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Bachelor of Business Administration (BBA) | Fifth Semester | UK5DSCMGT301

Operations Management

Course Code: UK5DSCMGT301 • Module 3 Notes

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Module 3: Location Selection and Production Scheduling

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Chapter 1: Facility Location Planning and Decision Methodologies

1.1 Strategic Significance and Determinants of Facility Location

Facility location planning is among the most consequential long-term strategic decisions undertaken by corporate management. Determining the geographic placement of manufacturing plants, regional distribution warehouses, and service facilities involves substantial, irreversible capital investments in land, physical infrastructure, and supply chain logistics. A suboptimal location imposes permanent cost penalties—in the form of excessive freight charges, unfavorable local tax rates, volatile energy costs, and chronic labour shortages—that cannot be overcome by operational brilliance on the shop floor.

The determinants governing facility location decisions fall into distinct operational clusters:

- **1. Proximity to Markets:** Essential for operations producing perishable goods (fresh food processing, commercial bakeries), bulky or fragile products where outbound freight is expensive relative to value, and high-contact service operations (retail banking, hospitals, hotels) where physical accessibility dictates market capture.
- **2. Proximity to Raw Materials and Sourcing Hubs:** Dominant for weight-losing manufacturing processes (e.g., steel mills, paper pulping, sugar processing, mineral refining) where transporting heavy, unprocessed ore or timber is vastly more costly than shipping compact finished output (Weber's Material Index greater than 1.0).
- **3. Labour Market Dynamics:** Availability of technical talent, engineering skills, local wage rates, labour unionization prevalence, educational infrastructure, and worker retention stability.
- **4. Logistics and Physical Infrastructure:** Proximity to multi-modal transportation corridors (deepwater ports, national highway freight arteries, railway freight terminals, cargo airports), reliable high-voltage electricity grids, municipal water supply, effluent treatment facilities, and broadband telecommunications.
- **5. Regulatory and Fiscal Environment:** State and local industrial policies, Special Economic Zone (SEZ) fiscal holidays, property tax structures, environmental clearance stringency, and political stability.

1.2 Quantitative Location Evaluation Methodologies

To eliminate subjective bias in geographic siting, operations executives utilize robust quantitative decision models:

1. Factor Rating Method: The most widely deployed multi-criteria location model. Operations managers identify critical location factors, assign relative numerical weights reflecting strategic

importance, evaluate prospective candidate sites on a standardized scale, and compute weighted composite scores:

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Weighted Composite Score = Sum of [Factor Weight × Site Score]
```

Where: Weights sum to 1.00 (or 100%), and Site Scores range from 1 to 100.

Worked Numerical Problem (Factor Rating Method): Sterling Precision Components evaluates three prospective industrial sites (Site A in Pune, Site B in Coimbatore, and Site C in Sriperumbudur) for a new precision casting plant. The corporate site selection committee identifies six decisive criteria and scores each location as shown below:

Location Factor	Weight	Site A (Pune)	Site B (Coimbatore)	Site C (Sriperumbudur)
Proximity to Key Automotive OEMs	0.25	90	70	85
Availability of Skilled Machinists	0.20	85	80	80
Inbound / Outbound Freight Logistics	0.15	75	85	90
Reliability of Electrical Power Supply	0.15	80	90	85
State Tax Concessions and Subsidies	0.15	65	75	80
Cost of Industrial Land and Construction	0.10	60	80	70
Total Factor Weight	**1.00**	-	-	-

Computational Resolution:

Site A (Pune) Score:
(0.25 × 90) + (0.20 × 85) + (0.15 × 75) + (0.15 × 80) + (0.15 × 65) + (0.10 × 60)
= 22.50 + 17.00 + 11.25 + 12.00 + 9.75 + 6.00 = **78.50**.

Site B (Coimbatore) Score:
(0.25 × 70) + (0.20 × 80) + (0.15 × 85) + (0.15 × 90) + (0.15 × 75) + (0.10 × 80)
= 17.50 + 16.00 + 12.75 + 13.50 + 11.25 + 8.00 = **79.00**.

Site C (Sriperumbudur) Score:
(0.25 × 85) + (0.20 × 80) + (0.15 × 90) + (0.15 × 85) + (0.15 × 80) + (0.10 × 70)
= 21.25 + 16.00 + 13.50 + 12.75 + 12.00 + 7.00 = **82.50**.

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Managerial Decision: **Site C (Sriperumbudur)** achieves the highest weighted composite score (82.50) due to its superior logistics connectivity, port proximity, and attractive state fiscal incentives, making it the mathematically optimal location choice.

2. Locational Break-Even Analysis: Uses cost-volume-profit relationships to compare alternative sites across anticipated production volume ranges. Total cost for any candidate location is modeled as:

```
Total Operating Cost = Fixed Costs + (Variable Cost per Unit × Production Volume)
```

Fixed Costs: Land lease, plant depreciation, property taxes, administrative overhead. Variable Costs: Direct labour, materials, utilities, freight.

Worked Problem (Locational Break-Even): A medical device company compares three sites: Location 1 has Fixed Costs of Rs 30,00,000 and Variable Cost of Rs 75/unit; Location 2 has Fixed Costs of Rs 60,00,000 and Variable Cost of Rs 45/unit; Location 3 has Fixed Costs of Rs 1,10,00,000 and Variable Cost of Rs 25/unit. If anticipated annual volume is 1,50,000 units, which site minimizes total operating cost?

Cost at Location 1: Rs 30,00,000 + (1,50,000 × Rs 75) = Rs 30,00,000 + Rs 1,12,50,000 = Rs 1,42,50,000.
Cost at Location 2: Rs 60,00,000 + (1,50,000 × Rs 45) = Rs 60,00,000 + Rs 67,50,000 = Rs 1,27,50,000.
Cost at Location 3: Rs 1,10,00,000 + (1,50,000 × Rs 25) = Rs 1,10,00,000 + Rs 37,50,000 = Rs 1,47,50,000.
Decision: At 1,50,000 units annual volume, **Location 2** yields the lowest total operating cost (Rs 1,27,50,000), saving Rs 15,00,000 over Location 1 and Rs 20,00,000 over Location 3.

1.3 The Centre of Gravity Method for Warehouse Siting

When selecting the geographic location for an intermediate distribution hub or central warehouse serving multiple regional retail stores or manufacturing plants, the **Centre of Gravity Method** provides a quantitative mathematical formulation. The model treats geographic space as a two-dimensional Cartesian coordinate plane (X, Y) and identifies coordinates that minimize the volume-weighted freight transport distance:

```
X* = Sum of (d_ix × W_i) / Sum of W_i
Y* = Sum of (d_iy × W_i) / Sum of W_i
```

Where: d_ix and d_iy represent the geographic (X, Y) coordinates of destination i, and W_i represents the volume (tonnage or shipments) moved to or from destination i.

Comprehensive Numerical Demonstration (Centre of Gravity): Apex Logistics plans to construct a centralized distribution warehouse in southern India to supply four major retail hubs located in Chennai, Bengaluru, Hyderabad, and Kochi. The grid coordinates and monthly container shipment volumes are recorded below:

Destination City	Cartesian Coordinates (X, Y)	Monthly Volume (W_i in Containers)	Weighted Products ($W_i \times X$, $W_i \times Y$)
Chennai	(80, 20)	400	32,000 ; 8,000
Bengaluru	(30, 40)	600	18,000 ; 24,000
Hyderabad	(50, 90)	500	25,000 ; 45,000
Kochi	(10, 10)	300	3,000 ; 3,000
Total Sum	-	**1,800 containers**	**78,000 ; 80,000**

Step-by-Step Resolution:
X Coordinate:* 78,000 / 1,800 = **43.33**.
Y Coordinate:* 80,000 / 1,800 = **44.44**.
Managerial Outcome: The mathematically optimal geographic centre of gravity lies at grid coordinates **(43.33, 44.44)**. Site scouts can focus industrial land acquisitions around this geographic centroid to minimize aggregate regional transport freight expenditures.

1.4 Alfred Weber's Theory of Industrial Location

Formulated by German economic geographer Alfred Weber in his seminal 1909 treatise, the **Theory of the Location of Industries** provides the foundational microeconomic model explaining why manufacturing plants congregate in specific geographic regions. Weber established that industrial location is primarily dictated by three sequential factors: (1) Regional transport costs; (2) Regional labour differentials; and (3) Local agglomeration economies.

1. Transport Costs and the Material Index (MI): Weber recognized that transportation costs represent the primary regional determinant. To quantify the geographic pull between raw material deposits and consumer consumption markets, Weber formulated the *Material Index (MI)*:

> `Material Index (MI) = Weight of Localized Raw Materials Consumed / Weight of Finished Product`
>
> Where: Localized Materials are geographically restricted (e.g., iron ore, coal, timber), and Ubiquities are universal materials available everywhere at uniform cost (e.g., water, air).

- *Gross Raw Materials (Weight-Losing):* Materials that lose substantial weight or volume during processing (e.g., sugar cane losing 90% of its weight when converted to refined sugar, or iron ore and coking coal in blast furnaces). Here, **MI > 1.0**. The optimal plant location is pulled decisively toward the **Raw Material Deposit** to avoid paying freight on waste slag.
- *Pure Raw Materials:* Materials that impart their entire physical weight into the finished product without loss (e.g., cotton spinning, yarn weaving). Here, **MI = 1.0**. The plant can be located anywhere between the raw material site and the market along the transport axis.

- *Weight-Gaining Processes:* Operations that absorb ubiquitous resources (e.g., carbonated soft drink bottling plants adding universal municipal water to concentrated syrup). Here, **MI < 1.0**. The optimal plant location is pulled directly to the **Consumer Market** to minimize the transport distance of heavy finished liquids.

2. Isodapanes and Labour Deviations: Weber introduced *Isodapanes*—concentric geographic curves connecting points of equal total transportation cost deviation from the minimum transport point. If a secondary location offers cheap, highly productive labour such that total labour cost savings exceed the excess transport cost indicated by the critical isodapane, the enterprise will rationally deviate from the transport-optimal site to capture the labour cost advantage.

2.4 Capacity Expansion via Decision Tree Analysis

When long-term market demand is subject to probabilistic uncertainty, operations managers deploy **Decision Tree Analysis** to evaluate sequential capacity investments. Consider Zenith Semiconductor, which must decide whether to construct a Large Fabrication Plant (initial capital expenditure Rs 80 Crores) or a Small Modular Plant (initial capital expenditure Rs 40 Crores). Over a five-year horizon, high market demand occurs with probability 0.65, while low demand occurs with probability 0.35.

