) 50% of items, 50% of value

Ans (b): CV = annual demand x unit cost; Pareto's shape appears every time.

Q8. The correct ordering-and-safety-stock policy for A items:

a) Big infrequent lots, minimal safety stock
b) Small frequent lots, minimal safety stock
c) Small frequent lots, MORE days of safety stock
d) Big infrequent lots, more safety stock

Ans (c): Lot size follows holding cost (small); safety stock follows supply risk (high - few irreplaceable suppliers).

Q9. A car chip - low value, but able to halt the industry - is, in the Kraljic view:

a) A leverage item
b) A strategic item
c) A bottleneck item
d) A routine item

Ans (c): Low value crossed with high supply risk = bottleneck; crude oil (high value, high risk) is strategic.

Q10. Shortage cost is best described as:

a) A warehouse expense
b) A transaction cost
c) Lost profit - revenue that never arrived, invisible in the accounts
d) A depreciation charge

Ans (c): It looks like a cost but no dashboard shows it - which is why efficiency metrics under-weigh it.

Q11. The two (and only two) inventory trade-offs are resolved by:

a) Cyclic stock (ordering vs holding) and safety stock (holding vs shortage)
b) Safety stock and buffer stock
c) EOQ and ABC
d) Ordering vs shortage and holding vs quality

Ans (a): There is no meaningful ordering-shortage trade-off; any inventory decomposes into Q/2 plus safety stock.

Q12. D = 12,000/yr, S = Rs. 120/order, C = Rs. 10, I = 0.2. The EOQ is:

a) 600 units
b) 1,000 units
c) 1,200 units
d) 2,400 units

Ans (c): H = I x C = 2; Q* = sqrt(2 x 12,000 x 120 / 2) = sqrt(1,440,000) = 1,200 - ten orders a year.

Q13. At the EOQ, which relationship always holds?

a) Ordering cost is double holding cost
b) Annual ordering cost equals annual holding cost
c) Holding cost is zero
d) Shortage cost equals holding cost

Ans (b): The U-curve's minimum sits exactly where the two annual costs cross.

Q14. Dell declaring a 30% holding rate (vs the ~20% thumb rule) was:

a) A measurement error
b) Deliberate: a bigger H drives Q down, pushing Dell into tiny lots, JIT and its made-to-order machine
c) A tax strategy
d) Imposed by suppliers

Ans (b): One parameter, chosen with intent, became a business model.

Q15. You order once every 30 days. Your cyclic stock, in days of demand:

a) 30 days
b) 15 days
c) 10 days
d) 60 days

Ans (b): Cyclic stock = Q/2. If average inventory is 25 days and Q/2 is 15, safety stock = 10 days.

Q16. Newsvendor: profit Rs. 7.5 per unit sold, Rs. 2.5 loss per leftover. The critical ratio is:

a) 0.25
b) 0.33
c) 0.60
d) 0.75

Ans (d): CR = Cu/(Cu+Co) = 7.5/10 = 0.75 - pick the smallest Q whose cumulative probability reaches it.

Q17. With cumulative probabilities 0.6 at 50, 0.7 at 60 and 0.8 at 70, the optimal stock at CR = 0.75 is:

a) 50
b) 60
c) 70
d) 80

Ans (c): First cumulative at or above 0.75 is 0.8, at Q = 70 - matching the grid's Rs. 295 optimum.

Q18. Service level, precisely, is:

a) Average delivery speed
b) The proportion of periods in which demand is met in full
c) Inventory turns
d) The critical ratio's complement

Ans (b): It is the cumulative probability you chose to satisfy - the newsvendor's dial.

Q19. The Chingrighata Saturday (one crossing shut, every 10km-plus journey an hour late) opened the session to prove:

a) Google Maps is unreliable
b) Operations theory has sat in textbooks for fifty-plus years, yet its usage - in firms and in cities - is still this thin
c) Airports should move closer
d) Flyovers should not be built

Ans (b): He nearly retired this lecture as too obvious around 2013-14; then Amazon's rise put cycle time back into boardrooms.

Q20. From the mid-1980s, operations 'fell out of several American MBA syllabi' because:

a) The subject was solved
b) The narrative was captured by marketing, strategy (Porter, BCG) and finance - until Walmart, Dell and Amazon dragged it back
c) Professors retired
d) India mandated its removal

Ans (b): 'Luckily, that did not happen in India' - and the firms that won the next decades won on operations.

Q21. Match the MAIN operations problems to the system:

a) MTS: delivery promises; MTO: forecasting
b) MTS: forecasting, production planning and inventory control; MTO: delivery promises and delivery time
c) Both share identical problems
d) MTO: inventory control only

Ans (b): MTS fights uncertainty before demand arrives; MTO fights the clock after it does.

Q22. The professor's childhood school uniform - designated-shop fabric, then a tailor sitting on it for a month - captured:

a) Pure MTS
b) Pure MTO
c) Both in one purchase: make-to-stock fabric feeding a make-to-order tailor
d) Continuous flow

Ans (c): And that old MTO tailoring has since migrated to MTS readymades - the opposite of the 1990s prophecy.

Q23. Which lead-time clock does the CUSTOMER feel in full under MTO?

a) Source-to-consumption
b) Order-to-delivery - the clock starts only when you order, and it is almost all processing
c) Neither
d) Warehouse dwell time

Ans (b): MTS total lead time is longer (your June chips were made in April), but the customer-facing clock is short because stock sits nearby.

Q24. Why can a pure MTO system never satisfy capital's demand for utilisation?

a) Machines break more often
b) Run MTO near 100% and customers queue forever - the busy-ness capital demands is structurally incompatible with responsiveness
c) MTO uses no capital
d) Labour laws prevent it

Ans (b): MTS runs near 100% against a forecast; MTO must hold idle capacity to promise speed.

Q25. Southwest squeezing 13-14 flying hours from an 18-hour day with 20-minute turnarounds is:

a) Proof MTO can chase utilisation
b) A standardised, MTS-style service chasing utilisation - the counter-current that proves the rule, not customisation
c) A luxury niche
d) Assemble-to-order

Ans (b): Utilisation obsession works when the service is standardised; it kills you when the promise is responsiveness.

Q26. Ferrari, Rolls-Royce and Rolex survive as pure MTO because they are:

a) Disruptors killing trade-offs at scale
b) Profitable value-over-volume niches - which is exactly what disruption is NOT
c) Secretly make-to-stock
d) Loss leaders

Ans (b): A niche customising for the wealthy few existed a century ago; scale is what separates a niche from a disruption.

Q27. The ATO scorecard from the slide reads:

a) More inventory and slower than MTO
b) Less inventory and faster service than pure MTO, at the price of some work-in-process inventory
c) Zero inventory of any kind
d) Identical to pure MTS

Ans (b): Measures that matter: speed of service, inventory levels, quality - and the design question is where the boundary sits.

Q28. The professor mourned Big Basket's old hub-and-spoke model because dark stores mean:

a) More variety near you
b) Variety is shrinking - a store close to you holds only so many items; you buy 500g of bhindi because that is the pack
c) Cheaper vegetables
d) Faster hubs

Ans (b): His single weekly one-store trip has splintered into five or six app orders because no single app stocks everything.

Q29. Match the Kraljic quadrants:

a) Strategic = low value, low risk
b) Bottleneck = low value but high supply risk; strategic = high value, high risk (crude oil); leverage = high value, low risk; the rest are non-critical
c) Leverage = high risk items
d) Non-critical = crude oil

Ans (b): ABC is the vanilla cut by value; Kraljic crosses value with supply risk - the chip that halts a car plant is a bottleneck item.

Q30. 'COVID's chip crunch has become AI's' was the warning that:

a) Kraljic labels are permanent
b) Which item wears which label keeps rotating; no formula rescues you - this is where managers become stars or failures (beware hindsight)
c) Chips are now C items
d) AI eliminates shortages

Ans (b): Every bold inventory call looks like grand strategy only after it pays.

Q31. Open a manufacturer's P&L;: where is 'inventory cost'?

a) A clearly labelled line
b) Nowhere - it arrives in disguises (interest, rent, preservation, security, handling, depreciation): 'like Vishnu, inventory has many incarnations'
c) Inside revenue
d) In the COGS line as a true cost

Ans (b): COGS (opening + purchases - closing) is a flow computation, not the carrying cost - which is why silo owners each optimise a sliver.

Q32. China's strategic petroleum reserve (~100 days) 'flattened the Hormuz spike' by:

a) Raising prices
b) Simply stopping purchases of some three million barrels a day and living off the reserve - prices touched ~110-120 and were back near 70 in about three months
c) Selling reserves to India
d) Closing the strait

Ans (b): By any inventory-cost yardstick, a hundred billion dollars sleeping in tanks is madness - which is exactly why it is called strategic.

Q33. Which is NOT an assumption of the basic EOQ model?

a) Constant, uniform demand
b) Constant lead time and price
c) Demand uncertainty explicitly modelled
d) All demand is met

Ans (c): Uncertainty is precisely the NEXT model's job (the newsvendor); EOQ lives in the textbook world of constants.

Q34. The newsvendor's interior optimum at 70 exists because:

a) Profit rises forever with stock
b) Expected sales climb at a DECREASING rate while leftovers climb at an INCREASING rate - the good news flattens exactly as the bad news steepens
c) Demand is certain
d) Leftovers are free

Ans (b): Peak at 70, falling away on both sides - too much cushion is as costly as too little.

Q35. The safety stock hiding inside the newsvendor solution (expected sales 47 at Q*=70):

a) Zero
b) 70 units
c) About 23 units above expected sales
d) 47 units

Ans (c): Starting stock minus expected sales - the cushion the critical ratio decided you should pay for.

Q36. Milk and bread are 'India's best-run supply chains' because:

a) They are government-run
b) Perishability forced mastery - near-zero stockouts, nothing stale sold, almost nothing thrown away; chains without that whip tolerate sloppiness
c) Demand never varies
d) They use EOQ software

Ans (b): In twenty-plus years he has almost never faced a stockout - the newsvendor clock, mastered.

Q37. Aged whisky is worth holding only while:

a) Prices fall
b) Storage is free
c) Each year's price appreciation beats that year's carrying cost - sell the moment it does not
d) Demand is uncertain

Ans (c): The mirror image of perishability - and on gold as an investment he remains a confessed sceptic.

Q38. Once an engine sits inside a finished car, asking 'how many engines do you hold?' counts:

a) All engines ever bought
b) Only the loose ones - the fitted engine's identity is absorbed into car inventory (raw material, WIP, finished goods)
c) Fitted engines only
d) Engines at suppliers

Ans (b): Inventory changes form as it flows - exactly as the accounting sessions taught.

SESSION 4 OF 5 - Prof. Peeyush Mehta - Live Online, 5 July 2026

Supply Chain as Strategy: Intel, Boeing, DMart and the Mathematics of Flexibility

Two spectacular failures and two quiet masterclasses show that the biggest supply chain calls - what to keep in-house, how much variety to promise, where to hold inventory - are business strategy calls in disguise. Then the statistics of risk pooling.

01 FROM COST TO RESILIENCE - AND OS vs OM

For thirty years supply chain ran on one commandment: make it cheaper. Then the shocks arrived and refused to leave - the pandemic, chip shortages, wars and sanctions, Brexit-style ruptures, and now the AI build-out - and boardrooms flipped the conversation from cost to resilience: just-in-time rebadged as just-in-case, the new vocabulary all decoupling, reshoring, near-shoring, friend-shoring, de-risking. Prof. Mehta's framing: these are not quarterly stories but decade-long redesigns, and the battery, semiconductor and energy-security supply chains will keep them on the front page for the rest of our careers. First, a level-check the exam will test. Think of a kirana owner: deciding whether to open a second shop near the bus stand, whether to buy a delivery scooter, whether to stay groceries-only - that is **Operations Strategy (OS)**, designing the system. Deciding how much atta to order this week and which shelf the Maggi goes on - that is **Operations Management (OM)**, running the system well. Sessions 2-3 lived in OM; this session climbs to OS, where decisions are infrequent, board-level, capex-heavy and very hard to reverse.

Operations Strategy (OS)	Operations Management (OM)
Design the system - 'doing smart things'	Run the system - 'doing things smartly'
How much capacity, what kind, when, where	Forecasting, inventory, scheduling, process flow
Infrequent, strategic, billions in capex	Continuous, managerial, optimisation
Hard to reverse (Intel's fabs, Boeing's contracts)	Correctable within quarters

Live OS questions right now: how many data centres should a hyperscaler build (they lose sleep over compute capacity); how much GPU capacity should Nvidia commit; how many million square feet of fulfilment centres and robots for Amazon. Capacity means different things in different industries - square feet, machines, human capital - but the sizing, nature, timing and location of resources is always the OS core. The module's non-negotiable: operations takes its mandate from the business strategy - the razor-sharp answer to 'on what basis do we compete?'. If the basis of competition is fuzzy, every functional strategy below it wobbles. And the anchor frame returns: **V = C x (A + P)** (Van Mieghem, 2008) - assets carrying sizing, timing, type, location; processes carrying supply, technology, demand, innovation, risk. Every box hides a serious optimisation problem, and every corporate story in this session is one of those boxes going right or wrong.

