LEC-1b Introduction

8/29/2024

INDENG 250 2024 Fall
Introduction to Production Planning and Logistics Models
University of California, Berkeley

Huiwen Jia
Assistant Professor
Industrial Engineering & Operations Research

About the Instructor

Instructor: **Huiwen Jia** (huiwenj@berkeley.edu)

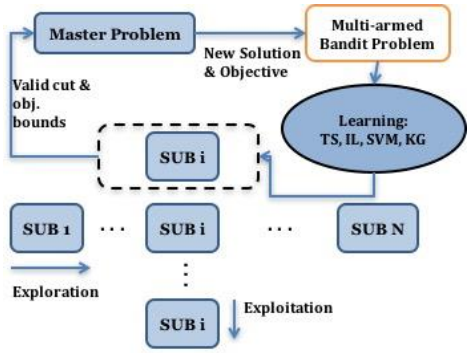
B.S. @ Tsinghua University

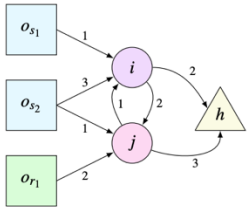
Ph.D. @ University of Michigan, Ann Arbor

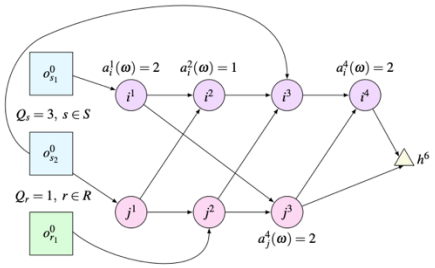
Applied Scientist @ Amazon

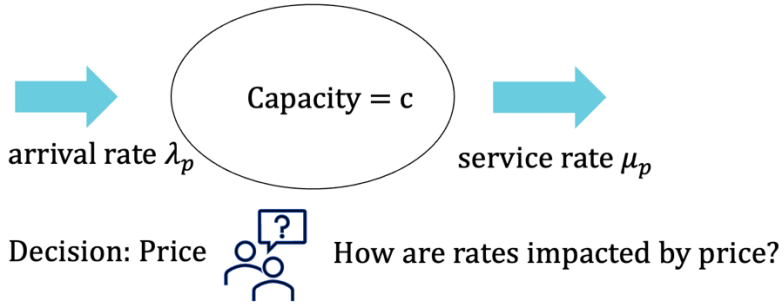
Research Areas:

- Theory: Stochastic Optimization, Robust Optimization, Machine Learning, Online Learning
- Applications: Supply Chain, Transportation, Revenue Management







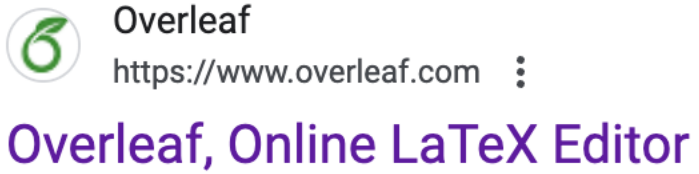


Course Details

- Instructor office hours @ Etcheverry Hall 4175
  - Tues 4-5pm,
  - Thu 1-2pm,
  - By appointment.

- The course materials are self-contained.
- This course also covers numerical implementation with *Python + Gurobi.*

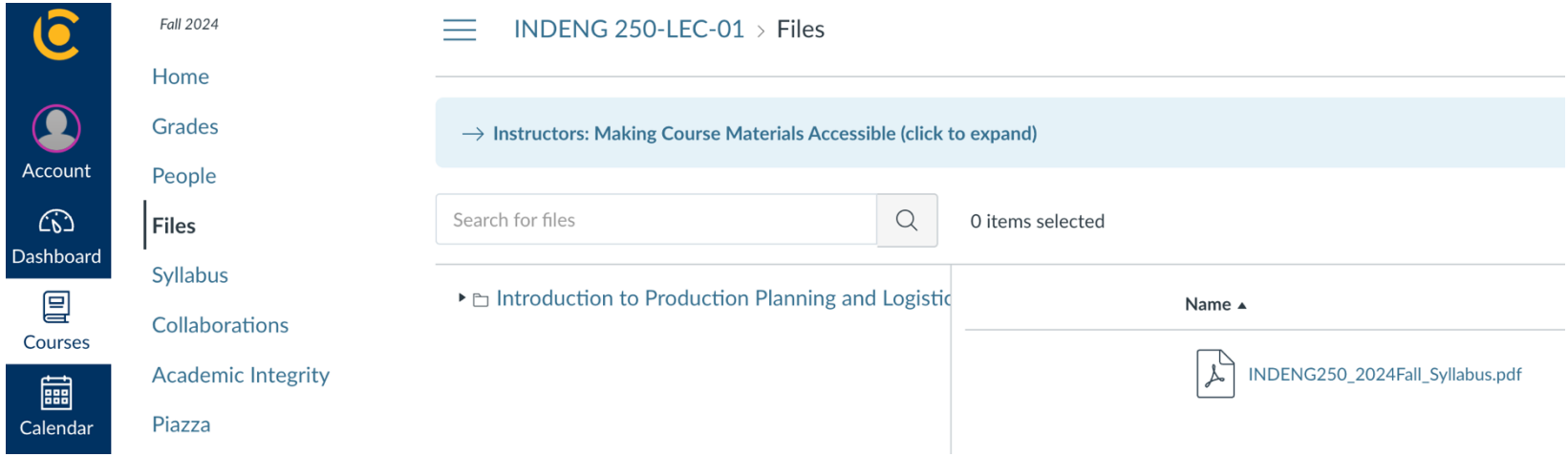
- Grades:
  - Participation (5%) 2 quizzes
  - Homework (20%) 4 problem sets (coding questions) – Typed
    - www.overleaf.com
  - In-class open-book midterm 1 (25%)
  - Take-home three-day open-book midterm 2 (25%) - Typed
  - Group project (25%) 2-3 students in each group. 10-min presentation and 5-page paper report.