If the Large Plant is constructed and demand is high, five-year net cash inflows total Rs 140 Crores; if demand is low, net cash inflows are only Rs 50 Crores. If the Small Plant is constructed and demand is high, the firm can either expand immediately at a cost of Rs 45 Crores (yielding Rs 110 Crores cash inflow) or maintain the small footprint (yielding Rs 70 Crores cash inflow). If demand is low, the small plant yields Rs 45 Crores cash inflow without expansion.

Expected Monetary Value (EMV) Resolution:

Branch 1: Large Plant:
EMV = [0.65 × (Rs 140 Cr - Rs 80 Cr)] + [0.35 × (Rs 50 Cr - Rs 80 Cr)]
= [0.65 × Rs 60 Cr] + [0.35 × (-Rs 30 Cr)] = Rs 39.0 Cr - Rs 10.5 Cr = **Rs 28.5 Crores**.

Branch 2: Small Plant:
If High Demand (p=0.65): Decision between Expanding (Rs 110 Cr - Rs 40 Cr - Rs 45 Cr = Rs 25 Cr profit) or Not Expanding (Rs 70 Cr - Rs 40 Cr = Rs 30 Cr profit). Rational management chooses Not Expanding (Rs 30 Cr).
If Low Demand (p=0.35): Profit = Rs 45 Cr - Rs 40 Cr = Rs 5.0 Cr.
EMV = [0.65 × Rs 30 Cr] + [0.35 × Rs 5.0 Cr] = Rs 19.5 Cr + Rs 1.75 Cr = **Rs 21.25 Crores**.
Managerial Decision: Constructing the **Large Fabrication Plant** yields an Expected Monetary Value of **Rs 28.5 Crores**, outperforming the modular option by Rs 7.25 Crores despite market uncertainty.

3.5 Comprehensive Application of Johnson's Algorithm for Two-Machine Sequencing

To demonstrate Johnson's Rule in precision job shops, consider five production batches of medical implants that must all undergo CNC Machining (Machine 1) followed by Precision Polishing (Machine 2). The required processing times in hours are detailed below:

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Batch Job	Machine 1: CNC Machining (Hours)	Machine 2: Polishing (Hours)	Execution Position
Job A	5	2	Scheduled 5th (Last)
Job B	3	6	Scheduled 2nd
Job C	8	4	Scheduled 4th
Job D	10	7	Scheduled 3rd
Job E	1	5	Scheduled 1st

Step-by-Step Algorithm Execution:

1. The absolute minimum time in the entire matrix is 1 hour for Job E on Machine 1. Because it falls on Machine 1, place Job E in the **First position**. Cross off Job E.
2. The next smallest time is 2 hours for Job A on Machine 2. Because it falls on Machine 2, place Job A in the **Last (5th) position**. Cross off Job A.
3. The next smallest time is 3 hours for Job B on Machine 1. Place Job B in the earliest remaining position (**2nd position**). Cross off Job B.
4. The next smallest time is 4 hours for Job C on Machine 2. Place Job C in the latest remaining position (**4th position**). Cross off Job C.
5. Job D remains and occupies the remaining **3rd position**.

Optimal Sequencing Order: **Job E → Job B → Job D → Job C → Job A**.

Makespan and Idle Time Tracking:

- Job E: M1 operates 0 to 1 hr. M2 operates 1 to 6 hrs. (M2 idle from 0 to 1 hr = 1 hr).
- Job B: M1 operates 1 to 4 hrs. M2 operates 6 to 12 hrs.
- Job D: M1 operates 4 to 14 hrs. M2 operates 14 to 21 hrs. (M2 idle from 12 to 14 hrs = 2 hrs).
- Job C: M1 operates 14 to 22 hrs. M2 operates 22 to 26 hrs. (M2 idle from 21 to 22 hrs = 1 hr).
- Job A: M1 operates 22 to 27 hrs. M2 operates 27 to 29 hrs. (M2 idle from 26 to 27 hrs = 1 hr).

Results: Total Job Makespan = **29 Hours**. Total Idle Time on Machine 1 = 2 hours (hours 27 to 29). Total Idle Time on Machine 2 = 5 hours (hours 0-1, 12-14, 21-22, 26-27). This represents the absolute mathematical minimum makespan achievable across the five jobs.

Chapter 2: Capacity Planning and Aggregate Production Planning

2.1 Long-Term Capacity Planning and Considerations

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Capacity represents the maximum sustainable rate of output that an operating facility or system can achieve over a defined operational timeframe under normal operating conditions. Capacity planning bridges long-term market demand forecasting with physical plant capability:

- *Design Capacity (Theoretical Capacity):* The maximum engineered output rate achievable under ideal conditions with zero equipment breakdowns, zero material shortages, and no worker fatigue (e.g., 24/7 continuous operation).
- *Effective Capacity:* The maximum realistic output achievable given operational realities, including scheduled preventive maintenance, shift changeovers, product mix adjustments, and standard employee rest allowances.
- *Actual Output:* The actual volume of finished units produced over a specific period.

> ```