One more pillar before the cases: **process innovation beats product innovation for moats**. Product innovations are glamorous but visible, therefore copyable; process innovations are messy, slow and cultural - and precisely for that reason durable. Dell's build-to-order engine, Zara's speed machine and Toyota's production system created moats rivals could not clone; Toyota itself struggles to replicate its own system outside Japan, because obsession and culture are part of the process. Meanwhile even the mighty get questioned on products: Apple has faced 'end of the innovation pipeline' headlines since 2017, still cannot meaningfully leave China (only a sliver of its activity sits outside), and its closed, product-first ecosystem is one reason its AI game lagged the open, collaborative world of large language models - it is now partnering with Google to catch up. Note the leadership symbolism too: the supply-chain-era CEO, Tim Cook, hands over to a product person this September. (From the deck, tying back to Session 1: US retailers' inventory-to-sales ratio climbs into recessions and peaks mid-recession - an operations metric quietly doubling as a lagging macro indicator.)

KEY INSIGHT

A process moat outlasts a product moat because it cannot be reverse-engineered from outside - and sometimes not even from inside (Toyota outside Japan). When rivals can see the what but not the how, the advantage endures.

02 INTEL: TOO LITTLE OUTSOURCING

Imagine a kirana owner who insists on farming his own wheat, milling his own atta and printing his own packets - while the shop next door simply buys the best atta in the market and sells more of it. For two decades, Intel was that first shopkeeper. This is the story of how the firm that defined the PC era - 'Intel Inside', the Wintel duopoly everyone in this class grew up on - became a takeover rumour. The scoreboard is brutal: three CEO changes in roughly three years (Pat Gelsinger was brought in to rescue the firm in 2021 and was out by December 2024; Lip-Bu Tan now runs the turnaround), acquisition chatter through much of last year, and the US government stepping in with a roughly 10 percent stake to steady its most pampered semiconductor asset. The stock has bounced in recent weeks - but hold that thought; the bounce is not what it looks like. First, how this industry actually creates value:

Stage	What happens	Who dominates
1 - Design	Chip architecture and IP; the deepest science	US firms: Nvidia, AMD, Qualcomm, Apple silicon
2 - Fabrication (foundry)	Actually printing chips at 2-3 nanometre	TSMC and the Taiwan cluster - enabled by ASML's lithography monopoly (Europe's most valuable firm; the only maker of these machines)
3 - Assembly and test	Packaging and testing; cost-driven	China, South Korea, Japan; India taking baby steps

The critical fact: this industry deliberately **dis-integrated**. No single firm could fund every layer at innovation speed, so specialised giants emerged at each stage and cross-pollinated - TSMC's cutting-edge fabs turned Nvidia's GPU designs from drawings into the hardware that trains ChatGPT and Claude; ASML's machines made TSMC possible; Nvidia's monopoly exists because someone else's fab and someone else's lithography made it feasible. Outsourcing here was never a cost trick; it was the industry's **innovation engine**. Intel kept everything - design, fabs, assembly - close to its chest: a control-first operations strategy in an industry whose next source of value creation had moved outside firm boundaries. By the time it admitted the miss, it sat on massive fab capacity of the wrong kind, under-utilised, while demand stampeded toward AI-grade silicon it could not supply. That is what really explains the CEO churn: capacity decisions are OS decisions, and OS mistakes cannot be fixed in a quarter.

Why the recent bounce is not redemption. In recent months the AI world's weight has shifted from training frontier models - which demands Nvidia-class GPUs - to **inference**, the everyday serving of millions of users, which runs happily on routine chips. That derived demand lifts Intel, AMD and Qualcomm alike; add Washington's hand-holding, and the stock revived. Nothing structural has been solved - the professor was explicit: no clean chit. **The irony file:** Andy Grove - employee number three and Intel's most celebrated CEO - literally wrote 'Only the Paranoid Survive', the management classic about giants who stop seeing innovation outside their walls. Intel preached the innovator's dilemma and then performed it. The Economist's 'curse of the top dog' data makes it general: the most valuable company in the S&P 500 massively outperforms before reaching the top, and underperforms the index after. Contrast Google: it saw its dependence on Nvidia's monopoly, refused to accept it, and built its own TPUs. Dell is the softer parallel - a vertically-integrated mindset that never diversified beyond PCs (no Dell phones, no Dell TVs), lost its mojo and had to delist for years.

CONCEPT TRAP

'So vertical integration is bad.' No - and this will be tested. Vertical integration buys CONTROL. Intel's industry did not want control; it wanted distributed innovation. Zara's industry wanted speed - and vertical integration is exactly how Zara delivers speed. Same tool, opposite verdicts. The context decides, not the tool.

KEY INSIGHT

Keep one question on a loop: where is the NEXT source of value creation - and does it sit inside or outside my boundary? Core stays in; non-core goes out; and the definition of core shifts over time. Miss the shift and you become Intel.

03 BOEING: TOO MUCH OUTSOURCING

Some corporate crises are natural disasters; Boeing's, in the professor's words, are completely man-made - which is why the 'wisdom in hindsight' mercy extended to Intel was withdrawn here. America's largest exporter and a century-old engineering icon is now a standing chapter in supply chain courses on how NOT to design one - a chapter it earned years before any crash. The visible wreckage: two 737 MAX crashes within months of each other, both rooted in quality rather than pilot error; the January 2024 Alaska Airlines incident, where a door plug blew out mid-air because four bolts were never replaced; three CEOs gone in three years; cash dwindling; trust gone. The 787 Dreamliner was, to be fair, genuinely aspirational - the once-in-two-decades fuel-efficiency leap, which is why Air India ordered early and the Tata fleet is 787-heavy today. But it arrived five years late, and soon after entering service the entire global fleet was grounded over quality troubles - the first fleet-wide grounding of a jet type since 1979. Prof. Mehta has taught this supply chain as a cautionary case since 2013, long before any crash; his aside stunned the class - on 12 June last year his MBA sections were mid-way through this very Dreamliner discussion when hands went up: the news from Ahmedabad had just broken.

Dimension	737 programme	787 Dreamliner programme
Sourcing	35-50% outsourced	About 70% outsourced
Suppliers	Thousands, directly managed	About 50 tier-1 'strategic partners'; no visibility beyond tier 1
Supplier role	Built parts to Boeing's designs	Developed and built entire sections; suppliers own the IP
Contracts	Fixed price, with delay penalties	Risk-sharing: supplier is paid only when the airline pays Boeing
Final assembly	About 30 days at Boeing	3-day snap-together of complete sections (source: Tang and Nelson, 2009, via the class deck)

Why the clever contract boomeranged. On paper, pay-on-delivery bought speed - nobody gets paid until the aircraft is delivered, so everyone hurries; in exchange, suppliers keep the IP and fat margins. Then 2008 arrived, European suppliers defaulted, and every survivor did the rational maths: why deliver early and lock up working capital waiting for the slowest partner? A contract designed as a speed race became a race to the bottom - a slow race. The professor's fairness note: this specific failure deserves partial hindsight-mercy; the intent was good, the incentives were never stress-tested. The deeper disease deserves none: an aircraft is a quality-obsessed engineering marvel - quality is this industry's currency the way innovation is the semiconductor industry's - yet the Dreamliner chain was approved by a finance-first board on one condition: that it be a massively cost-controlled model. A **cost culture in a quality industry**. The executive who designed the chain lost the CEO race and went on to run Ford; the finance-minded board member who demanded the cost model became CEO. For two decades Boeing also sliced itself into silos - separate verticals, even separate headquarters, for R&D, engineering and manufacturing, partly to break unions and squeeze cost - destroying the intimacy between design and making that an aircraft demands. In the words of the class reading, the culture drifted from ingenuity and quality to shareholder returns.

Where it stands. The industry term is **'traveled work'**: jobs done out of sequence, unfinished planes pushed down the line to meet quotas. Today an estimated 30-40 percent of Boeing's assembly line is rework; the regulator caps monthly output while quality systems are rebuilt; and the new CEO found entire production lines inside the 737 and 787 factories repairing recently assembled jets instead of building new ones ('It seems like 30 percent of everybody's job is fixing something'). The costliest single mistake - spinning off its own fuselage subsidiary, Spirit AeroSystems, to cut costs - has now been reversed by buying it back at enormous expense. OS course-corrections are the most expensive corrections in business.

	Intel	Boeing
Industry's currency	Innovation	Quality
The OS error	Too much vertical integration	Uncontrolled outsourcing
What was lost	The fab and ecosystem revolution	Process and quality control
The symptom	Idle capacity of the wrong kind	Rework, groundings, crashes
The scoreboard	3 CEOs in about 3 years	3 CEOs in about 3 years
The root cause	Misread where value creation lived	Misread what the product demands

KEY INSIGHT

Outsourcing did not sink Boeing; outsourcing the one thing its competitiveness depends on - quality control - did. Intel under-weighted the outside world; Boeing over-weighted it. Opposite errors, identical root: an operations strategy misaligned with the basis of competition.

EXAM TIP

If a question contrasts two firms' sourcing choices, do not grade the LEVEL of outsourcing - grade the FIT between what is outsourced and the order winner (innovation, quality, speed, cost). That one line is the entire Intel-Boeing-Zara triangle.

04 CHOOSING YOUR BATTLES: FOUR CLASS DEBATES

Session 4 was unusually interactive, and four exchanges are worth preserving because each ended in a reusable principle. **1. 'But outsourcing risks IP leakage' (Bandu's point).** True - and sometimes you do it anyway, with open eyes. Tesla knew that building the Shanghai Gigafactory meant handing China's ecosystem its EV playbook. Musk took the call because without China's scale and cost efficiency, Tesla would never have escaped its overpromise-and-underdeliver phase - the gigafactories were the disruption that made Tesla, and the first big one was in China. The same soil grew BYD, which has since overtaken Tesla in global EV sales. Not an accident - a calculated trade-off. The discipline is calibrated outsourcing: define what is core (it never leaves the building) and what is not. **2. Outsourcing as an innovation engine - the PCB story.** The printed circuit board - the heart of every electronic device - was pioneered not by the famous OEMs (Bell Labs, AT&T, Cisco) but by a contract manufacturer: only a firm aggregating everyone's volumes had the scale to fund it. That is exactly the TSMC story two decades later - at scale, outsourcing is not a cost lever but an R&D engine no single OEM could afford. Even 'sleeping with the enemy' becomes rational: Samsung is simultaneously Apple's fiercest rival and one of its most critical component suppliers - at one point reportedly earning more from selling Apple components than from its own handsets.

3. The EV capacity question (Venkatesh's point). Volkswagen and others sprinted to build EV plants; demand then softened and some of that capacity is being de-rated. Toyota stayed conservative - world-class hybrids, experiments with hydrogen, deliberately slow on pure EVs - was mocked for years, and is now having the last laugh; rival CEOs have publicly conceded Toyota read it right. The professor's nuance: EV softness is **demand risk, not dead capacity** - the plants have not vanished, and policy swings can reignite demand. Being smartly late is also an operations strategy. **4. 'How do I analyse SpaceX / Uniqlo / my company?' (Arka's point).** The professor's consistent answer, delivered twice with feeling: there is no standard script, and this classroom does not do brand-by-brand consulting. Take the first principles - the OS boxes, the capacity questions, the flexibility logic - and do the heavy lifting on your own context. The examples are disposable; the template is the takeaway.

We are not discussing Zara here. Zara is not important; the process is important. You are here at IIM Calcutta to learn to ask questions, not to solve questions.

PROF. PEEYUSH MEHTA - IN CLASS, 5 JULY 2026

05 THE DMART MASTERCLASS: SYMPTOM vs INFECTION

Everyone 'knew' why DMart wins: it pays suppliers fast, it is cash-rich, it owns its real estate. The professor let every answer land and then said, in effect: you are telling me the patient has a fever; I asked what the infection is. The next twenty minutes were the best Socratic chain of the module - worth preserving step by step. **Step 1 - start from strategy:** DMart's business strategy is one line, low-cost retail, period; every operations choice must serve that line and nothing else. **Step 2 - find the industry's cost lever:** in retail, the giant cost is inventory holding, the way fuel and maintenance are for an airline - so a low-cost retailer must run low inventory, equivalently high inventory turns (class benchmarks: Zara turns stock roughly twice as fast as H&M or Gap; the Trent group - Westside, Zudio, Star Bazaar - runs at about 45 days). **Step 3 - ask what actually drives inventory:** not demand volume - demand VARIABILITY. Inventory is a fight against uncertainty: safety stock scales with noise and with the service level you promise; a high-volume but perfectly predictable SKU needs almost no buffer, a small but erratic SKU needs plenty. **Step 4 - see DMart's real move:** it carries only 20-30 percent of a typical retailer's variety, and not a random 30 percent - a curated basket of fast movers. Fast-moving, by definition, means predictable; predictable means low variability; low variability is music to inventory cost. **Step 5 - watch the flywheel spin:** low inventory -> tiny working-capital needs -> high liquidity -> DMart pays suppliers in 5-6 days while rivals take 3-4 weeks -> suppliers hand it discounts nobody else gets -> the discounts pass to shoppers -> prices fall -> volumes rise -> stock moves even faster. The loop feeds itself. **Step 6 - file the rest under icing:** owned real estate, negotiating muscle, cash discipline - all real, all helpful, none of it the cake. Remove the curated low-variability assortment and the whole flywheel stops.

CONCEPT TRAP

'Inventory is a function of demand.' Incomplete - and a classic exam trap. Inventory is a function of demand VARIABILITY (noise) and service level, not demand volume. Predictable high volume needs near-zero safety stock; erratic low volume can need lots.

EXAM TIP

Be ready to run the chain in reverse for any low-cost player the paper throws at you. The class already sketched Zudio (limited styles, high turns) and IndiGo (single fleet type -> standardised maintenance, spares and training). The diagnostic habit - keep asking why until symptoms give way to the cause - is itself examinable.