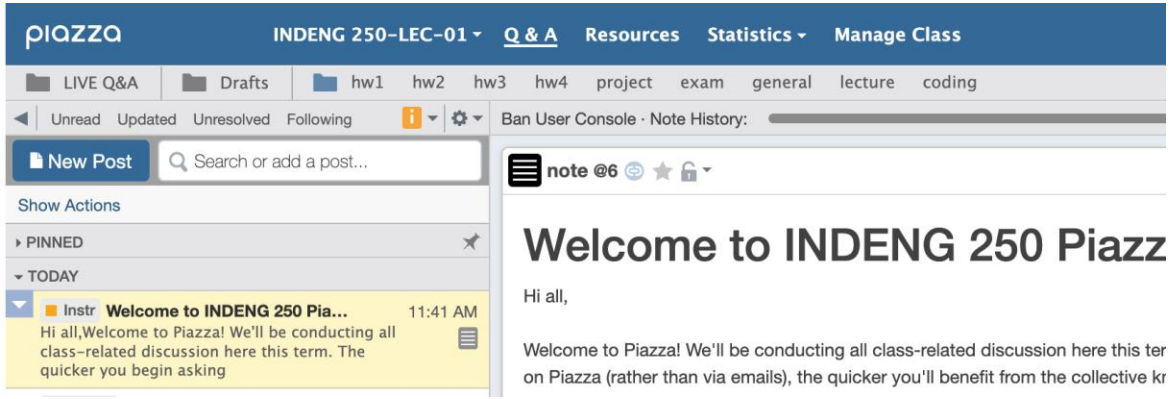
Any questions?

bCourses

- https://bcourses.berkeley.edu/



- Announcements
- Class materials – syllabus, lecture notes, problem sets, take home exams, project requirements
- Grades
- Use Piazza for Q&A's with classmates and the instructional team (optional, recommended)



Class Schedule

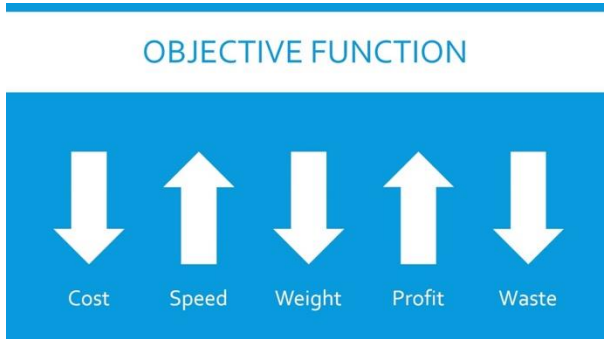
Table 1: Tentative Class Schedule (subject to changes)

Lecture	Date	Topic
1b	Aug 29	Introduction & preliminary techniques
2a	Sept 3	Demand Forecasting I - Smoothing, linear regression
2b	Sept 5	Demand Forecasting II - ARIMA, gradient boosting
3a	Sept 10	Inventory Management I - EOQ model and extensions
3b	Sept 12	Inventory Management II - Dynamic lot sizing & Wagner-Whitin model
4a	Sept 17	Inventory Management III - Newsvendor model I
4b	Sept 19	Inventory Management IV - Newsvendor model II
5a	Sept 24	Inventory Management V - Two/Multi-Echelon Problem
5b	Sept 26	Inventory Management VI - Continuous review
6a	Oct 1	Production Planning I - Scheduling
6b	Oct 3	Review and Discussion
7a	Oct 8	In-class Midterm 1
7b	Oct 10	Production Planning II - Knapsack problem, aggregate production planning
8a	Oct 15	Network & Logistics I - Maximum flow
8b	Oct 17	Network & Logistics II - Multi-commodity distribution system design
9a	Oct 22	No class (INFORMS Annual Meeting)
9b	Oct 24	Network & Logistics III - Maximum covering & set covering
10a	Oct 29	Network & Logistics IV - Deterministic facility location problem
10b	Oct 31	Network & Logistics V - Stochastic facility location problem
11a	Nov 5	Algorithms - Decomposition algorithm, greedy algorithm
11b	Nov 7	Network & Logistics VI - Guest lecture or paper reading
12a	Nov 12	Revenue Management I - Newsvendor with pricing
12b	Nov 14	Revenue Management II - Pricing & MAB
13a	Nov 19	Review and Discussion
13b	Nov 21	No Class - Midterm 2
14a	Nov 26	No Class - Meeting between instructor and each project group
14b	Nov 28	No Class - Holiday
15a	Dec 3	Project presentation session 1
15b	Dec 5	Project presentation session 2
	Dec 10	RRR Week, no class, student work on project report
	Dec 19	Project report due

https://registrar.berkeley.edu/wp-content/uploads/UCB_AcademicCalendar_2024-25.pdf