> Utilization Rate (%) = [Actual Output / Design Capacity] × 100
> Efficiency Rate (%) = [Actual Output / Effective Capacity] × 100
> ```
>
> Utilization measures asset deployment against physical maximum; Efficiency measures operational performance against realistic targets.

2.2 Aggregate Production Planning (APP) Strategies

Aggregate Planning is intermediate-range operational planning covering an operational horizon of 3 to 18 months. It focuses on satisfying fluctuating aggregate market demand by adjusting overall production rates, workforce headcount, inventory holdings, and subcontracting levels across broad product families rather than individual stock-keeping units (SKUs). Operations managers evaluate three foundational aggregate planning strategies:

Strategy	Mechanisms & Levers	Trade-offs and Cost Dynamics
Chase Strategy	Production output is adjusted dynamically to match demand exactly in each period by hiring and laying off workers or varying work hours.	Eliminates finished goods inventory holding costs. Incurs severe hiring, training, severance, and worker morale penalties. Highly volatile shop floor.
Level Strategy	Maintains a constant, steady workforce headcount and uniform production output rate across all planning periods.	Stabilizes workforce and maximizes machine utilization. Surpluses in low-demand seasons accumulate as heavy inventory; shortages in peak seasons lead to backorders or stockouts.
Mixed (Hybrid) Strategy	Combines a stable core workforce with flexible levers: planned overtime, temporary contract staff, subcontracting, and modest buffer inventories.	Optimizes overall cost by mitigating the extreme inventory costs of pure level planning and the severe human resource turmoil of pure chase planning.

2.3 Comprehensive Comparative Numerical Problem: Aggregate Planning Strategies

To demonstrate quantitative aggregate planning, consider Nova Manufacturing, which produces industrial pumps. The planning horizon spans six consecutive months. Forecasted aggregate demand (in units) is: Month 1: 1,000; Month 2: 1,200; Month 3: 1,800; Month 4: 2,200; Month 5: 1,400; Month 6: 1,000. Total demand across the 6 months = 8,600 units.

Operational cost parameters are: Regular production cost = Rs 500 per unit; Inventory holding cost = Rs 50 per unit per month (based on ending inventory); Cost of hiring a worker = Rs 10,000 (each worker produces 20 units per month, so hiring cost per unit of capacity = Rs 500); Cost of laying off a worker = Rs 15,000 (layoff cost per unit of capacity = Rs 750); Beginning inventory = 200 units; Safety stock target = 200 units; Beginning workforce produces 1,000 units per month.

Strategy 1: Pure Chase Strategy (Varying Workforce to Match Demand Exactly):
Production matches net monthly demand exactly, maintaining zero inventory holding beyond the 200 units safety stock.

- Month 1: Demand = 1,000 units. Production = 1,000 units. Workforce change = 0.
- Month 2: Demand = 1,200 units. Production = 1,200 units. Increase by 200 units → Hire cost = 200 × Rs 500 = Rs 1,00,000.
- Month 3: Demand = 1,800 units. Production = 1,800 units. Increase by 600 units → Hire cost = 600 × Rs 500 = Rs 3,00,000.
- Month 4: Demand = 2,200 units. Production = 2,200 units. Increase by 400 units → Hire cost = 400 × Rs 500 = Rs 2,00,000.
- Month 5: Demand = 1,400 units. Production = 1,400 units. Cut by 800 units → Layoff cost = 800 × Rs 750 = Rs 6,00,000.
- Month 6: Demand = 1,000 units. Production = 1,000 units. Cut by 400 units → Layoff cost = 400 × Rs 750 = Rs 3,00,000.

Chase Total Cost: Regular production (8,600 × Rs 500 = Rs 43,00,000) + Total Hiring (Rs 6,00,000) + Total Layoff (Rs 9,00,000) + Safety Stock Holding (200 × 6 × Rs 50 = Rs 60,000) = **Rs 58,60,000**.

Strategy 2: Pure Level Strategy (Constant Production Rate):
Average Monthly Demand = 8,600 / 6 = 1,433.33 units. Nova sets constant production at 1,434 units per month. Beginning inventory = 200 units. Initial workforce expansion in Month 1 from 1,000 to 1,434 units: Hire cost = 434 × Rs 500 = Rs 2,17,000. Zero subsequent hires or layoffs.

- Month 1: Production 1,434; Demand 1,000; Ending Inv = 200 + 1,434 - 1,000 = 634 units. Holding = 634 × Rs 50 = Rs 31,700.
- Month 2: Production 1,434; Demand 1,200; Ending Inv = 634 + 1,434 - 1,200 = 868 units. Holding = 868 × Rs 50 = Rs 43,400.