06 THE PRODUCT-PROCESS MATRIX

One picture organises everything above. Put product variety on the horizontal axis - narrow and standardised on the left, one-of-a-kind customisation on the right - and process flexibility on the vertical. Well-run firms live on the diagonal: the zone of alignment (Hayes and Wheelwright's classic, via Mieghem). Variety is complexity: more SKUs mean messier forecasts, more suppliers, more skills, more inventory - complexity must be absorbed by flexibility, and flexibility costs money. The matrix is really a billing counter: every step rightward must be paid for with a step upward. Fall below the diagonal - high variety on a rigid process - and you are writing cheques your process cannot cash: infeasible promises, heavy opportunity costs. Float above it - a flexible process serving a narrow range - and you are paying for flexibility you never use: pure out-of-pocket waste.

Firm	Where it sits	Why it works
Ford's Model T	Far left, by choice	Moved from craft customisation to one standardised car ('any colour so long as it is black') and invented low-cost scale
Narayana Hrudayalaya	Left	Dr. Devi Shetty read Henry Ford and rebuilt cardiac care as a focused factory - smooth flow, balanced utilisation, scale economics; the 'Henry Ford of heart surgery'
DMart / IndiGo	Left	Curated variety on a standardised process; cost leadership

Firm	Where it sits	Why it works
Fortis / Apollo	Right	Multi-speciality means jumbled flows (X-ray flooded today, CT tomorrow); they must buy flexibility - cross-trained staff, multi-purpose equipment, buffer capacity
Amazon / Flipkart	Far right	Extreme variety absorbed through inventory depth and network design
Dell	ON the diagonal, cleverly	Mass customisation without leaving the diagonal: standardise the bulk of every machine like a left-side player, customise the final configuration like a right-side one

The class vote on Dell scattered across the matrix ('B?' 'D?' 'between B and D'?) until the professor closed it: calling Dell rigid does a disservice to its variety; calling it fully flexible does a disservice to its cost. Dell's genius is remarkable consistency - it never leaves the diagonal. It mass-produces the standard 70-80 percent of every machine and lets the customer's choices ride only on the final slice. That is what made mass customisation a process moat for a decade.

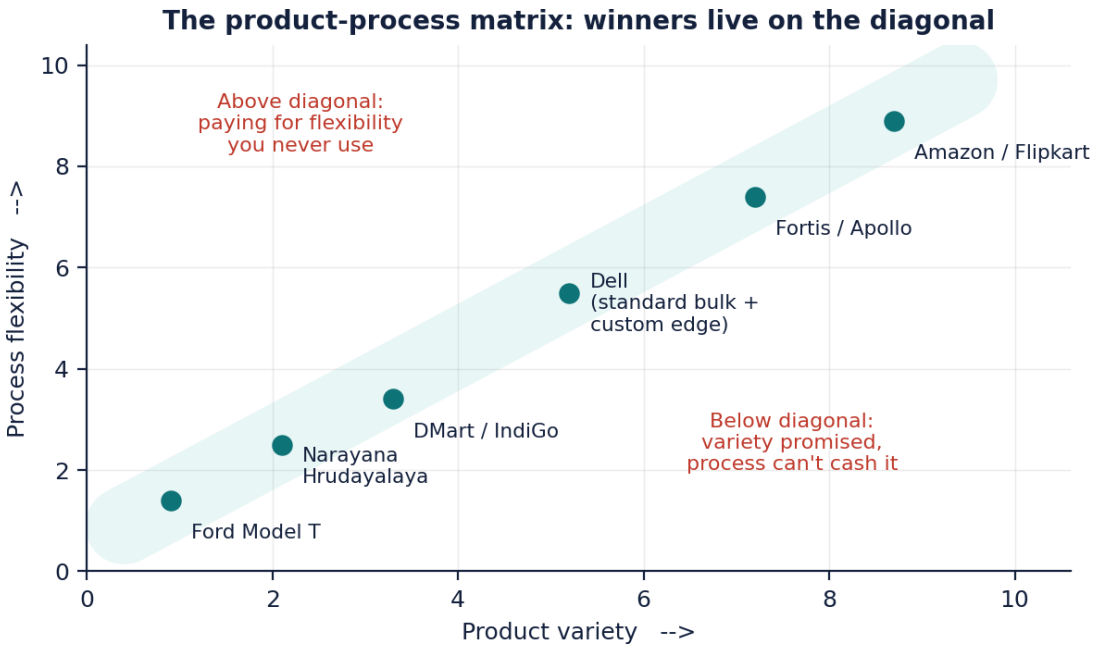


Fig 4.1 - The product-process matrix with the class examples placed. Every step rightward must be paid for with a step upward; Dell wins by never leaving the diagonal.

> *What health care needs is process innovation, not product innovation.*
> **DR. DEVI SHETTY, NARAYANA HRUDAYALAYA - FROM THE CLASS DECK**

> **KEY INSIGHT**
> **Variety is a promise of flexibility. Either budget honestly for that flexibility, or curate the variety down. Firms die off-diagonal: promising right-side variety on a left-side process, or paying top-row costs for a bottom-row range.**

07 FLEXIBILITY AND RISK POOLING

A toy example that says everything. Two plants, capacity 100 each. Product A's demand turns out to be 110; B's is 90. With dedicated plants you sell 100 + 90 = 190 - ten customers of A walk away while B's plant sits ten units idle. Let each plant make both products and you sell all 200. The cross-links are not free - flexible capacity, cross-training and tooling cost real money - but they convert stranded capacity into sales. Flexibility, formally: the ability to make multiple products and ramp volumes up and down. The professor's one-liner: flexibility is the tool you deploy to absorb shock - demand shocks, supply shocks, processing-time shocks, lead-time shocks. What it looks like is contextual: positioned inventory in retail, multiple nodes in logistics, multi-product lines in manufacturing, cross-skilled people in services and software who

move to where the spike is (recall Fortis vs Narayana).

The pooling experiment. An Amazon-style setup: a North and a South warehouse; for one SKU, each market's demand noise (standard deviation) is 5; company policy holds inventory at 10 times the noise, so each warehouse holds 50 - 100 units system-wide. Merge them into one pooled warehouse and the stock needed falls - the class instinct said less than 100, correctly, and the reason why is the most useful statistics in this module. A 60-second refresher: variance is the average of squared deviations from the mean - we square so overshoots and undershoots do not cancel (both are bad; a manager wants accurate point estimates, not errors that average out) and to punish large misses disproportionately. The square root of variance is the standard deviation - the noise; in finance the same quantity wears a suit and is called volatility.

THE POOLING FORMULA

SDpool = sqrt(SDN^2 + SDS^2 + 2 x r x SDN x SDS), where r is the correlation between the two demands (-1 to +1). It follows that SDpool can never exceed SDN + SDS.

Correlation r (SDN = 3, SDS = 4; standalone sum = 7)	Pooled SD	What it means
r = -1 (perfect hedge: one up, the other down)	1	Massive saving - the mutual-fund dream
r = 0 (independent markets)	5	Solid saving from pure independence
r = +1 (they move in lockstep)	7	No saving - but never worse than standalone

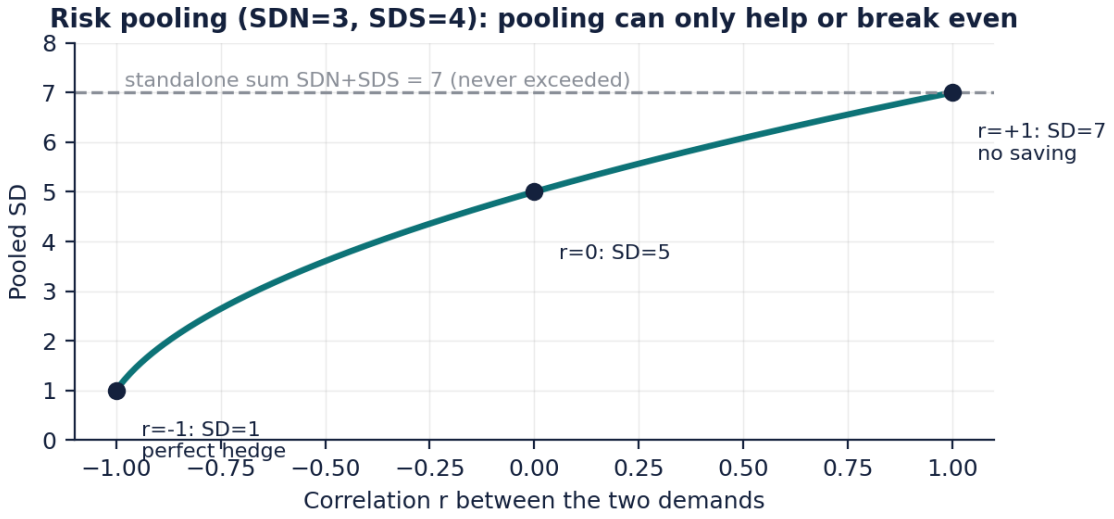


Fig 4.2 - Pooled SD against correlation for SDN=3, SDS=4: a perfect hedge collapses noise to 1, independence gives 5, and even lockstep never exceeds the standalone 7.

This is exactly the mutual-fund argument the class landed on: when you diversify, you are - in the professor's phrase - **knocking at the door of negative correlation**. And the comfort: even a hopeless fund manager who picks perfectly correlated stocks leaves you no worse than holding them separately. Pooling can only help or break even; it cannot hurt the risk. **The catch - pooling is not a free lunch.** If it is so magical, why does Amazon not run one giant national warehouse? Because pooling trades holding cost for **lead time**: centralise and you save inventory but move away from the customer - fatal in speed-first retail, which is why quick commerce runs dark stores in every locality and Amazon runs regional fulfilment centres rather than one mega-hub. State the saving and the trade-off together, always.

EXAM TIP

Memorise the pooled-SD formula's behaviour at r = -1, 0 and +1; remember pooled SD can never exceed the sum of individual SDs; and never write about pooling without naming the lead-time trade-off. That trio is a ready-made 5-mark answer.

08 EXAM RADAR: QUICK REVISION

Eleven ideas from this session, compressed for the night before the paper.

Concept	One line to remember	Trap to avoid
OS vs OM	OS designs the system, OM runs it - smart things vs things smartly	Intel executes OM brilliantly; its OS failed. Do not mix the levels
V = C x (A + P)	Value = Capabilities x (Assets + Processes); assets = sizing, timing, type, location	The professor's anchor frame (Mieghem) - use its vocabulary
Vertical integration	Buys control; right when your differentiator needs control (Zara), wrong when value creation moved outside (Intel)	Never answer good or bad without naming the basis of competition
Outsourcing	At scale it funds innovation (TSMC, the PCB story); uncontrolled, it exports your core (Boeing)	The NATURE of outsourcing matters more than the level
Risk-sharing contracts	Pay-on-delivery speeds everyone up - until one partner slips and rational suppliers slow down (2008)	Contracts change behaviour; model the incentives, not the intent
Core vs non-core	Core stays in, non-core goes out - and core shifts over time	Innovator's dilemma / curse of the top dog: giants stop seeing outside
Product-process matrix	Variety needs flexibility; winners stay on the diagonal	Dell is ON the diagonal (standard bulk + custom edge), not off it
Inventory driver	Safety stock scales with demand variability and service level	'High demand needs high inventory' is FALSE if demand is predictable
DMart flywheel	Curated fast movers -> low noise -> low stock -> liquidity -> supplier discounts -> low prices	Early payment is the symptom; assortment curation is the cause
Risk pooling	SDpool = sqrt(SD1^2 + SD2^2 + 2 r SD1 SD2), never above SD1 + SD2	Pooling raises lead time - always state the trade-off
Traveled work	Out-of-sequence rework pushed down the line (30-40% at Boeing today)	It is a culture metric wearing an operations costume

SESSION 4 IN ONE BREATH

OS designs the system, OM runs it. Intel under-weighted the outside world; Boeing over-weighted it - opposite errors, identical root: an operations strategy misaligned with the basis of competition. DMart's cause is assortment curation, not fast payment. Variety must be paid for with flexibility; pooling cuts noise by sqrt-of-sums but costs lead time.

MCQ SESSION 4 DRILL - 31 QUESTIONS

Q1. Deciding how many fulfilment centres to build is OS; deciding this week's ordering quantities is OM. The distinction is:

a) OS is cheaper
b) OS designs the system (infrequent, capex-heavy, hard to reverse); OM runs it (continuous, correctable)
c) OM is board-level
d) There is no real difference

Ans (b): 'Doing smart things' vs 'doing things smartly' - Intel executed OM brilliantly while its OS failed.

Q2. In the semiconductor value chain, TSMC dominates:

a) Stage 1 - design
b) Stage 2 - fabrication
c) Stage 3 - assembly and test
d) Lithography machines

Ans (b): Design is Nvidia/AMD/Qualcomm; fabrication is TSMC (enabled by ASML's lithography monopoly); assembly is China/Korea/Japan.

Q3. Intel's core error was:

a) Too much outsourcing
b) Vertical integration in an industry whose next source of value creation had moved outside firm boundaries
c) Underpricing its chips
d) Ignoring the PC market

Ans (b): A control-first OS in a deliberately dis-integrated ecosystem - outsourcing there was the innovation engine.

Q4. Intel's recent share bounce is 'not redemption' because it rides on:

a) A breakthrough 2nm fab
b) The AI shift from training to inference, which runs on routine chips and lifts AMD and Qualcomm equally
c) New smartphone wins
d) Lower US taxes

Ans (b): Derived demand plus government hand-holding - nothing structural solved; no clean chit.

Q5. On the 787, Boeing's outsourcing share and supplier structure were approximately:

a) 35-50% with thousands of suppliers
b) 70% with about 50 tier-1 partners and no visibility beyond tier 1
c) 90% with 10 partners
d) 50% with full multi-tier visibility

Ans (b): Versus the 737's 35-50% and thousands of directly managed suppliers building to Boeing's designs.