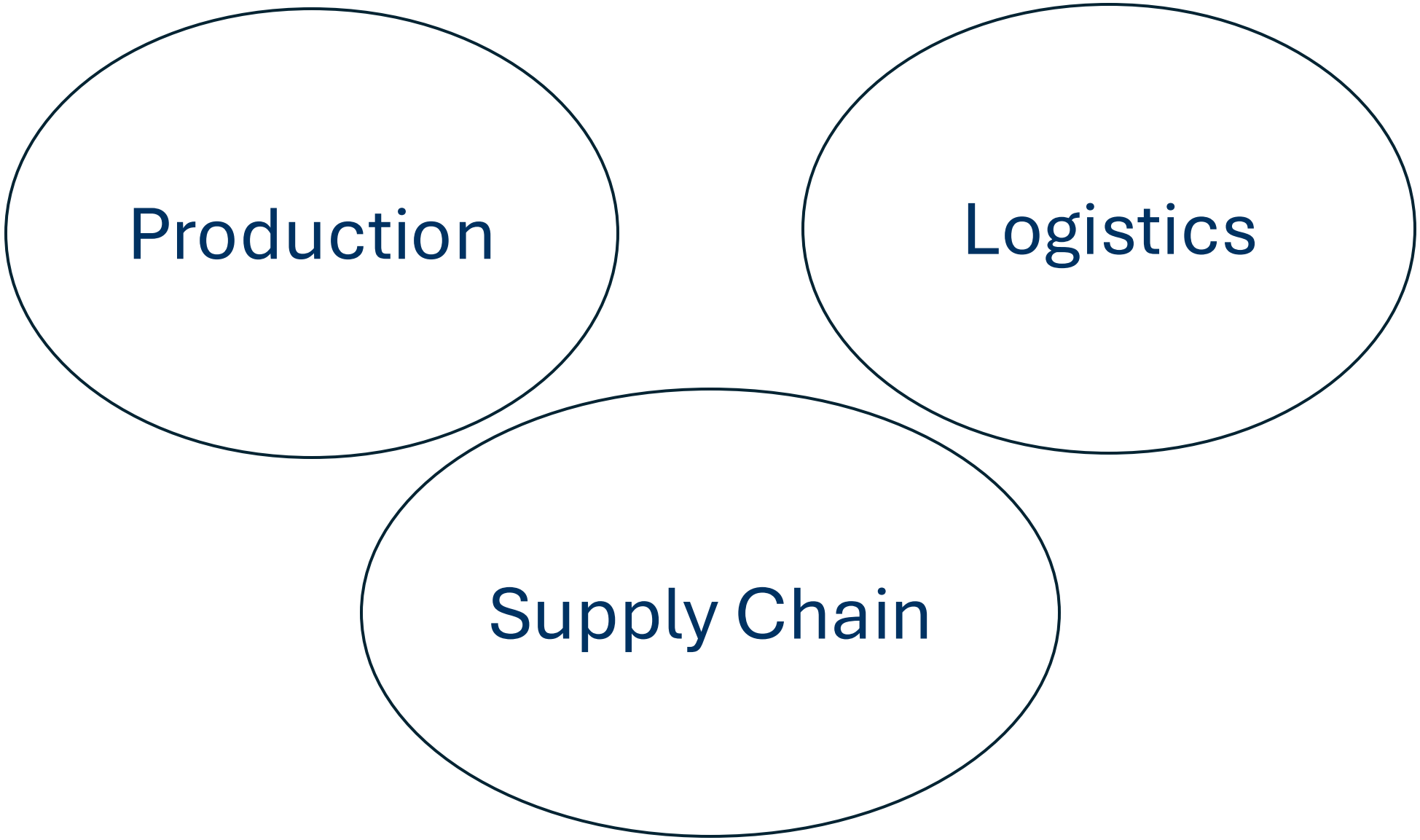
Course Objective

Introduction – Survey Course

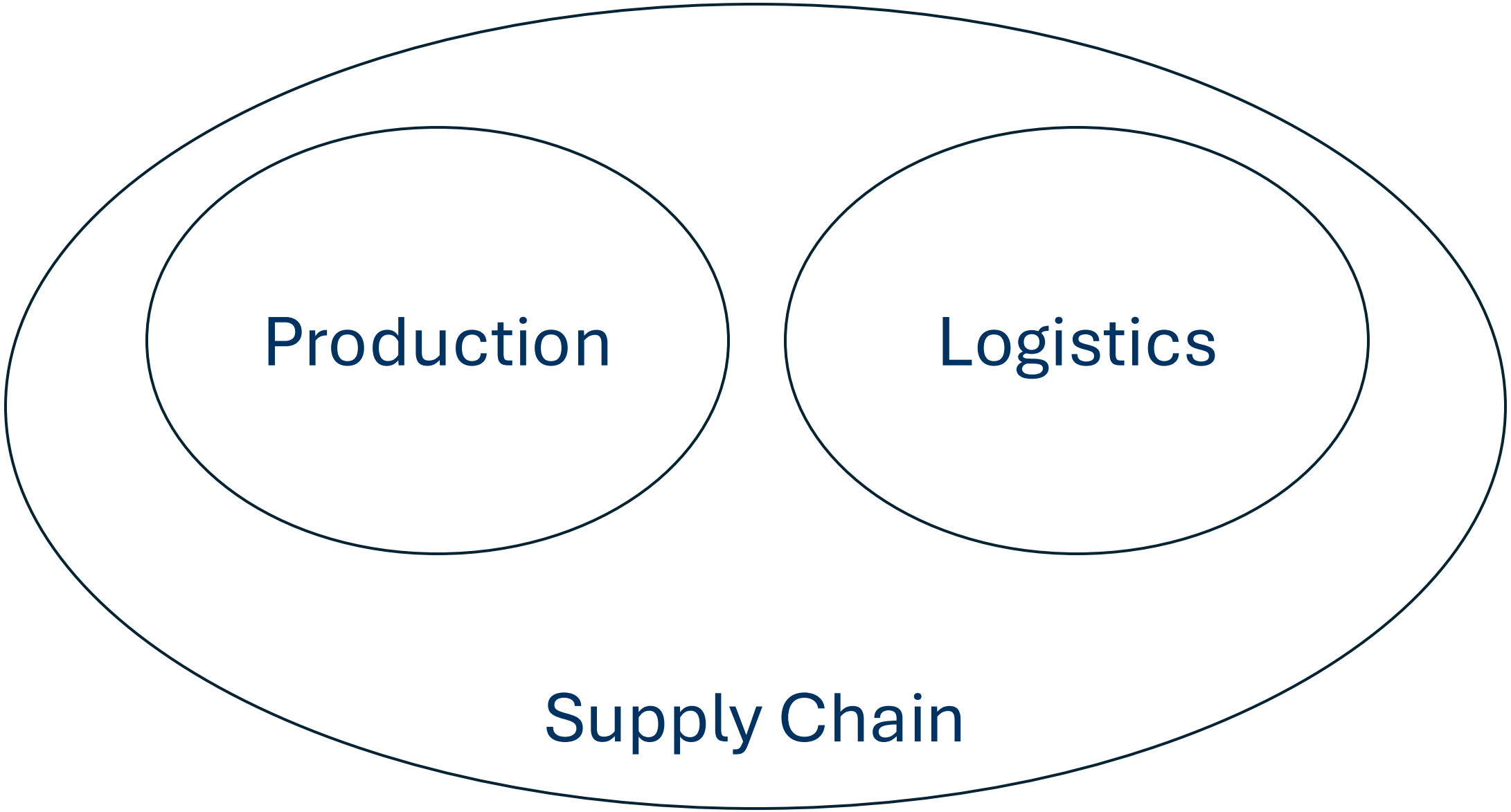


- Goal 1: Problem
  - Problems
  - Decisions
- Goal 2: Methodology
  - Models
    - Linear (mixed integer) programming, stochastic programming, dynamic programming
  - Algorithms
    - Lagrangian relaxation, decomposition algorithm, greedy algorithm
- Goal 3: Analysis
  - Coding
  - Performance metrics

Production & Logistics



Production & Logistics



What is Supply Chain?

All the activities and infrastructure whose purpose is to move products from where they are produced to where they are consumed.