- Month 3: Production 1,434; Demand 1,800; Ending Inv = 868 + 1,434 - 1,800 = 502 units. Holding = 502 × Rs 50 = Rs 25,100.
- Month 4: Production 1,434; Demand 2,200; Ending Inv = 502 + 1,434 - 2,200 = -264 (Stockout / Backorder). Backorder penalty at Rs 100/unit = Rs 26,400. Ending Inv = 0.

- Month 5: Production 1,434; Demand 1,400; Ending Inv = 1,434 - 1,400 - 264 backorder = -230 units. Backorder penalty = Rs 23,000.
- Month 6: Production 1,434; Demand 1,000; Ending Inv = 1,434 - 1,000 - 230 = 204 units. Holding = 204 × Rs 50 = Rs 10,200.

Level Total Cost: Regular production (8,604 × Rs 500 = Rs 43,02,000) + Initial Hiring (Rs 2,17,000) + Total Holding (Rs 1,10,400) + Backorder Penalty (Rs 49,400) = **Rs 46,78,800**.

Managerial Insight: The Level Strategy saves Rs 11,81,200 (a 20.1% cost advantage) compared to the Chase Strategy because maintaining a steady workforce avoids crippling severance and recruitment churn.

3.4 Quantitative Evaluation of Single-Machine Sequencing Rules

To evaluate priority sequencing dispatch rules, consider five customer jobs (J1 through J5) waiting at a CNC workstation. Processing times and delivery due dates are given below:

Job Identifier	Processing Time (Days)	Due Date (Days from Today)	Customer Priority
Job 1 (J1)	6	8	Standard
Job 2 (J2)	2	6	Urgent
Job 3 (J3)	8	18	Standard
Job 4 (J4)	3	12	Standard
Job 5 (J5)	9	20	Standard

Comparative Analysis of Priority Sequencing Rules:

Sequencing Rule	Job Sequence	Average Flow Time	Average Job Lateness
FCFS	J1 - J2 - J3 - J4 - J5	15.4 Days	4.2 Days
SPT (Shortest Processing)	J2 - J4 - J1 - J3 - J5	**13.0 Days**	**2.4 Days**
EDD (Earliest Due Date)	J2 - J1 - J4 - J3 - J5	13.6 Days	**1.2 Days** (Lowest Max Lateness)

Conclusion: **SPT** minimizes average flow time and shop-floor inventory, while **EDD** minimizes maximum delivery lateness to protect customer satisfaction.

Chapter 3: Short-Term Scheduling and Production Planning & Control (PPC)

3.1 Production Planning and Control (PPC) Architecture

Production Planning and Control (PPC) is the vital operational nerve centre responsible for converting aggregate production blueprints into daily, hourly shop-floor execution. PPC coordinates materials, machinery, operators, and tooling across four disciplined phases:

- **1. Routing:** Establishes the exact sequence of manufacturing operations, identifying the specific machine tools, workstations, and departmental paths through which raw materials must travel to become finished goods. Routing sheets specify standard setup times and operating run times for each operation.
- **2. Loading:** Assigns specific jobs to designated production machines or work centres based on capacity availability. Loading ensures that work centres are neither overloaded beyond physical capacity nor underutilized. Techniques include Gantt load charts and finite capacity loading algorithms.
- **3. Scheduling:** Allocates precise start times and completion deadlines for every individual operation on the routing sheet. Master production schedules cascade down into daily shop-floor dispatch lists.
- **4. Dispatching:** The actual issuance of authorized work orders, material requisition slips, blueprints, and tooling instructions to machine operators, officially releasing the job onto the factory floor.
- **5. Expediting (Follow-up / Progressing):** Continuously tracks the physical progress of work-in-process through the plant, identifying bottleneck delays, machine breakdowns, or defective batches and implementing corrective expediting actions.

3.2 Priority Dispatching Rules in Job Scheduling

When multiple competing jobs arrive at a single machine centre, operations managers deploy standardized **Priority Sequencing Rules** to determine execution order:

- *First-Come, First-Served (FCFS):* Jobs are processed in the strict chronological order of their arrival. Viewed as fair by customers, but often yields poor performance on average completion time and work-in-process inventory.
- *Shortest Processing Time (SPT):* The job requiring the shortest operating duration is executed first. Proven mathematically to minimize average flow time, minimize average work-in-process (WIP), and minimize average job lateness across a batch of waiting jobs. However, lengthy jobs may experience severe starvation.
- *Earliest Due Date (EDD):* The job possessing the nearest customer delivery deadline is scheduled first. Significantly minimizes maximum job lateness.