Q6. The risk-sharing contract (paid only when the airline pays Boeing) backfired in 2008 because:

a) Suppliers went on strike
b) Rational suppliers slowed down - why deliver early and lock working capital waiting for the slowest partner?
c) Boeing cancelled orders
d) Fuel prices rose

Ans (b): A contract designed as a speed race became a slow race - model the incentives, not the intent.

Q7. 'Traveled work' at Boeing refers to:

a) Global logistics
b) Jobs done out of sequence - unfinished planes pushed down the line, now 30-40% rework
c) Executive travel budgets
d) Outsourced flight testing

Ans (b): It is a culture metric wearing an operations costume.

Q8. The correct verdict on vertical integration, per the Intel-Zara contrast:

a) Always bad
b) Always good
c) Context decides: it buys CONTROL - right when your differentiator needs control (Zara's speed), wrong when value creation moved outside (Intel)
d) Only for retailers

Ans (c): Same tool, opposite verdicts - never answer good or bad without naming the basis of competition.

Q9. The CAUSE (not symptom) of DMart's flywheel is:

a) Paying suppliers in 5-6 days
b) Owning its real estate
c) A curated assortment of fast movers - low variability that makes low inventory possible
d) Cash-rich promoters

Ans (c): Fast payment, liquidity and discounts are downstream; remove the curation and the flywheel stops.

Q10. What actually drives safety stock levels?

a) Demand volume
b) Demand variability (noise) and the promised service level
c) Product price alone
d) Number of stores

Ans (b): Predictable high volume needs near-zero buffer; erratic low volume can need plenty - the classic trap.

Q11. A firm offering huge variety on a rigid, standardised process sits:

a) On the diagonal
b) Above the diagonal - paying for unused flexibility
c) Below the diagonal - writing cheques its process cannot cash
d) Outside the matrix

Ans (c): High variety on low flexibility means infeasible promises and heavy opportunity costs.

Q12. Dell's position on the product-process matrix is:

a) Far left, like Ford
b) Far right, like Amazon
c) ON the diagonal - mass-producing the standard 70-80% and customising only the final slice
d) Below the diagonal

Ans (c): Calling Dell rigid disserves its variety; calling it fully flexible disserves its cost - its genius is staying on the line.

Q13. Two plants (capacity 100 each) serve demands of 110 and 90. Dedicated vs flexible sales:

a) 190 vs 200
b) 200 vs 190
c) 190 vs 190
d) 200 vs 200

Ans (a): Dedicated: 100 + 90 = 190 with stranded capacity; full flexibility serves all 200 - what the cross-links buy.

Q14. SDN = 3, SDS = 4. Pooled SD at r = 0 and at r = -1:

a) 7 and 5
b) 5 and 1
c) 5 and 7
d) 1 and 5

Ans (b): sqrt(9+16) = 5 at independence; sqrt(9+16-24) = 1 at perfect hedge; at r = +1 it is 7 - never worse than the sum.

Q15. The one trade-off you must ALWAYS name alongside pooling's inventory saving:

a) Higher wages
b) Longer lead time - the pooled stock sits farther from the customer
c) Lower quality
d) More suppliers

Ans (b): It is why Amazon runs regional centres and quick commerce runs dark stores, not one national mega-hub.

Q16. When grading two firms' sourcing choices in an exam answer, grade:

a) The level of outsourcing
b) The fit between WHAT is outsourced and the order winner (innovation, quality, speed, cost)
c) The number of suppliers
d) The contract length

Ans (b): The Intel-Boeing-Zara triangle in one line.

Q17. Hyperscaler data-centre counts, Nvidia's GPU commitments and Amazon's fulfilment square footage are all:

a) OM decisions
b) Live OS questions - sizing, timing, type and location of resources
c) Marketing budgets
d) Working-capital items

Ans (b): Capacity means different things per industry, but the resource questions are the OS core everywhere.

Q18. The semiconductor industry deliberately dis-integrated because:

a) Regulators forced a break-up
b) No single firm could fund every layer at innovation speed - specialised giants at each stage cross-pollinated (ASML made TSMC possible; TSMC made Nvidia feasible)
c) Labour was cheaper in Taiwan
d) Intel demanded it

Ans (b): Outsourcing here was never a cost trick; it was the industry's innovation engine - the fact Intel misread.

Q19. ASML matters to the chip story because it is:

a) A Chinese assembler
b) Europe's most valuable firm and the only maker of the lithography machines cutting-edge fabs need
c) Intel's design arm
d) A GPU designer

Ans (b): A one-firm chokepoint enabling stage 2 - which is why export controls target its machines.

Q20. The Andy Grove irony:

a) He founded TSMC
b) Intel's most celebrated CEO literally wrote 'Only the Paranoid Survive' - and Intel then performed the innovator's dilemma it preached against
c) He banned outsourcing
d) He designed the 787

Ans (b): Giants stop seeing innovation outside their walls - Intel taught the lesson twice, once in print and once in person.

Q21. The Economist's 'curse of the top dog' data shows the most valuable S&P; 500 firm:

a) Keeps outperforming after reaching the top
b) Massively outperforms BEFORE reaching the top and underperforms the index AFTER
c) Always goes bankrupt
d) Never changes

Ans (b): Google's TPU response - refusing to accept Nvidia dependence - is the counter-example of a giant that kept looking outside.

Q22. Three Intel CEO changes in roughly three years (Gelsinger in 2021, out by December 2024; Lip-Bu Tan now) prove:

a) Boards are impatient with OM
b) Capacity decisions are OS decisions, and OS mistakes cannot be fixed in a quarter
c) CEOs cause chip shortages
d) Turnarounds need no leadership

Ans (b): The scoreboard row Boeing shares: 3 CEOs in about 3 years - both firms paying for decade-old design calls.

Q23. The 787 was 'genuinely aspirational' because:

a) It was the cheapest jet
b) It promised the once-in-two-decades fuel-efficiency leap - which is why Air India ordered early and the Tata fleet is 787-heavy
c) It used no outsourcing
d) It never had problems

Ans (b): Five years late, then the first fleet-wide grounding of a jet type since 1979 - aspiration executed through a broken chain.

Q24. 'A cost culture in a quality industry' refers to:

a) Zara's fashion model
b) A finance-first board approving the Dreamliner chain only as a massively cost-controlled model - in an industry whose currency is quality
c) IndiGo's fleet choice
d) Toyota's supplier pricing

Ans (b): The deeper disease that deserves no hindsight-mercy; the culture drifted from ingenuity and quality to shareholder returns.

Q25. The corporate-politics coda of the Dreamliner design:

a) The designer became Boeing CEO
b) The executive who designed the chain lost the CEO race and went on to run Ford; the finance-minded board member who demanded the cost model became CEO
c) Both executives left aviation
d) The regulator chose the CEO

Ans (b): Incentives and careers shaped the chain as much as engineering did.

Q26. Boeing slicing itself into separate verticals - even separate headquarters - was done partly to:

a) Improve design intimacy
b) Break unions and squeeze cost - destroying the intimacy between design and making that an aircraft demands
c) Satisfy the FAA
d) Speed up the 737
Ans (b): Two decades of silos, then a new CEO finding 'about 30 percent of everybody's job is fixing something'.

Q27. Tesla handing China its EV playbook via the Shanghai Gigafactory was:

a) An accident
b) A calculated trade-off: without China's scale, Tesla never escapes overpromise-and-underdeliver - and the same soil grew BYD
c) Forced by regulators
d) A licensing error
Ans (b): Calibrated outsourcing: define what is core (it never leaves the building) and pay knowingly for the rest.

Q28. The printed circuit board was pioneered by a contract manufacturer because:

a) OEMs lacked interest
b) Only a firm aggregating everyone's volumes had the scale to fund it - outsourcing as an R&D; engine, the TSMC story two decades early
c) Patents were free
d) Bell Labs outsourced by law
Ans (b): At scale, the outsourcer can out-innovate any single customer - Samsung even earned more from Apple components than its own handsets at one point.

Q29. Toyota's EV conservatism (world-class hybrids, slow on pure EVs) is now read as:

a) A fatal error
b) Vindicated - rival CEOs publicly conceded Toyota read it right; EV softness is demand risk, not dead capacity, and being smartly late is also an operations strategy
c) Proof hybrids failed
d) A regulatory accident
Ans (b): Mocked for years, last laugh delivered - the sizing-and-timing boxes of V = C x (A+P) in action.

Q30. Variance squares deviations because:

a) Squaring is traditional
b) Overshoots and undershoots must not cancel (both are bad) and large misses deserve disproportionate punishment
c) Negative numbers are illegal
d) It makes numbers smaller
Ans (b): The square root - standard deviation - is the noise; in finance the same quantity wears a suit and is called volatility.

Q31. Asked to analyse SpaceX, Uniqlo or 'my company', the professor's consistent answer was:

a) Detailed brand-by-brand verdicts
b) No standard script and no classroom consulting - take the first principles and do the heavy lifting on your own context
c) Read more case studies
d) Wait for the exam
Ans (b): 'You are here at IIM Calcutta to learn to ask questions, not to solve questions.'

SESSION 5 OF 5 - Prof. Peeyush Mehta - Live Online, 12 July 2026

The Finale: Pooling in the Wild, Cognition as a Cost, Lean, and the Queueing Law

Session 4's statistics meet the real world - Amazon un-pools for speed, Netflix pooled its way to a disruption, Southwest and IndiGo pay for rigidity - then two new fronts: agentic AI through a make-vs-buy lens, lean as philosophy, and why running hot under variability guarantees collapse.

01 ONE FRAME, NEW HEADLINES

Five sessions, one frame. The module's question was always: how does operations create value for a business model? The answer lives in **V = C x (A + P)** - your differentiation decides the capabilities, and the boxes underneath decide how you build them: sizing (how much capacity - today's data centres, compute, electricity and GPUs in the AI build-out), timing (when to expand or convert - auto firms swapping fossil-fuel capacity for EV lines), type (how flexible - Session 4's whole story), location. Sessions 2-3 with Prof. Avittathur were the OM layer underneath: process analysis and inventory, the daily running of what OS designs. The product-process matrix earned one more outing: **Apple** sits well left, carrying a ruthlessly narrow range (launch iPhone 17, kill the 11 and 12 - the Cook-era supply chain kept ruthlessly simple); **Samsung** competes at every price point, so it must carry variety, inventory and suppliers - a right-side model by design. The visible symptom: Apple runs inventory turns of roughly 70, Samsung roughly 20. **Neither number is a competence score** - it is the business model showing up in an operations KPI, which is why benchmarking inventory metrics across different diagonals is unfair and meaningless.

The variety question (Senthil's point). How does a focused firm decide the right amount of variety? First, a correction: focus is not about quality - quality must be complied with at any variety level, so a narrow range buys you cost and simplicity, not a quality badge. Second, there is no analytical optimum and no rigid boundary on the matrix; it is a continuum. The call is part OS, part marketing: keeping old iPhones alive would mean lower price points that dilute a premium brand, markdowns, and channel inventory complexity - so Apple consciously phases them out. Post-pandemic, many firms slashed variety as a reflex; premium players do the opposite, leveraging variety as their differentiation and knowingly paying the process cost. Functional strategies are always concurrent - operations never decides this alone.

The Intel story moved again - in one week. Session 4 left Intel as a rescue case; the rescue is now a headline. The deck carried it: the White House has made fixing Intel its pet project, and it is working - the share price has run from about USD 36 in mid-December to well north of 100 by early July. Beyond the 10 percent state stake and the inference-demand tailwind, the new twist discussed in class: Apple will now buy some chips from Intel (and Qualcomm). Capability-wise Apple cannot leave China, India and Vietnam - but sourcing American silicon buys tariff escape and de-risking optics, and it handed Intel a windfall. Underneath, the professor's verdict stands: still a catch-up game. **And Apple's AI stumble, the HR edition:** its AI leadership has bled talent to OpenAI and Meta, and - reported on the very day of this session - Apple has sued OpenAI, alleging its product and process designs leaked through departed employees. Hold that thought for Section 05: capabilities walk out of doors, and getting them back is the costliest project in business.

> **KEY INSIGHT**
> **Operations KPIs are strategy readouts, not skill scores. Apple's ~70 turns against Samsung's ~20 is a difference of business model, not of inventory management. Benchmark within a diagonal, never across it.**

02 AMAZON: UN-POOLING FOR SPEED

Session 4 ended with a warning: pooling is not a free lunch, because it costs lead time. Amazon is the firm that stared at that trade-off and deliberately chose the expensive side - and made it pay. The numbers first: Amazon treats fulfilment-centre capacity as a strategic moat built ahead of demand, and in the three years after the pandemic it added as much fulfilment capacity as in its entire first twenty-five - the deck's map of red circles (the first 25 years) drowned in blue ones (the next 3). Why? Because e-commerce differentiation has moved from product category to **speed**. Everyone

can stock the same catalogue; the race is Prime delivery going 7 days to 5 to 3 to 2 to 1 to half a day. (Minutes-level quick commerce stays an India story - Blinkit-style unit economics do not survive developed-market labour costs.) Read it with Session 4's lens: a denser network is **un-pooling**. Inventory must now sit at many more warehouses, which surrenders the correlation benefit; inventory cost rises, inbound logistics cost rises (many more supplier-to-warehouse links), and only outbound cost falls, because the parcel starts closer to the customer. Amazon even tweaked its algorithm so items stocked in your region rank higher in search - advertising the speed it just bought.