Production → activities & infrastructure → Consumption

2024 Annual Business Logistics Cost ~ 2.3 trillion
(~ 8.7% of total US GDP)

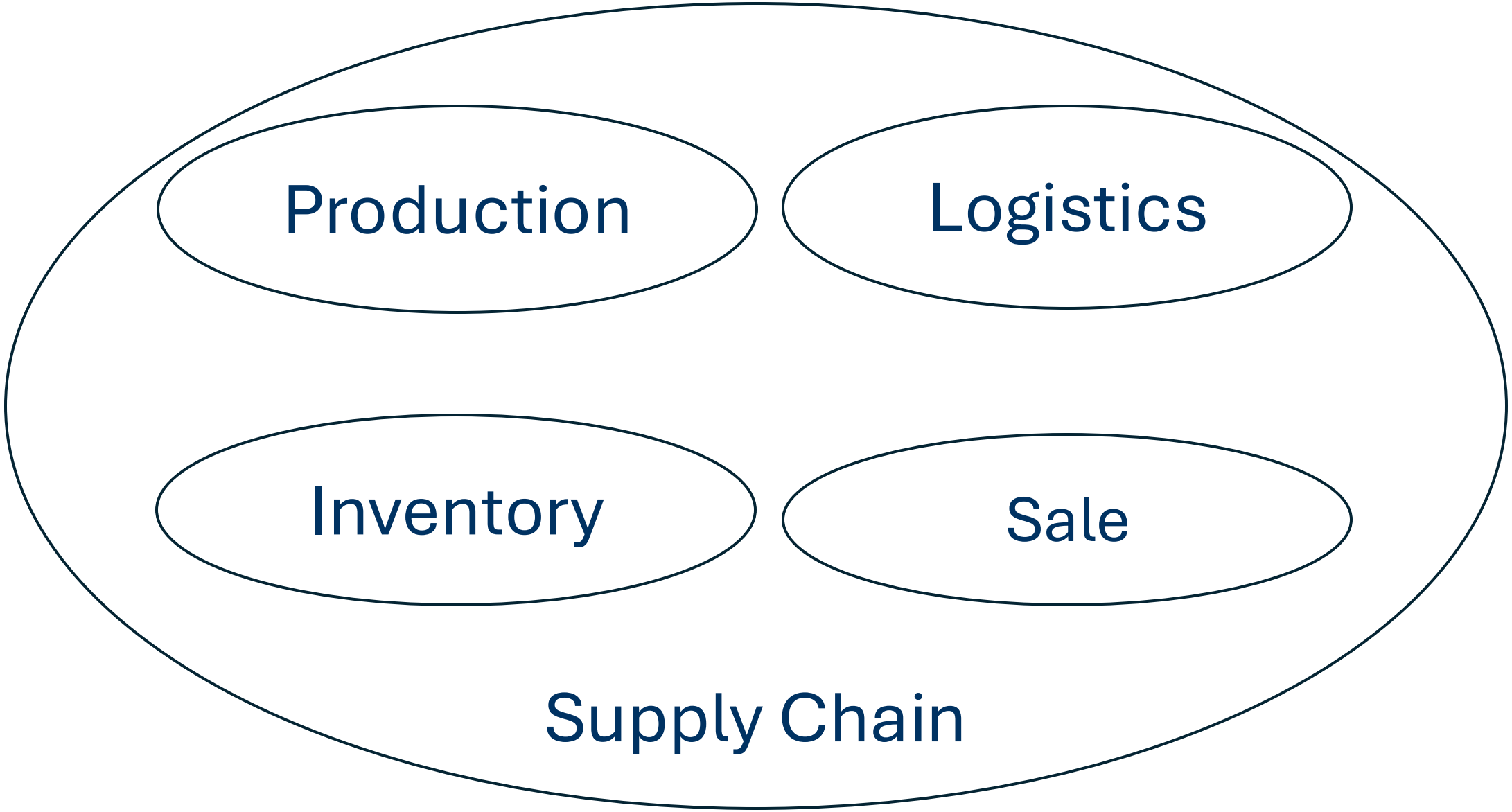
Behind the Definition

- A supply chain consists of **all stages** involved, directly or indirectly, in fulfilling a (final) customer request.
  - It not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves.

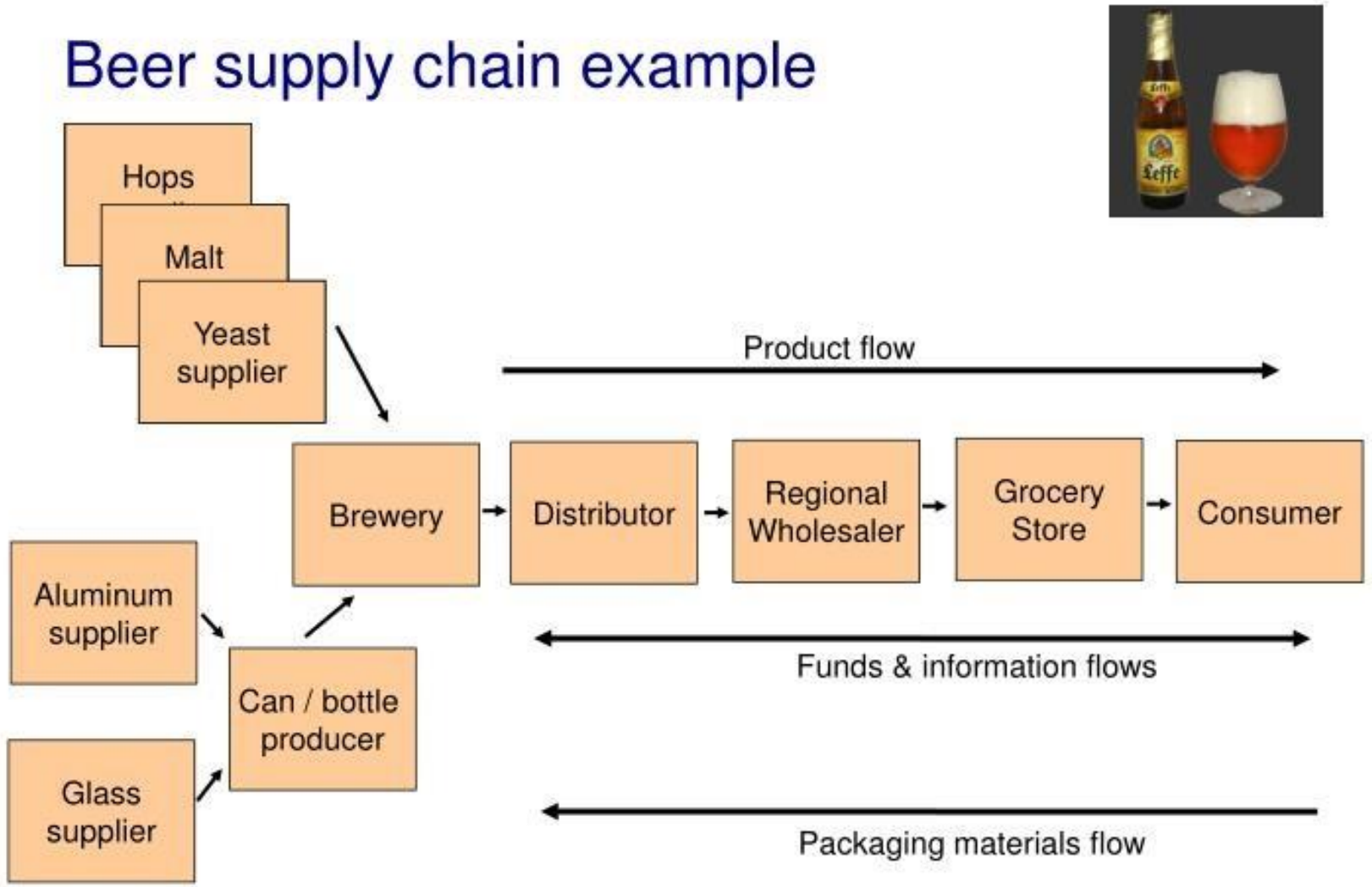
- Two roles: customer & operator
  - **Duality**: one agent can be both customer & operator

- **Infrastructure** & **Activities**
  - Materials/Equipment/Locations
  - Human resources/Scheduling
  - Services/Sales