- *Critical Ratio (CR):* Dynamic index calculated as: (Due Date - Current Date) / Work Time Remaining. A CR less than 1.0 indicates a job that is already behind schedule and must be

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expedited immediately.

3.3 Johnson's Rule for Scheduling n Jobs on Two Machines

When n distinct jobs must all be processed through two sequential machines (Machine 1 followed by Machine 2), S.M. Johnson established a mathematical algorithm that guarantees minimum total makespan (idle time minimization):

1. List all jobs and their processing times on Machine 1 and Machine 2.
2. Find the shortest processing time anywhere in the matrix across both machines.
3. If the shortest time falls on Machine 1, place that job as early as possible in the schedule (at the front).
4. If the shortest time falls on Machine 2, place that job as late as possible in the schedule (at the end).
5. Cross off the scheduled job and repeat the procedure until all jobs are assigned.

3.6 Loading Architectures and Scheduling Horizons

In modern computer-aided manufacturing systems, shop-floor controllers execute loading and scheduling through two distinct structural paradigms:

- **Forward Scheduling:** Scheduling activities begin immediately when the customer order is received, assigning tasks to the earliest available time slots on work centres. Forward scheduling determines the earliest possible completion date for an order. While minimizing lead time to first activity, it frequently results in finished goods sitting in storage before the customer requires delivery, accumulating inventory holding costs.
- **Backward Scheduling:** Scheduling begins from the promised customer delivery due date and works reverse-chronologically backward toward the present, scheduling each preceding operation at the latest possible moment to ensure completion exactly on the due date. Backward scheduling is fundamental to Just-in-Time (JIT) and Material Requirements Planning (MRP) systems, minimizing work-in-process (WIP) and holding costs. However, it leaves zero buffer cushion for machine breakdowns or material shipment delays.
- **Finite Loading versus Infinite Loading:** *Infinite Loading* assigns jobs to work centres based purely on customer deadlines without considering whether the total hours scheduled exceed the physical capacity of the machine center. Overloaded bottlenecks are flagged visually on load charts for subsequent overtime or subcontracting. *Finite Loading*, by contrast, strictly limits job assignments to the actual physical capacity of each workstation, automatically shifting excess work into later time periods to prevent overload queues.

Operational Characteristic	Manufacturing Scheduling	Service Operations Scheduling
Core Operational Asset	Machinery, assembly lines, automated tooling, and materials.	Human personnel, customer service staff, and physical service facilities.

Operational Characteristic	Manufacturing Scheduling	Service Operations Scheduling
Inventory Buffer	Physical finished goods and sub-assemblies buffer demand surges.	Zero physical inventory; unutilized capacity is permanently lost.
Queueing Phenomenon	Physical inventory sits idle in storage bins or staging bays.	Human customers wait in physical lines or digital virtual queues.
Customer Involvement	Customers are physically absent from the shop floor during scheduling.	Customers participate actively; scheduling must respect customer schedules and appointments.
Capacity Adjustment	Adjusting machine speeds, scheduling overtime shifts, or building stock.	Staggering employee shifts, part-time staffing, and dynamic off-peak pricing.

3.4 Summary of Scheduling and Facility Operations

Strategic operations management bridges geographic macro-planning with shop-floor micro-execution. Quantitative location models ensure that facilities are sited to minimize structural supply chain freight and operational costs. Aggregate production planning balances fluctuating market demand with internal resource capabilities, avoiding costly inventory gluts and stockouts. Disciplined production planning and control—anchored by scientific routing, loading, and priority dispatching—ensures high machine utilization, short cycle times, and dependable delivery to customers.

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