The counterintuitive cost curve. Business 101 says cost as a percentage falls with scale. Amazon's fulfilment cost curve is bending UP with scale - genuinely rare - and Amazon does it on purpose, because the sales growth that speed unlocks dominates the cost growth. Andy Jassy said as much on an earnings call: the claim that Amazon chases speed customers do not care about is simply wrong - faster delivery promises make customers buy meaningfully more, and change whether they even consider you next time. For same-day delivery, the order must be pick-packed and ready in about **11 minutes**. That is what the blue circles are for. **The newest vertical: selling the supply chain itself.** Prachi's question - does Amazon outsource any of this? - opened the best story of the day. No: it owns the machine, and last month it began renting the machine out. Amazon Supply Chain Service offers Amazon's logistics muscle to other firms - and one of the first customers is P&G, for diapers, a category where P&G competes head-on with Amazon Basics. The pattern is pure Amazon: 1998, open the marketplace despite cannibalisation fears; 2006, open AWS despite exposing your IT backbone; 2026, open the supply chain. Build a moat for yourself, run it to a scale nobody can match, then sell it to your rivals - next stop, DHL and FedEx territory.

CONCEPT TRAP

'With scale, cost percentage always falls.' Amazon breaks this rule knowingly: un-pooling bends the fulfilment cost curve upward, and the strategy still wins because speed-driven revenue growth outruns it. Un-pooling is only a mistake when it is a drift instead of a decision.

03 SOUTHWEST, UNITED AND INDIGO'S DECEMBER

December 2025: IndiGo cancels flights by the hundreds, airports overflow, the press is merciless. The same week, on the other side of the world, Trump waives the penalty Biden's regulator had imposed on Southwest Airlines for its own December meltdown three years earlier. The class spent a half hour showing these are the same story - and that our five sessions fully explain both. **Southwest, the original low-cost innovator** - the airline IndiGo is modelled on; Porter's classic 'What is Strategy?' devotes roughly half its length to it. Its playbook went beyond one fleet type: open seating (board in any order, faster turnarounds); bags-fly-free for four decades (dump everything into check-in, empty the cabin, save minutes - discontinued only last year, partly because rivals' bag fees became too big an opportunity loss, partly because belly-heavy aircraft were choking baggage handling); deliberately cheaper, less congested secondary airports; relentless turnaround-time focus everywhere. The deepest choice was the network: **point-to-point** - independent city pairs, no consolidating hubs. United is the contrast: a visible hub-and-spoke web. A hub is **pooling** - one consolidated node serving many spokes, exactly the centralised warehouse of our toy example; point-to-point is the un-pooled, decentralised design, whose charm is that a local shock stays local. Fog in Delhi cascades through a hub carrier's whole network; a point-to-point network shrugs.

December 2022: when the whole map is the shock. A storm hit the entire US at once - no local shock to contain; everyone got rattled. The difference was the bounce-back. Hub carriers re-pooled their way out: crew, pilots and aircraft concentrated at hubs were reallocated, schedules rebuilt, high-demand routes identified, the network redesigned in days. Southwest's independent design had nothing to reallocate with - rigid crew-to-aircraft mappings, no pooled slack - and it cancelled over 16,000 flights in the holiday week, nearly three-quarters of its schedule on the worst Monday (about 2,900 flights), took a roughly USD 825 million hit, and needed months to recover while rivals needed weeks. Not an argument that point-to-point is wrong: an argument that **every design chooses which disaster it cannot absorb**. **IndiGo, explained by this module:** far left of the product-process matrix - one fleet type, razor-tight utilisation, the leanest crew-to-aircraft ratio, no spare aircraft waiting in Calcutta to rescue a delayed arrival. That system is not designed to absorb variability - and that is fine; it is what makes the fares low. So when weather strikes, blaming IndiGo is unfair. The fair criticism of December: the pilot-rostering change was **deterministic** - fully plannable, long in advance - and management injected it at short notice into a system built to run without shock. If your model has no shock absorbers, your one duty is to never create the shock yourself. (The professor published this exact diagnosis in Business Today that

week, and shared the link with the class.)

> *That system works well only when things go well, not under noise. One shock, one disturbance, one small spike in variability, and it will collapse.*
> **PROF. PEEYUSH MEHTA - ON INDIGO'S DECEMBER, IN CLASS**

04 NETFLIX, FEDEX AND THE POOLING PLAYBOOK

Quick quiz from class: what was Netflix's disruption? Everyone said streaming. Wrong - OTT was a natural progression it merely surfed. The real disruption came a decade earlier, and it is a pure supply chain story. **The broken economics of DVD rental:** studios sold DVDs to rental retailers like Blockbuster at a wholesale price of USD 65-70, while a rental earned about USD 3 - a title had to rent twenty-plus times just to break even, on demand as fickle as a movie's fate. So retailers under-ordered, hits went out of stock, customers fumed. The industry's first fix was contract design: the **revenue-sharing contract** - wholesale price cut to about USD 10, the distributor taking roughly half of every rental. Under-ordering vanished. Revenue sharing remains one of supply chain's most loved contracts - it is literally how Messi's Inter Miami deal works: he rejected a Saudi offer at some five times the wage for a contract with a modest base but a share of every new Apple TV subscription and every Adidas jersey in a closed-loop ecosystem. (Also, on a lighter note from class: Mrs. Messi preferred Miami.)

Netflix's actual disruption: DVD by mail, risk-pooled. Reed Hastings, stung by a late-return penalty, turned the model on its head: a flat monthly fee, no late fees, DVDs arriving and returning by post. The quiet operations genius: instead of an e-commerce-style network of local warehouses, Netflix served the whole country from roughly **50 pooled strategic warehouses**. The customer's only sacrifice - your queue arrives out of order (request 1, 2, 3, 4; receive 3, 1, 2, 4) - is precisely what let Netflix aggregate demand and run allocation algorithms on pooled stock. Twenty-five years ago the differentiator was variety, convenience and price, not speed - so pooling's lead-time cost did not bite. Unlimited variety at low cost killed a trade-off, and killed trade-offs are what disruptions are made of (done expensively, it would have been a 2 percent niche). And the massive subscriber base built by mail became the first-mover moat when OTT arrived - customer acquisition being OTT's hardest problem. **FedEx: re-pooling when demand flips.** For four decades FedEx ran two deliberately separate networks - Ground for cost-conscious shipments, Express air for time-sensitive ones. Then digitisation shrank B2B (documents and signatures going digital) while e-commerce exploded B2C - two demand streams moving in opposite directions, textbook negative correlation. Result: Ground drowning, air fleet idling. Under its India-born CEO, FedEx has merged the networks over the last couple of years - air and ground now serve one pooled demand. Same toolkit as our warehouse example: when demand streams turn negatively correlated, pooling is exactly the shock absorber you want.

Firm	The pooling move	Why it worked (or bit back)
Netflix	Pooled from day one: ~50 warehouses for the whole US	Differentiator was variety + price, not speed, so the lead-time cost did not matter; the saved cost WAS the disruption
Amazon	Deliberately un-pooled after the pandemic	Differentiator became speed; sales growth dominates the extra inventory and inbound cost - a conscious trade
FedEx	Re-pooled two rigid networks into one	B2B and B2C demand turned negatively correlated; pooling absorbed the structural shift
Southwest	Structurally cannot pool (point-to-point)	Brilliant against local shocks; months-long recovery when a system-wide shock demanded reallocation

> **KEY INSIGHT**
> **Pooling is a dial, not a doctrine. Netflix set it high on day one, Amazon turned it down on purpose, FedEx turned it up when demand flipped, Southwest cannot turn it at all. The dial's right position is decided by one thing: what your differentiation makes expensive - lead time, inventory, or recovery from shock.**

05 COGNITION AS A VARIABLE COST

The professor flagged this as genuinely unprecedented from an operations lens: for the first time in management history, **cognition is being priced as a variable cost**. To see why that sentence is loaded, walk the hundred-year ladder of what became variable, and when: the 1910s - scientific management (Taylor) made worker output variable via per-piece compensation on the shop floor, while managerial cognition stayed a fixed salary with zero marginal cost; the 1990s - labour arbitrage made labour itself variable through offshoring (manufacturing to China, services to India); the 2000s - the services wave, BPO and software-as-a-service; the 2020s - agentic AI makes cognition itself variable, agents billed per token, per call, per task. And **Jevons paradox** is unfolding again: when the steam engine made coal-energy efficient, coal consumption was supposed to fall - it exploded instead, because efficiency multiplied the use cases. The cost per token keeps falling, but N - the number and depth of calls a task consumes - keeps exploding. The bill is C x N, and N is winning.

The cognition curve. The deck's centrepiece chart plots cost per task against agentic depth. The salary line - fixed human cognition - runs nearly flat. The variable-cognition curve starts far below it: Klarna's assistant deflects routine queries at about USD 0.19 a resolution, doing the work of some 700 full-time agents across 2.3 million conversations, worth roughly USD 40 million in profit improvement. Then the curve bends up, crosses the salary line, and enters what the class called the Microsoft-Uber zone: agentic AI can eat up to 1,000x the tokens of standard AI; Uber's FY2026 AI budget was burnt in four months; Microsoft told engineers to stop using expensive coding agents; Meta and Amazon are pressing staff about 'tokenmaxxing'. Shallow depth: AI is cheaper than humans. Deep agentic loops: humans are cheaper than AI. Where your workload sits relative to the crossover is the whole cost story. **The supply chain reading: make-vs-buy, again.** Outsourcing **tasks** to agents is exactly what operations has always prescribed: unbundle, automate, harvest the low-hanging fruit. Outsourcing **capabilities** is the Boeing-Spirit mistake at organisational scale: once the capability leaves, the recovery cost is enormous and sometimes infinite. US manufacturing cannot re-shore from China at any price - the constraint is lost process capability, not money; Boeing bought Spirit back and inherited a decade of trouble. If the team is gone and the process one day needs a tweak, a redesign, an innovation - there is nobody left who can.

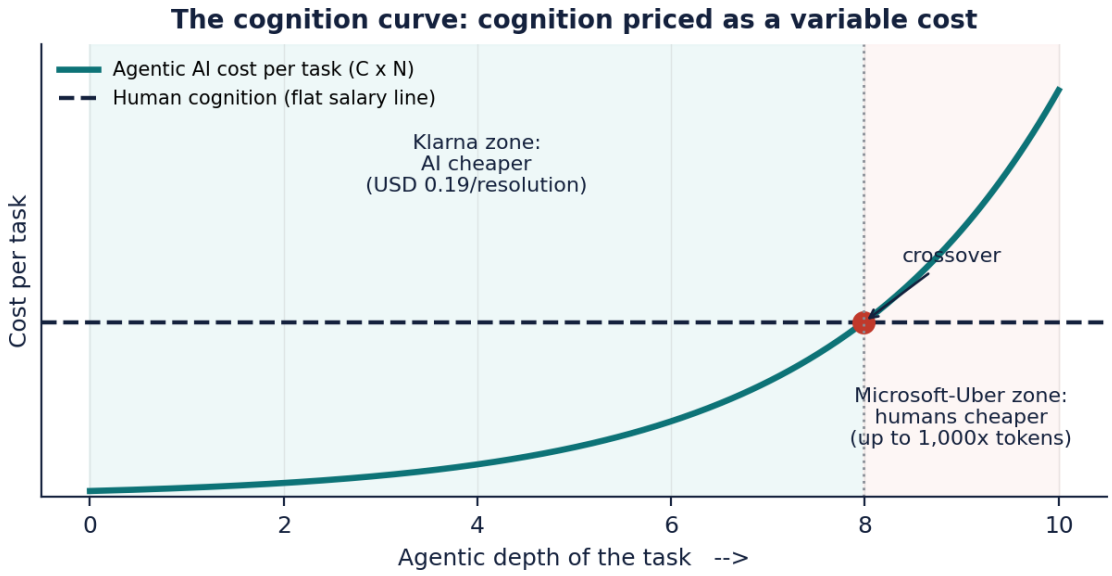


Fig 5.1 - The cognition curve: agentic AI starts far below the flat salary line (the Klarna zone), bends up with depth, and crosses into the Microsoft-Uber zone.

> *Outsource tasks, yes. But do not transfer capability. Once you outsource capabilities, you lose the entire control.*
> **PROF. PEEYUSH MEHTA - ON THE AGENTIC-AI DEBATE, IN CLASS**

CONCEPT TRAP

'Cheaper tokens mean a smaller AI bill.' Jevons paradox says the opposite: as unit cost falls, use cases and agentic depth multiply, and total spend can explode. Budget for C x N, not for C.

06 LEAN: A PHILOSOPHY, NOT A CHECKLIST

The textbook line first: anything that does not add value to the final customer is waste - even transportation, because the customer does not care where the product travelled from. The classic waste list: transport, inventory, motion (unnecessary movement at the workstation), waiting, defects and rework. Maruti Suzuki engineered this thinking into geography in the 80s: its vendors sit within a 5-km radius, synchronising deliveries three or four times a day - transport and inventory waste designed out at the network level. **From TPS to 'lean':** for decades this was simply the Toyota Production System; the neutral name arrived around Toyota's partnership with General Motors so the idea could travel across industries - and Toyota was generous with it. Services took it furthest: every Kaizen, Six Sigma and waste workshop you have attended traces here; Starbucks shaving coffee-making from 60 to 40 seconds is lean in a speed-sensitive market (in India, where the product is the sitting experience, lean means something else entirely). Even Musk's famous 'production hell' was a lean confession - Tesla lacked the decades of lean maturity that Toyota and Honda carry, though he joked Tesla would one day teach Toyota lean manufacturing.