Production & Logistics

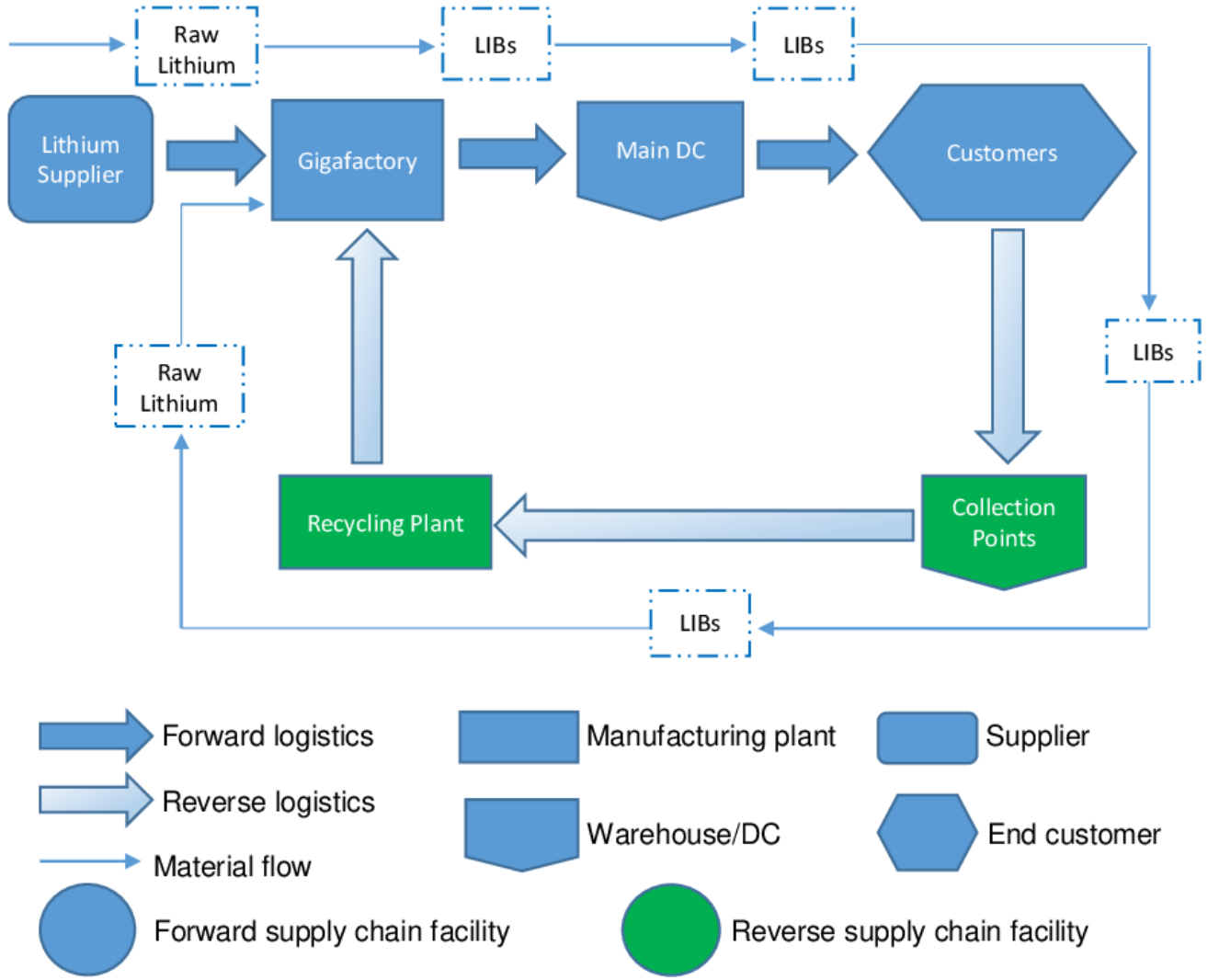


Example of a Supply Chain



Picture from: https://www.pinterest.com/pin/beer-supply-chain--530369293620086784/

Example of a Supply Chain



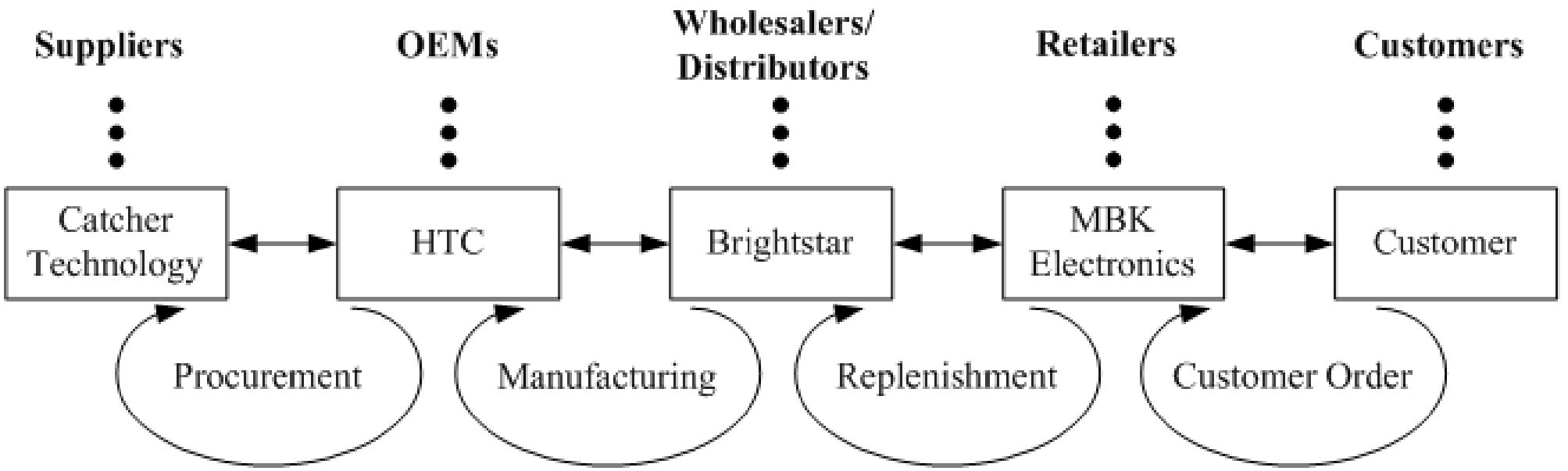
Question: which company?