GM vs Toyota: the boardroom mistake. The uncomfortable question GM faced at bankruptcy: how did you go bankrupt with the best-in-class as your joint-venture partner? Because GM parked lean in the OM box - an optimisation, a low-hanging fruit, never a boardroom agenda. The contrast shows sharpest in quality. For GM, quality compliance is a checklist of N boxes: start there, end there; stop the line outside the list and you might be fired - an arm's-length, transactional, spot relationship with your own workforce. For Toyota, the list is where quality STARTS: any engineer, manager or worker is empowered to pull the **andon cord** and stop the entire line even outside the N boxes, no questions asked. Most stops are false alarms - and that is the point: the culture surfaces quality problems instead of hiding them. Amazon borrows the language deliberately ('we are a Toyota firm'): managers empowered to pull a product line or accept a return on judgement. **Lean past the factory gate.** GM's supplier relationships: annual or six-monthly bureaucratic renewals, full blueprints handed over, strictly contractual. Toyota's: decades-long relational contracts built on assured demand and trust - Toyota famously does not hand suppliers detailed drawings, only performance characteristics; the design, the creativity, even the patents belong to the supplier, with collaborative handholding where needed. And no cost-plus-margin pricing: a guaranteed margin breeds supplier lethargy and kills every incentive to innovate cost out of the product. Yes, this openness can be exploited, and Toyota learned that the hard way - which is exactly why lean is so hard to copy; rivals cannot replicate it, and Session 4 told us Toyota itself struggles to scale it outside Japan: culture is part of the process.

Toyota's EV vindication. Remember the Session 4 aside: Toyota was slow on EVs, supreme in hybrids, experimental with hydrogen - and sat at the bottom of ESG rankings for years while being mocked for it. The founding-family chairman, stepping back from the president's role, was unapologetic: given a redo, Toyota would do it the same way - continuous improvement, no big-bang bets, match supply to demand. Rivals who sprinted into EV capacity spent the last two years sitting on idle plants; several of their CEOs publicly conceded Toyota read it right. Efficiently matching supply and demand is music to operations - and it is lean thinking applied to a technology transition. **Lean's hardest frontier: trust under information asymmetry** - the session's most advanced idea, told as a game. Nvidia tells a key supplier: a blockbuster chip is coming, build big capacity. The supplier's dilemma: build high and demand disappoints - stuck with billions in capex; build low and demand booms - a painful opportunity loss. The killer: the supplier cannot verify whether Nvidia genuinely mis-forecast or set a trap - and once stuck, a monopoly can dictate terms and margins. Economics calls this the **hold-up problem**. Solutions exist: Nvidia sharing the capex burden makes its forecast credible; pharma runs the same play through contract menus - in a Pfizer-Biocon style R&D deal, the partner holding private information reveals itself by what it picks: high upfront with low royalty signals low confidence, low upfront with high royalty signals belief. Contract design as a lie detector. All of this - empowerment, relational contracts, credible information sharing - is lean at its broadest.

KEY INSIGHT

Lean is not a cost programme; it is a trust-and-empowerment operating system that extends past your factory gate into your contracts. GM copied the checklist, kept the arm's-length culture, and went bankrupt beside its teacher.

07 QUEUES AND THE UTILISATION MYTH

One last analytical gift, and it starts with a question you answer every week: three counters each with its own line, or three counters fed by one single line? Even with the same nine people ahead of you, the single line wins - one slow customer delays only one register instead of everyone behind him. That is risk pooling in miniature, and it is why banks, airports and McDonald's redesigned their queues. **Little's Law: three flows, one line.** I = R x T - inventory (congestion) equals throughput rate times time in system. Join a supermarket queue building at 10 customers a minute, wait 5 minutes, look back: 50 people stand behind you. The same law reads a balance sheet: daily sales of 1 million against inventory of 5 million means a rupee spends 5 days inside your system - and flipping it gives the dashboard favourite, **inventory turns = sales / average inventory = 1/T**. The longer a unit lingers, the fewer the turns: Zara doubling H&M and Gap, DMart's flywheel, and Section 01's Apple (~70) vs Samsung (~20), all in one formula.

Lambda, mu and the collapse curve. The service version: demand arrives at rate lambda, the system serves at rate mu, utilisation rho = lambda/mu. On average lambda must stay below mu or the system cannot exist at all - queues form in transient windows when lambda briefly exceeds mu (the whole class hitting the campus ATM at 6:40, an airport's half-hour peak). For a simple single-server system with variable arrivals and variable service, expected congestion is **L = rho / (1 - rho)**:

Demand rate lambda (mu = 10)	Utilisation rho	Expected congestion L
1	10%	0.11
7	70%	2.3
9	90%	9
9.5	95%	19
9.9	99%	99

Read the last three rows again: the system does not degrade linearly - it collapses exponentially as utilisation approaches 100 percent. The professor's closing message, delivered as a rule: **high utilisation under variability is a crime**. The more the noise, the earlier the collapse - a healthy zone is typically 70-90 percent, but your system's variability sets the number, not a benchmark deck. Too little utilisation is its own crime: when Mumbai airport tells airlines to cut peak flights, it is killing lambda - killing sales - when the better lever is raising mu: adding capacity or speed. And left-side, standardised, low-variability systems can and should run hot. This closes every loop of the day: buffers are not waste when variability is real - resilience is quantified slack, and lean without it is fragility. IndiGo's December now has its arithmetic: a system running at 99 percent utilisation has a congestion multiplier of 99 - no room for a self-inflicted rostering shock.

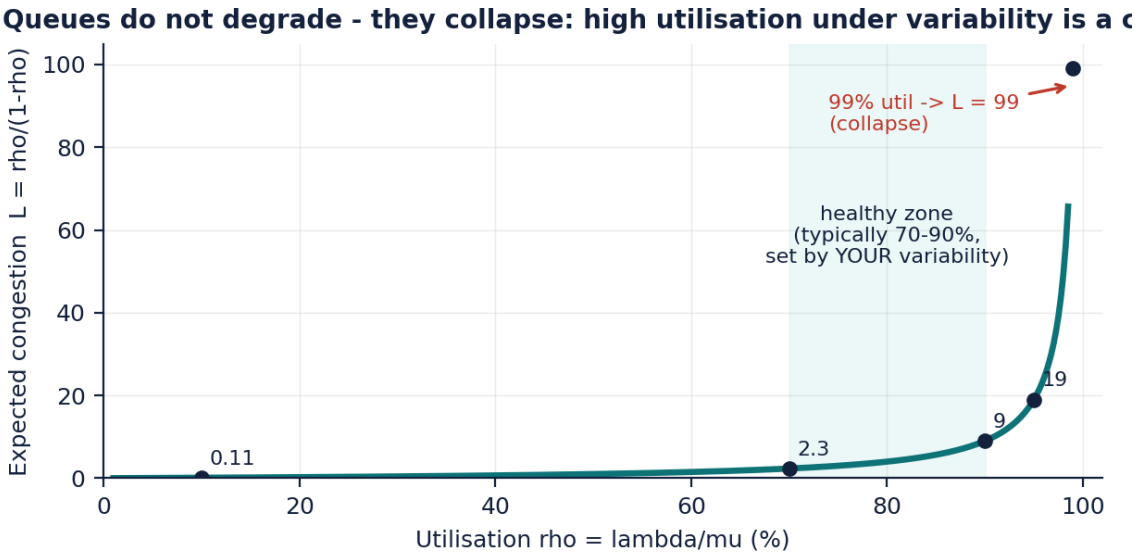


Fig 5.2 - L = rho/(1-rho): the system does not degrade linearly, it collapses. The healthy band is set by your variability, not by a benchmark deck.

EXAM TIP

Three memorisables: L = rho/(1-rho) and its explosion near rho = 1; Little's Law I = R x T with turns = 1/T; and the one-liner 'high utilisation under variability is a crime' - with the counterweight that curbing demand (lambda) kills sales, so the better lever is capacity (mu).

08 EXAM RADAR: QUICK REVISION

Twelve ideas from the finale, compressed for the night before the paper.

Concept	One line to remember	Trap to avoid
Apple vs Samsung turns	Turns of ~70 vs ~20 is business model (variety), not competence	Never benchmark ops KPIs across different diagonals of the matrix
Un-pooling (Amazon)	Trade higher inventory + inbound cost for speed; works while sales growth dominates	'Cost % always falls with scale' - Amazon bends it up on purpose
P2P vs hub-and-spoke	Point-to-point contains local shocks; hubs pool and recover faster from systemic ones	Southwest: ~16,000 holiday cancellations - your design chooses your disaster
IndiGo, Dec 2025	Far-left system, tight ratios, zero slack - never self-inject variability	Weather is not their fault; the deterministic rostering shock is
Revenue sharing	Cut the wholesale price, share the rental/subscription upside (DVDs, Messi's Miami deal)	It exists to fix under-ordering caused by high wholesale price + uncertain demand
Netflix's disruption	DVD-by-mail on ~50 pooled warehouses; variety + price beat speed in that era	Disruption = killing a trade-off; done expensively it is only a niche
FedEx network merge	B2B and B2C demand turned negatively correlated -> pool the two networks	Pooling is a dial you re-set when demand patterns shift
Cognition curve / Jevons	Token cost per task bends up with agentic depth; cheap C, exploding N	Klarna wins at shallow depth; Microsoft-Uber zone lies past the crossover
Tasks vs capabilities	Outsource tasks; never capabilities - recovery cost can be infinite	Boeing-Spirit and failed US re-shoring are the cautionary parallels

Concept	One line to remember	Trap to avoid
Lean	Empowerment (andon), relational contracts, no cost-plus - a philosophy, not a checklist	GM copied the boxes, kept the arm's-length culture, went bankrupt beside its teacher
Hold-up problem	Unverifiable forecasts + sunk capacity let the powerful party dictate terms	Fixes: shared capex stakes, screening contracts (Pfizer-Biocon menus)
Little's Law + queues	I = R x T, turns = 1/T; L = rho/(1-rho) explodes near 100% utilisation	High utilisation under variability is a crime; curbing lambda kills sales - raise mu instead

SESSION 5 IN ONE BREATH

Pooling is a dial: Netflix high, Amazon down on purpose, FedEx up when demand flipped, Southwest stuck. Cognition just became a variable cost - outsource tasks, never capabilities. Lean is trust and empowerment, not a checklist. And queues collapse exponentially near full utilisation - design your slack, or your December designs it for you.

MCQ SESSION 5 DRILL - 32 QUESTIONS

Q1. Apple's inventory turns (~70) vs Samsung's (~20) primarily reflect:

a) Apple's superior inventory managers
b) Different business models - narrow curated range vs every-price-point variety
c) Samsung's factory inefficiency
d) Currency effects

Ans (b): Operations KPIs are strategy readouts; benchmarking across different diagonals is meaningless.

Q2. When Amazon densifies its warehouse network (un-pooling), which cost FALLS?

a) Inventory holding cost
b) Inbound logistics cost
c) Outbound delivery cost
d) All three

Ans (c): Inventory and inbound rise (correlation benefit surrendered, more supplier links); only outbound falls - the parcel starts closer.

Q3. Amazon's fulfilment cost percentage bending UP with scale is:

a) An accounting error
b) A drift it failed to notice
c) A conscious trade - speed-driven sales growth dominates the cost growth
d) Proof that pooling always wins

Ans (c): Un-pooling is only a mistake when it is a drift instead of a decision.

Q4. A hub-and-spoke airline network is, in pooling terms:

a) Un-pooled
b) Pooled - one consolidated node serving many spokes
c) Neither
d) Point-to-point

Ans (b): Hubs pool crew, aircraft and slack; point-to-point keeps city pairs independent.

Q5. Southwest's December 2022 meltdown (16,000+ cancellations, months to recover) happened because:

a) Its aircraft were old
b) A system-wide storm demanded reallocation, and its point-to-point design had no pooled slack to reallocate
c) Fuel ran out
d) It flies too few routes

Ans (b): Hub carriers re-pooled their way out in days. Every design chooses which disaster it cannot absorb.

Q6. The FAIR criticism of IndiGo's December 2025 is:

a) Its fares are too low
b) It should carry spare aircraft everywhere
c) Management injected a fully plannable (deterministic) rostering change at short notice into a zero-slack system
d) Weather planning failed

Ans (c): Weather is not their fault; a self-inflicted shock into a system with no absorbers is.

Q7. Netflix's REAL disruption was:

a) Streaming (OTT)
b) Original content
c) DVD-by-mail on ~50 pooled warehouses - unlimited variety at low cost, killing a trade-off
d) Recommendation algorithms

Ans (c): OTT was a progression it surfed; the moat was the subscriber base the pooled mail model built.

Q8. The revenue-sharing contract fixed DVD rental's broken economics by:

a) Raising the wholesale price
b) Cutting wholesale to ~USD 10 and sharing roughly half of every rental with the distributor
c) Banning late fees
d) Selling DVDs to customers

Ans (b): High wholesale plus uncertain demand caused under-ordering; sharing the upside made retailers stock fully.

Q9. FedEx merged Ground and Express because B2B and B2C demand streams had turned:

a) Perfectly correlated
b) Negatively correlated - textbook pooling territory
c) Both flat
d) Seasonal

Ans (b): One shrank as the other exploded; pooling is exactly the shock absorber for negatively correlated streams.

Q10. The 2020s' entry on the hundred-year variable-cost ladder is:

a) Worker output
b) Labour
c) Services
d) Cognition itself - agents billed per token, per task

Ans (d): Taylor made output variable, the 90s labour, the 2000s services; agentic AI prices thinking.

Q11. Jevons paradox, token edition, warns that:

a) Cheaper tokens shrink the AI bill
b) As unit cost falls, use cases and agentic depth multiply - budget for C x N, not C
c) Tokens will get costlier
d) AI cannot do deep tasks

Ans (b): Klarna wins at shallow depth (~USD 0.19/resolution); the Microsoft-Uber zone lies past the crossover.