Hint: LIBs
- Lithium-ion batteries
- dominating rechargeable batteries

Picture from: https://www.semanticscholar.org/paper/Closed-loop-supply-chain-simulation-with-disruption-Gianesello-Ivanov/8381dbba8b0007042fce82e50bf9f95b6da872bc

Example of a Supply Chain

Material/product flow is from upstream → downstream

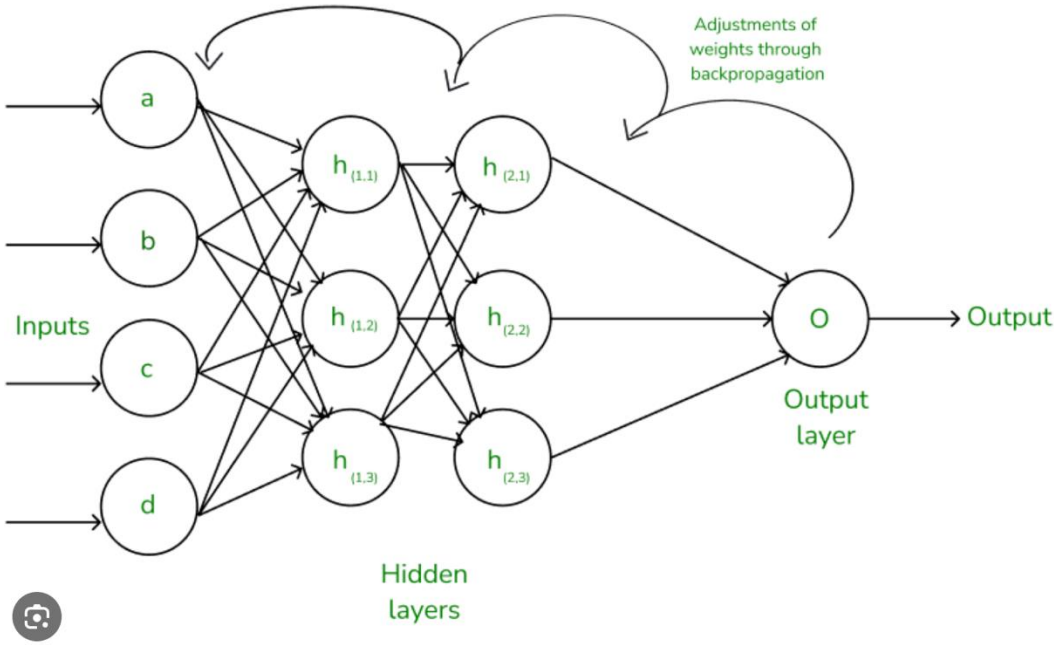


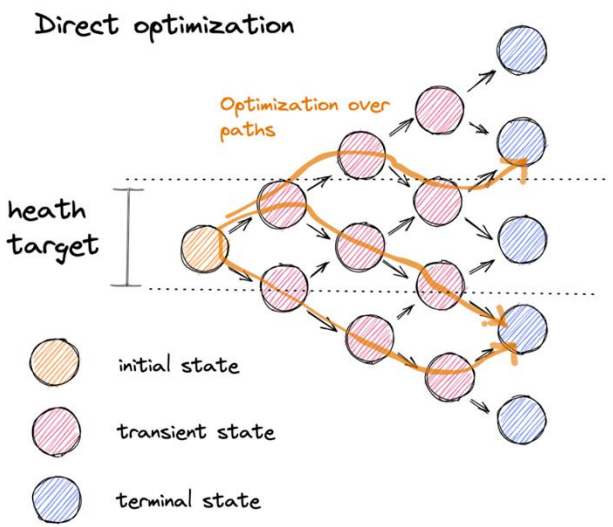
But the decisions/requests, they come from downstream → upstream.

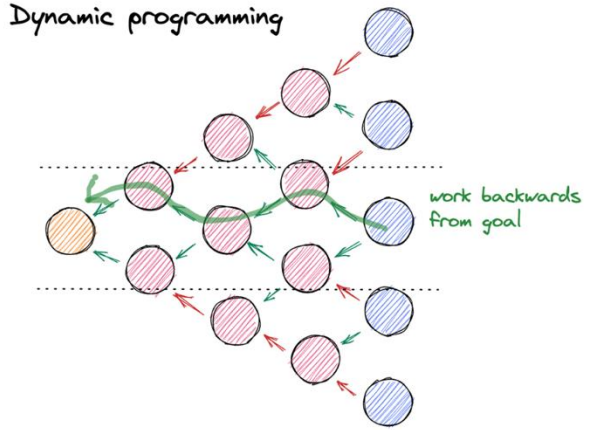
Picture from : https://www.perlego.com/book/1602771/supply-chain-management-for-engineers-pdf

Example of a Supply Chain

Material/product flow is from upstream → downstream



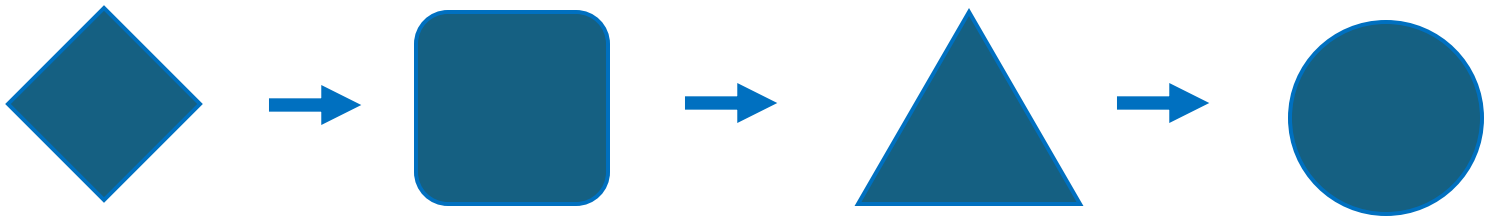




But the decisions/requests, they come from downstream → upstream.

Pictures from https://lamontbiophysics.com/research/treatment-design-with-dynamic-programming & https://www.geeksforgeeks.org/backpropagation-in-neural-network/