Q12. Per the module, the correct stance on agentic AI is:

a) Outsource nothing
b) Outsource everything
c) Outsource tasks; never transfer capabilities - recovery cost can be infinite
d) Wait for regulation

Ans (c): The Boeing-Spirit mistake at organisational scale: once the team is gone, nobody is left to redesign.

Q13. The andon cord's real function at Toyota is:

a) Punishing slow workers
b) Surfacing quality problems - anyone can stop the line, and most stops being false alarms is the point
c) Reducing electricity use
d) Signalling shift changes

Ans (b): GM's checklist culture hid problems; Toyota's empowerment culture surfaces them - the difference that survived a 15-year partnership.

Q14. Toyota avoids cost-plus supplier pricing because:

a) It is illegal
b) A guaranteed margin breeds lethargy and kills every incentive to innovate cost out
c) Suppliers refuse it
d) It complicates accounting

Ans (b): Relational contracts hand suppliers the design and the patents - and the incentive.

Q15. The hold-up problem arises when:

a) Contracts are too short
b) One party sinks capacity against another's unverifiable forecast, then faces dictated terms
c) Demand is stable
d) Both parties share capex

Ans (b): Fixes: shared capex stakes (credible forecasts) and screening contract menus (the choice reveals private information).

Q16. mu = 10, lambda = 9. Expected congestion L = rho/(1-rho) is:

a) 0.9
b) 9
c) 19
d) 99

Ans (b): rho = 0.9, L = 0.9/0.1 = 9; at 95% it is 19 and at 99% it is 99 - exponential collapse, not linear degradation.

Q17. When Mumbai airport cuts peak flights to ease congestion, the module's critique is:

a) It should cut more
b) It is killing lambda - killing sales - when the better lever is raising mu (capacity or speed)
c) Congestion is unrelated to flights
d) Utilisation should hit 100%

Ans (b): Too little utilisation is its own crime; the healthy zone (typically 70-90%) is set by YOUR variability, not a benchmark deck.

Q18. On 'how much variety is right', the module's first correction was:

a) Focus improves quality
b) Focus is NOT about quality - quality must be complied with at any variety level; a narrow range buys cost and simplicity, not a quality badge
c) Variety improves quality
d) Quality needs high variety

Ans (b): And there is no analytical optimum: the call is part OS, part marketing - functional strategies are concurrent.

Q19. Apple buying some chips from Intel (and Qualcomm) while unable to leave China buys it:

a) Frontier 2nm capability
b) Tariff escape and de-risking optics - sourcing American silicon without moving the ecosystem
c) Lower chip prices
d) AI leadership

Ans (b): Capability-wise the China-India-Vietnam ecosystem stays; the sourcing line item moves - and Intel gets a windfall.

Q20. Apple suing OpenAI (reported the day of the session) over designs leaving with departed employees illustrates:

a) Patent law trivia
b) Capabilities walk out of doors - and getting them back is the costliest project in business
c) AI cannot be sued
d) Apple leads AI hiring

Ans (b): The HR edition of the tasks-vs-capabilities lesson: its AI leadership had bled talent to OpenAI and Meta.

Q21. Amazon's post-pandemic build-out added:

a) 10% more capacity
b) As much fulfilment capacity in three years as in its entire first twenty-five - the map's red circles drowned in blue
c) Only international warehouses
d) No new capacity

Ans (b): Because e-commerce differentiation moved from category to speed - and speed demands a denser, un-pooled network.

Q22. For same-day delivery, an order must be pick-packed and ready in about:

a) 2 hours
b) 45 minutes
c) 11 minutes
d) 5 seconds

Ans (c): That number is what the blue circles - and the upward-bending cost curve - are buying.

Q23. Amazon tweaking search to rank locally-stocked items higher is:

a) A bug
b) Advertising the speed it just bought - operations design surfacing in the customer interface
c) Illegal tying
d) Random personalisation

Ans (b): The network and the algorithm are one strategy: make the fast promise, then make the fast promise visible.

Q24. Amazon Supply Chain Service signing P&G; (diapers!) follows the pattern:

a) 1998 marketplace, 2006 AWS, 2026 supply chain - build a moat, scale it beyond rivals, then rent it to them
b) Copy FedEx
c) Exit retail
d) Outsource fulfilment to DHL

Ans (a): Even head-on competitors become customers - next stop, DHL and FedEx territory.

Q25. Minutes-level quick commerce 'stays an India story' because:

a) Indians are impatient
b) The unit economics do not survive developed-market labour costs
c) Regulation bans it abroad
d) Dark stores need heat

Ans (b): Blinkit-style density prices out where riders cost ten times more - geography is an economics filter.

Q26. Southwest ended bags-fly-free after four decades partly because:

a) Regulators banned it
b) Rivals' bag fees became too big an opportunity loss - and belly-heavy aircraft were choking baggage handling
c) Customers stopped checking bags
d) Fuel prices fell

Ans (b): Even a signature policy is a design choice with a shelf life; the relentless turnaround focus stayed.

Q27. Old DVD economics (wholesale ~USD 65-70, rental ~USD 3) caused:

a) Over-ordering of every title
b) Systematic under-ordering - a title had to rent twenty-plus times to break even, so hits went out of stock and customers fumed
c) Free rentals
d) Studio bankruptcies

Ans (b): The revenue-sharing fix (wholesale ~10, split each rental) realigned incentives and killed the under-ordering.

Q28. Messi's Inter Miami deal was cited as revenue sharing because he:

a) Took the highest fixed wage
b) Rejected a Saudi offer at some five times the wage for a modest base plus a share of new Apple TV subscriptions and Adidas sales
c) Bought the club
d) Deferred all pay

Ans (b): A closed-loop ecosystem contract - the DVD lesson wearing football boots. (Also: Mrs. Messi preferred Miami.)

Q29. Netflix customers receiving requests 3,1,2,4 instead of 1,2,3,4 was:

a) A software bug
b) The one sacrifice that let ~50 pooled warehouses aggregate demand and run allocation algorithms on shared stock
c) A pricing trick
d) Proof pooling failed

Ans (b): Variety and price were the differentiators then, not speed - so pooling's lead-time cost did not bite; done expensively it would have been a 2 percent niche.

Q30. Match the hundred-year ladder of what became variable:

a) 1910s offshoring; 1990s Taylor; 2020s BPO
b) 1910s per-piece worker output (Taylor); 1990s labour via offshoring; 2000s services (BPO, SaaS); 2020s cognition per token
c) All in the 2020s
d) 1910s tokens

Ans (b): Each rung made a fixed cost variable; agentic AI just did it to managerial cognition itself.

Q31. Klarna's numbers on the shallow end of the cognition curve:

a) USD 19 per resolution
b) About USD 0.19 a resolution, the work of some 700 full-time agents across 2.3 million conversations - roughly USD 40 million in profit improvement
c) 1,000x token overruns
d) A failed pilot

Ans (b): Shallow depth: AI cheaper than humans. The Microsoft-Uber zone begins past the crossover.

Q32. Toyota handing suppliers performance characteristics instead of detailed drawings means:

a) Toyota owns all supplier patents
b) The design, creativity and even patents belong to the supplier - relational trust replacing blueprint control
c) Suppliers cannot innovate
d) Contracts renew monthly

Ans (b): Paired with no cost-plus pricing: a guaranteed margin breeds lethargy and kills the incentive to innovate cost out.

13 THE GRAND MCQ BANK - 30 CROSS-SESSION QUESTIONS

Every question below deliberately pulls from two or more sessions - the way the paper's best questions will. If any answer surprises you, the explanation names the session to revisit.

Q1. Intel and Boeing made opposite sourcing errors. Their common root cause was:

a) Weak CEOs
b) An operations strategy misaligned with the industry's basis of competition
c) Too little capital
d) Government interference

Ans (b): Intel hoarded control in an innovation-ecosystem industry; Boeing gave away quality control in a quality industry. Fit, not level.

Q2. DMart and IndiGo share the same left-of-matrix playbook. Its essence is:

a) Premium pricing
b) Curated low variety on a standardised process, collapsing variability and cost
c) Maximum variety at any cost
d) Outsourcing everything

Ans (b): Curated fast-mover assortment / single fleet type - low noise, low inventory or spares, low training cost.

Q3. Read Zara through three module lenses. Which combination is correct?

a) MTO player; high utilisation; product innovation moat
b) Vertical integration for speed (S1); small lots trading inventory risk for shortage risk (S1); roughly twice H&M;'s inventory turns (S4-S5)
c) Hub-and-spoke network; EOQ-driven; cost leadership
d) Fully outsourced; pooled; product-led

Ans (b): One firm, three sessions: integration serves speed, small lots swap risk types, and Little's Law shows up as turns.

Q4. Netflix (DVD era), Amazon (post-pandemic), FedEx (recently) and Southwest set the pooling dial at:

a) High, low, raised, cannot turn
b) Low, high, lowered, maximum
c) All four maximise pooling
d) All four minimise pooling

Ans (a): Netflix pooled ~50 warehouses day one; Amazon un-pooled for speed; FedEx merged two networks; point-to-point cannot pool.

Q5. The single principle deciding the right pooling level is:

a) Always centralise
b) Whatever your differentiation makes expensive - lead time, inventory, or shock recovery
c) Match the industry leader
d) Minimise warehouse count

Ans (b): Pooling is a dial, not a doctrine; the differentiator prices the trade-off.

Q6. EOQ and the newsvendor solve different trade-offs. Match them correctly:

a) EOQ: overage vs underage; newsvendor: ordering vs holding
b) EOQ: ordering cost vs cyclic holding cost; newsvendor: overage (leftover) vs underage (shortage)
c) Both solve ordering vs holding
d) Both solve overage vs underage

Ans (b): EOQ balances setup against carrying for repeat items; the newsvendor balances leftovers against lost profit for one-shot demand.

Q7. Safety stock levels should primarily follow:

a) Demand volume
b) Item price
c) Demand/supply variability and target service level
d) Lot size

Ans (c): S3's ABC logic and S4's DMart chain agree: noise and promised service level set the buffer - volume does not.

Q8. A firm has daily sales of Rs. 1 million and average inventory of Rs. 5 million. By Little's Law:

a) Inventory turns are 5 per day
b) A rupee spends 5 days inside the system (turns = 1/T)
c) Throughput is 5 million/day
d) The data is insufficient

Ans (b): I = R x T gives T = 5 days; turns = 1/T. The same law read Zara, DMart, Apple (~70) and Samsung (~20).

Q9. A bank replaces three separate teller lines with one single line feeding all counters. This is:

a) Un-pooling
b) Risk pooling applied to queues - one slow customer delays only one register
c) A bottleneck shift
d) Little's Law violation

Ans (b): The single line pools arrival variability across servers - the S5 queue example and the S4 warehouse are the same mathematics.

Q10. Per the module's law of disruption, Netflix's DVD-by-mail qualified because it:

a) Used the internet
b) Killed the variety-vs-cost trade-off at scale via pooled warehouses and flat fees
c) Had better films
d) Was first to stream

Ans (b): Unlimited variety at low cost, cheaply delivered - done expensively it would have been a 2% niche, not a disruption.

Q11. The agentic-AI make-vs-buy principle taught in Session 5 is:

a) Outsource everything AI can do
b) Outsource tasks, never capabilities
c) Never use AI agents
d) Buy only the cheapest tokens

Ans (b): Klarna-style task outsourcing is classic unbundling; capability transfer is the Boeing-Spirit mistake at organisational scale.

Q12. Lemon Tree employing a large share of persons with disabilities (Session 2) worked because:

a) It cut wages
b) Effectiveness (stakeholder value) was designed first, and efficiency followed from loyal, low-attrition, high-skill staff
c) It was a CSR compliance rule
d) Customers never noticed

Ans (b): Avittathur's point: design for effectiveness and efficiency often follows - the reverse rarely holds.

Q13. Apple turns inventory ~70 times a year; Samsung ~20. The correct inference is:

a) Apple manages inventory better
b) Samsung is inefficient
c) Different diagonals of the product-process matrix - benchmark within a diagonal, never across
d) Samsung should copy Apple

Ans (c): Narrow curated range vs every-price-point variety: the KPI reads the business model, not the competence.

Q14. 'High utilisation under variability is a crime' because L = rho/(1-rho) implies:

a) Congestion grows linearly with utilisation
b) Congestion explodes as rho approaches 1 (rho 0.9 gives L=9; rho 0.99 gives L=99)
c) Utilisation cannot exceed 50%
d) Queues vanish at high utilisation

Ans (b): The collapse is exponential; a 99%-utilised system has congestion multiplier 99 - IndiGo's December arithmetic.

Q15. When Mumbai airport caps peak flights to cut congestion, the module's critique is:

a) Correct - always curb demand
b) It kills lambda (sales); the better lever is raising mu (capacity or speed)
c) It raises utilisation
d) It violates Little's Law

Ans (b): Curbing arrivals sacrifices revenue; adding service rate attacks congestion without killing sales.

Q16. Which pair are PROCESS-innovation moats rather than product moats?

a) Apple and Nokia
b) Zara's fast supply chain and Toyota's production system
c) Kodak and Intel
d) Nvidia and ASML

Ans (b): S1's core claim: process moats are messy, cultural and durable; product moats are visible and copyable.

Q17. The hold-up problem (Nvidia-supplier capacity game) is best solved by:

a) Longer legal contracts
b) Shared capex stakes and screening contract menus that make private information reveal itself
c) Vertical integration always
d) Penalty clauses

Ans (b): Sharing the capex makes the forecast credible; Pfizer-Biocon style menus turn contract choice into a lie detector.