Schematic Diagram



(Tier 1, 2)
Supplier

Plants
Manufacturing
Assembly

Warehouses
Distribution Center

Retailers
Customers

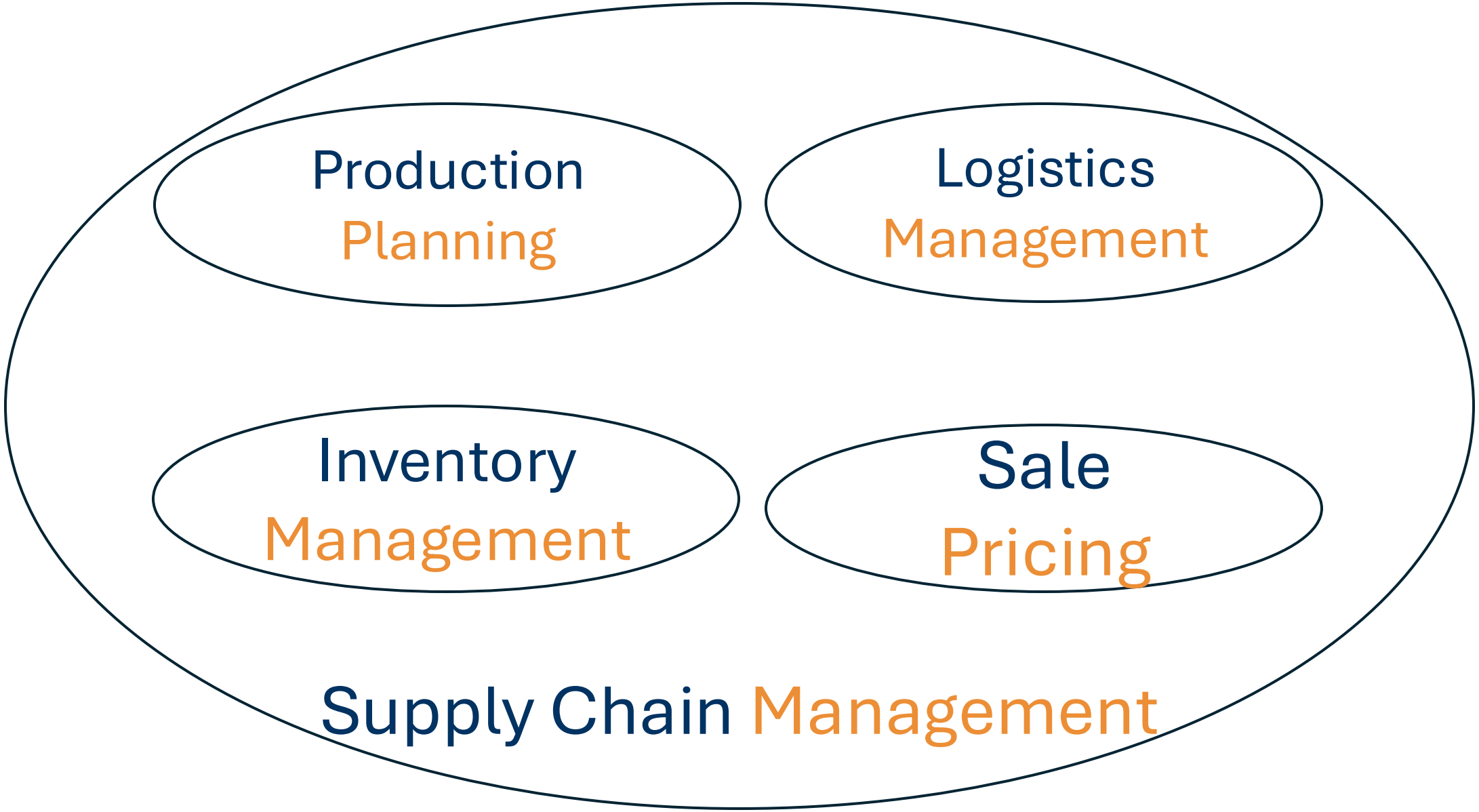
Upstream ----------> Downstream

Echelon 4 Echelon 3 Echelon 2 Echelon 1

Managing a Supply Chain

- The objective of every supply chain is to maximize the overall **value** generated.
- The value is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request. [**Price - Cost**]
- The total profit, to be shared across all supply chain stages, is called ***supply chain profitability***.

Production Planning & Logistics Management



What is Supply Chain Management?

SCM is the set of practices required to perform the functions of a SC and to make them

- more efficient
- more profitable
- more equitable
- more sustainable
- less costly
- less wasteful
- less stressful

Multi-dimensional objectives!

Typical Set of Practices

- Demand forecasting
- Production planning
- Inventory management
- Warehouse location (facility location)
- Supplier selection (sourcing)
- Transportation, shipping, last-mile delivery
- Revenue management (dynamic pricing)

Each part requires decisions → optimization!

Decisions of Industry Examples

- Amazon Fresh
  - Perishable Inventory Systems
  - Order Fulfillment (Service Level)

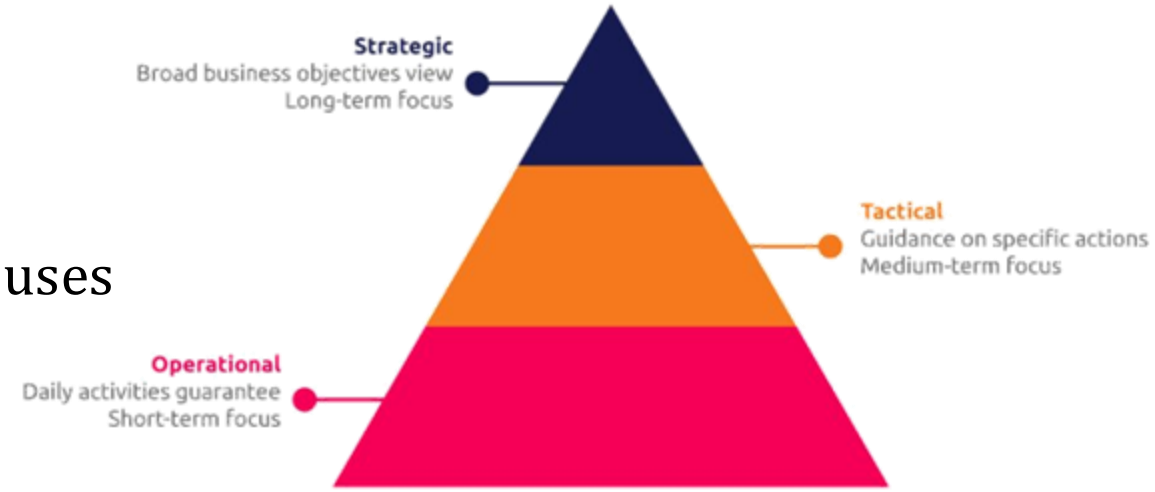
- Airline (Network) Revenue Management
  - Inventory and Capacity Constraints
  - Dynamic Booking and Pricing

- On-Demand E-Hailing/Ride-Sharing Platform (Uber, Lyft, DiDi)
  - Demand Prediction
  - Dynamic Matching
  - Dynamic Pricing

- Online Algorithms and Online Reinforcement Learning
  - Learning & Decision Making

Three Types/Layers of Decisions

- Strategic (long-term planning):
  - Location & sizes of warehouses
  - Location & capabilities of factories
  - Contracts with suppliers
- Tactical (medium-term planning):
  - Assignments of customers to warehouses
  - Inventory policies at warehouses
- Operational (short-term planning):
  - Filling customer orders
  - Routing of delivery vehicles



Picture from: https://scoreplan.com.br/blog/strategic-planning-levels/

Strategic Innovations

VMI (Vendor Managed Inventory)

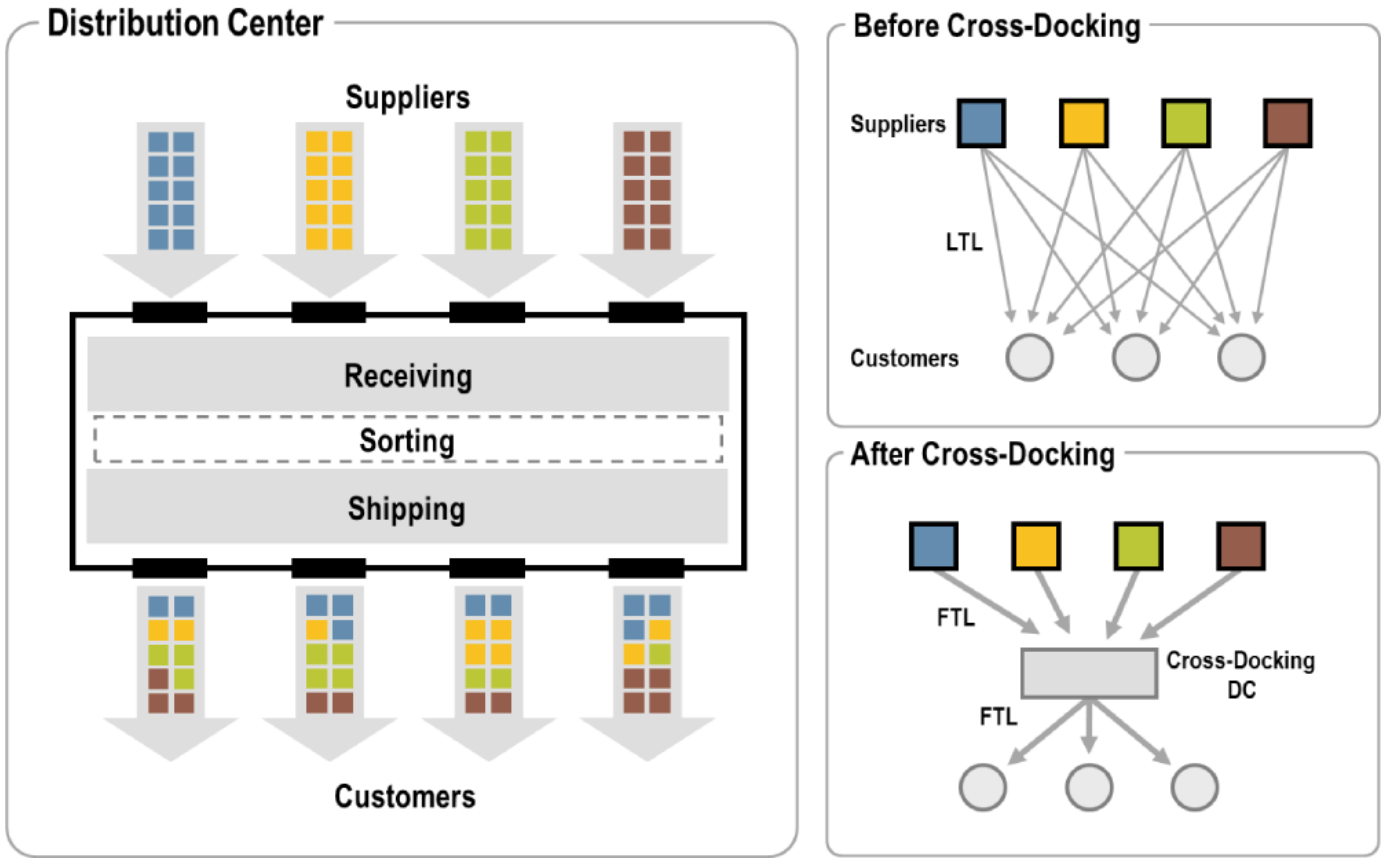
- Vendor employee is on-site of Walmart's facility
- Physically replenish inventory on a visit
- Vendor has (partial) access to Walmart's inventory system (MRP/ERP)

Benefits:

- Protect vendor from under-stock and lost-sales
- Better inventory carrying costs
- Easy "decentralized" management for Walmart

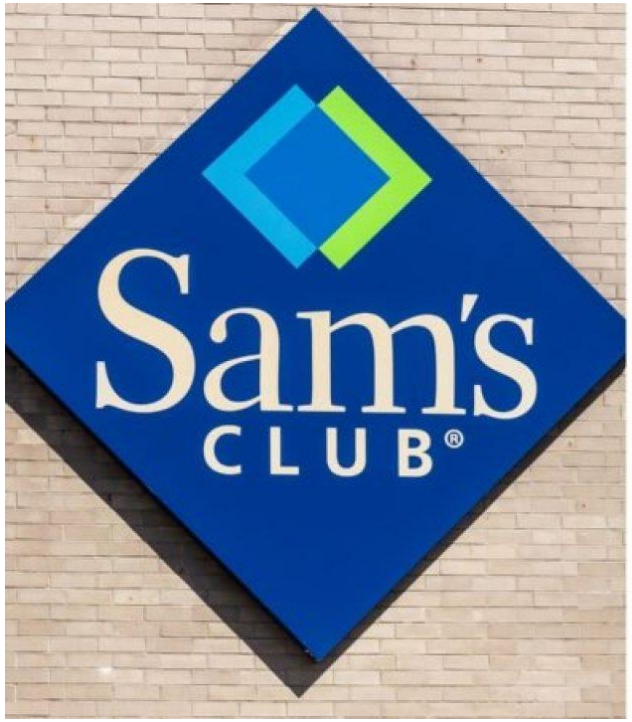
Centralized Optimization vs Distributed Optimization

Cross-Docking Strategy



Picture from: https://logisticsmgepsupv.wordpress.com/2020/04/06/logistic-strategies-and-cross-docking/

Strategic Innovations



Membership Fee (Sam's club): $50 basic, $110 premium
Membership Fee (Costco): $65 basic, $130 executive (2% cashback)

Costco made membership Fee $4.6 billion - accounts for 72% of net profit (2022)

Data from: https://www.fool.com/the-ascent/personal-finance/articles/you-wont-believe-how-much-money-costco-just-made-on-membership-fees/

Failure Case

- Expansion into Canada in 2013
- Had to close 133 stores and laid off 17600 employees
- Lost $2.5 billion

Problems:

- Wrong demand prediction (based on US sales)
- Poor SKU selection and inventory management
- Overstock and understock at the same time

From: https://hbr.org/2015/01/why-targets-canadian-expansion-failed

Failure Case

@Mt. Shasta

Single resource to support multiple products

- Pros: pooling effect
- Cons: cut off critical resource

Better to offer with other products!

Take Away

This class:

- Supply chain
  - Components
  - Examples
- Supply chain management
  - Objective
  - Practices
- Three types of decisions
  - Strategic innovations

Next class:

- Demand forecast