Q18. A quick-commerce dark store deliberately running riders at low utilisation illustrates:

a) Waste to eliminate
b) Slack purchased as the product itself - speed sold as the differentiator
c) Poor scheduling
d) The EOQ formula

Ans (b): S3's tyranny of utilisation: idle capacity is the cost of the 10-minute promise; the buffer IS the business model.

Q19. China holding roughly 100 days of crude oil imports is, in Kraljic terms, managing a:

a) Routine item
b) Leverage item
c) Strategic item with massive safety stock
d) Bottleneck item only

Ans (c): High value, high supply risk - strategic quadrant; the buffer is national-scale safety stock against disruption.

Q20. The retailers' inventory-to-sales ratio peaking mid-recession teaches that inventory is:

a) A leading indicator
b) A lagging indicator - stock piles up only after demand has already fallen
c) Uncorrelated with demand
d) A cause of recessions

Ans (b): S1's dial: by the time the pile is visible you are already deep inside the trouble.

Q21. Boeing buying back Spirit AeroSystems and America's struggle to re-shore manufacturing both show:

a) Outsourcing always fails
b) Once a capability leaves, recovery cost is enormous - sometimes infinite; money is not the constraint
c) Re-shoring is easy with subsidies
d) IP law is weak

Ans (b): S1's CHIPS Act lesson and S5's tasks-vs-capabilities rule are the same: lost process capability cannot simply be bought back.

Q22. GM went bankrupt beside its own teacher (a 15-year Toyota JV) because it:

a) Never saw the Toyota system
b) Copied the checklist but kept an arm's-length culture - lean parked in the OM box, never the boardroom
c) Paid workers too much
d) Over-invested in lean

Ans (b): Andon empowerment, relational contracts, no cost-plus - the philosophy did not transfer; culture is part of the process.

Q23. An exam asks whether a firm should raise service level for an item. The module's first questions are:

a) What is the brand budget?
b) What are the underage (shortage) and overage costs - and the critical ratio Cu/(Cu+Co)?
c) What do rivals stock?
d) What is the EOQ?

Ans (b): Service level is an economic choice: the newsvendor critical ratio prices exactly how much shortage risk to tolerate.

Q24. The one thread running through all five sessions is:

a) Minimise cost everywhere
b) Every operations design must take its mandate from the differentiation strategy - misalignment is the killer
c) Always pool
d) Always integrate vertically

Ans (b): Intel, Boeing, GM and Southwest's worst week are the same failure; Zara, Toyota, DMart and Amazon are the same success.

Q25. Amazon un-pools; Southwest cannot pool. The exam-grade distinction is:

a) Both are identical failures
b) Amazon's un-pooling is a priced DECISION serving a speed differentiation; Southwest's is a structural property of point-to-point that chose which disaster it cannot absorb
c) Pooling is always superior
d) Networks cannot change

Ans (b): Grade the fit and the consciousness of the trade-off, never the pooling level itself.

Q26. Klarna's USD 0.19 resolutions sit far below the human salary line. In Session 1's language, agentic AI at shallow depth has:

a) Left the industry unchanged
b) Shifted the industry frontier itself - the same service value now achievable at radically lower cost, redefining what 'on the line' means
c) Raised everyone's costs
d) Eliminated the frontier
Ans (b): When technology moves the frontier, yesterday's efficient players wake up below the curve without changing anything.

Q27. The newsvendor's 23-unit cushion, a retailer's safety stock, and China's 100 days of crude are:

a) Unrelated policies
b) The same logic at three scales: paying a known holding cost to escape being hostage to an uncertainty
c) All EOQ outputs
d) All shortage costs
Ans (b): Safety stock is the price of the uncertainties you refuse to be hostage to - from a paowala's tray to a superpower's tanks.

Q28. Zudio's ~47-day cover, DMart's curated fast movers and IndiGo's single fleet are one playbook:

a) Right-of-matrix variety plays
b) Left-of-matrix designs - curate variety down, standardise the process, let low variability drive low inventory and cost leadership
c) Premium differentiation
d) Pooling failures
Ans (b): Three industries, one diagonal position - and in each case the advantage hides in a process outsiders cannot see.

Q29. The old MDP's instant confirmations and IndiGo's short-notice rostering change share a failure mode:

a) Bad luck
b) Self-injected shocks: promising or changing before viability was confirmed, inside systems with no absorbers for the resulting variability
c) Regulatory sabotage
d) Under-pricing
Ans (b): If your design has no shock absorbers, your one duty is never to create the shock yourself - sequencing is a form of safety stock.

Q30. Lemon Tree's caring design, Toyota's relational contracts and the andon cord all monetise the same asset:

a) Cheap capital
b) Trust - designed into processes and contracts, it surfaces problems, retains people and converts 'extra' cost into extra revenue
c) Government subsidy
d) Brand advertising
Ans (b): Effectiveness compounding as design: the through-line from Session 2's definition to Session 5's lean.

14 EXAM CHEAT CODES

The formula card - everything numerical on one page

Formula	Meaning and the exam move
Cycle time (CT) = time of the slowest stage	The bottleneck sets the drumbeat. System capacity = 60 / CT per hour (or shift-time / CT).
Throughput time = setup + operation + waiting	Time ONE unit spends start to finish. Never confuse with cycle time: after the first unit, output arrives every CT.
Little's Law: I = R x T (WIP = throughput rate x time in system)	Works on queues, factories and balance sheets. Inventory turns = 1/T; sales 1M/day on 5M stock means T = 5 days.
Dumper move: CT(n) = max(loading time, round-trip / n); n* = round-trip / loading	Below n*, the shovel waits; above it, dumpers queue. Class answer: 3 dumpers minimise cost (Rs. 368.79/hr), 4 maximise speed.
EOQ: Q* = sqrt(2DS/H), with H = I x C; reorder point R = D x L	At Q*, annual ordering cost = annual holding cost. Class numbers: D=12,000, S=120, H=2 gives Q*=1,200 and 10 orders/yr.
Cyclic stock = Q/2; safety stock = average stock - Q/2	A 30-day order cycle means 15 days cyclic; average 25 days means 10 days of safety stock.
Newsvendor: critical ratio CR = Cu / (Cu + Co); pick smallest Q with cumulative probability >= CR	Cu = profit lost per shortage, Co = loss per leftover. Class: CR = 7.5/10 = 0.75, cumulative hits 0.8 at 70 - order 70.
Pooling: SDpool = sqrt(SD1^2 + SD2^2 + 2 x r x SD1 x SD2)	At r = -1, 0, +1 with SDs 3 and 4: pooled SD = 1, 5, 7. Never exceeds SD1 + SD2; always name the lead-time trade-off.
Queues: rho = lambda/mu; L = rho/(1 - rho)	rho 0.7 gives L=2.3; 0.9 gives 9; 0.99 gives 99. Exponential collapse - high utilisation under variability is a crime.
V = C x (A + P)	Value = Capabilities x (Assets + Processes). Assets carry sizing, timing, type, location - the professor's anchor vocabulary.

Ten one-liners that answer half the paper

1. Every operations design takes its mandate from the differentiation strategy - fit beats best practice.
2. Being off the benchmarking curve is the crime; the value level you choose is your prerogative.
3. Disruption = killing an accepted trade-off, at scale.
4. Process moats (Zara, Toyota, Dell) outlast product moats (Apple, Nokia) because culture cannot be copied.
5. Efficiency is doing things right; effectiveness is doing the right things - design for effectiveness first.
6. Inventory is a function of variability and service level, not volume.
7. Grade the FIT of outsourcing to the order winner, never the level. Outsource tasks; never capabilities.
8. Pooling is a dial, not a doctrine - set by whatever your differentiation makes expensive.
9. High utilisation under variability is a crime; curbing demand kills sales, so raise capacity instead.
10. Buffers are not waste when variability is real - resilience is quantified slack.

The flip list - classic traps and their corrections

The trap answer	The flip that earns the mark
Cycle time is how long one unit takes end to end	That is throughput time. Cycle time is the gap between successive units - the bottleneck's pace.
A items: order rarely in bulk; C items: order often	Reverse it. A items: small frequent lots AND the most safety stock attention; C items: bulk and forget.
MTO is better because inventory is zero	MTO trades inventory for the customer's waiting clock and low utilisation - MTS serves ~95% of the market for a reason.
High demand means high inventory	Only if it is noisy. Predictable high volume needs near-zero buffer (the DMart move).
Vertical integration is good / bad	It buys control. Right where your differentiator needs control (Zara), wrong where value creation moved outside (Intel).
Assembly line implies low-skill, low-quality work	Narayana Hrudayalaya runs world-class cardiac surgery as a focused factory - the line is a design choice, not a slur.
Dell is flexible / Dell is rigid	Dell is ON the diagonal: standard 70-80% bulk, customised final slice - mass customisation without leaving alignment.
Pooling always wins	It never hurts RISK, but it always costs LEAD TIME - Amazon un-pooled on purpose and let sales growth pay for it.
Benchmark against the industry leader	Only within your diagonal. Apple's 70 turns vs Samsung's 20 is business model, not competence.
Cheaper AI tokens will shrink the AI bill	Jevons paradox: the bill is C x N, and N (agentic depth, use cases) is exploding - budget for C x N.

One toolkit, two worlds - product and service applications

The paper loves asking you to transplant a concept across contexts. This table is the transplant kit.

Concept	Product world	Service world
Bottleneck / cycle time	Slowest machine on the packaging line caps the plant	The single X-ray room caps the hospital's OPD; check-in desks capped the class airport at 90/hr
MTS vs MTO	FMCG soap is MTS; a ship or a wedding lehenga is MTO	A buffet is MTS; a-la-carte is MTO; IT managed services run MTS-like standard catalogues with MTO project work
Safety stock	China's ~100 days of crude; DMart's thin buffers on predictable staples	Extra cross-trained nurses on weekend shifts; standby aircraft (which IndiGo chooses not to keep)
EOQ thinking	Lot sizes for atta at a kirana or components at Maruti	How many cash refills an ATM gets per week - ordering cost vs idle-cash holding cost
Newsvendor	Newspaper print runs, bakery output, fashion buys	Overbooking seats on a flight; staffing a call centre for an uncertain Monday spike
Risk pooling	One regional warehouse replacing five city depots	Single queue feeding all tellers; hub-and-spoke crew reallocation after a storm
Product-process matrix	Ford far left; Amazon far right; Dell on the diagonal	Narayana (focused factory) left; Fortis/Apollo multi-speciality right
Lean / waste	Maruti's 5-km vendor radius, 3-4 deliveries a day	Starbucks cutting coffee-making from 60 to 40 seconds; e-filing cutting Rs. 3 to Rs. 0.5 per Rs. 100 collected
Queueing law	WIP piling before a hot machine as rho nears 1	IndiGo's December: 99% utilisation means congestion multiplier 99 - one rostering shock collapses the system

The night-before plan (90 minutes)

Minutes 0-20: reread the five 'In One Breath' boxes and both professors' Exam Radar tables - that is the entire conceptual skeleton. **Minutes 20-50:** redo the six worked numericals with a pen: collate-and-staple, the dumpers, the airport, EOQ, the newsvendor grid, the pooling SDs. **Minutes 50-80:** attempt 20 questions from the Grand Bank cold; for every miss, read the one-line why and the session it points to. **Minutes 80-90:** the formula card and the flip list, once, slowly. Then sleep - a rested brain beats a crammed one on MCQs every single time.

> **AND FINALLY**
>
> **If one sentence must survive the exam hall: every operations choice is the business strategy wearing work clothes. Find the differentiation, and every answer - integration, variety, inventory, pooling, utilisation - falls into place.**

15 A CLOSING WORD - YOU ARE READY

Take a second to notice what you now carry. You can read any business as a process and find its bottleneck in minutes. You can tell efficiency from effectiveness - and explain why the firms that design for both, like Toyota and Lemon Tree, quietly out-earn the ones that squeeze. You know why the world makes to stock, what a ten-minute delivery really costs, and how to split any inventory into cyclic and safety with two formulas the industry still phones professors about. You can diagnose Intel and Boeing from opposite ends of the same mistake, run the DMart flywheel forwards and backwards, set the pooling dial, and see the exact arithmetic behind IndiGo's December. That is not exam preparation; that is a working operations lens for the rest of your career. The fee for this module has been paid - this document is you collecting the return on it.

Walk into the exam calm. Every question the paper can ask is one of six moves you have now drilled: classify the process, name the clock, find the bottleneck, run a formula, grade a fit, or spot a flip. Read slowly, anchor on the differentiation, and trust the 204 questions you have already answered here. And after the exam, keep the habit the professors kept pointing at: once a week, wander a process and ask 'is there some other way to do this?' - that is where the careers get made.

> *Efficiency is doing things right; effectiveness is doing the right things.*
> **PETER DRUCKER - THE LINE THIS WHOLE MODULE STANDS ON**

> *Be efficient and effective - be good to everyone, and be happy.*
> **PROF. BALRAM AVITTATHUR - THE SIGN-OFF THAT BOOKENDS THE MODULE**

ALL THE BEST, EPBM-32

To everyone in the batch reading this the night before the paper: you have done the hard part - the sessions, the assignments, the Sunday afternoons. This document exists so that nothing taught in class is ever more than a page-flip away. Go in, answer like the operations pro you now are, and come out smiling. All the very best - and see you on the other side of the exam.

FROM THE COMPILER

Compiled from the live transcripts and both professors' decks across all five sessions (18 April - 12 July 2026), with every framework, number, story and quote retained and only the language simplified. Built for the whole batch - share freely. Spot an error? Tell me and I will fix it in the next revision. - Abhinav