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M1 IEM + M1 BIT CORE TOPICS: SUPPLY CHAIN MANAGEMENT

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ABOUT ME

B.Sc. and M.Sc in Business Information Systems, Paderborn University, Germany

2016: PhD from the Decision Support & Operations Research Lab, Paderborn University

2016 – 2022: PostDoc and Assistant Professor, Department of Applied Mathematics and Computer Science, Technical University of Denmark

Since May 2022: Assistant Professor of Stochastic Operations Research at IEBIS section

Research: Optimization, decision-making under uncertainty, energy systems, health care, logistics

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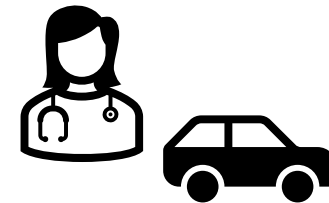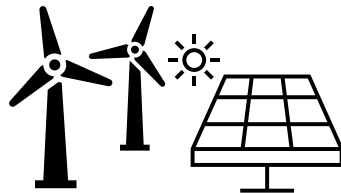
CORE TOPICS?

Supply Chain Management
Information Management
Financial Management

Why?
- To give you a broad overview of topics that you will experience during your studies. See them as teaser for later modules...

- To help you decide, if this is the right study programme for you.

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IEM MODULE 4

In Q4

202000405
Supply Chain Management

Course info

Course module	202000405	Academic year	2022
Credits (ECTS)	0	Starting block	2B
Course type	Module name	Application procedure	You apply via OSIRIS Student
Language of instruction	English	Registration using OSIRIS	Yes
Contact person	dr. D. Guericke		
E-mail	d.guericke@utwente.nl		
Lecturer(s)			
Contactperson for the course	dr. D. Guericke		

Module consists of the study units
202001222 Calculus 2 for IEM
202000406 Statistics
202000407 Demand Supply Planning and Inventory Management
202000408 Sourcing, Supply Network Design and Transport
202000409 Business Game

Module description
SCM is the management of a network of interconnected businesses involved in the ultimate provision of products and service packages required by end customers. The main goal is to profitably match the end customer's demand with the supply. It is not restricted to production and sourcing, but it also includes transportation, warehousing, sales, and even the customers themselves. Within each organization, the supply chain includes all functions involved in receiving and filling customer demand. These functions include new product development, marketing, operations, distribution, finance, and customer services.
In this module, we will mainly focus on how to manage inventories and forecast the demands, plan the re:quired resources, design distribution and transportation networks, and decide on the sourcing and purchasing activities in the supply chain. The content of the SCM module consists of nine blocks, including Math and Statistics. These blocks are:
Block 1- Strategic framework for supply chain analysis
Block 2- Demand and supply planning and coordination (DSP) in a supply chain:
Block 3- Inventory management (IM) in supply chain
Block 4- Transportation
Block 5- Designing and Planning Transportation Networks
Block 6- Sourcing decisions in a supply chain
Block 7- Supply chain network design (SCND)
Block 8- Mathematics (Calculus 2)
Block 9- Statistics

Required materials
Course material
See listing at associated study unit(s)

Recommended materials
Course material
See listing at associated study unit(s)

Instructional modes
Module
Presence duty Yes

Tests
Module

RESOURCES

Literature:
Chopra, Sunil: *Supply Chain Management – Strategy, Planning and Operation*, Seventh edition, Pearson Education (2019)
Link to eBook: https://ebookcentral.proquest.com/lib/itc/detail.action?docID=5601286

Relevant parts for this lecture:
- Chapter 1 – Introduction
- Chapter 10.1 – 10.4 – Bullwhip Effect

This book will also be used in Module 4 - Supply Chain Management

Mandatory Assignment:
Wood Supply Game
Link to description: https://www.forac.ulaval.ca/en/transfer/wood_supply_game/description/\
Link to game: http://forac-old.fsg.ulaval.ca/woodSupplyGame/AideJeuBois/EN/indexEN.htm
- In your project groups of 4-7 students
- Detailed instructions will follow at the end of this lecture

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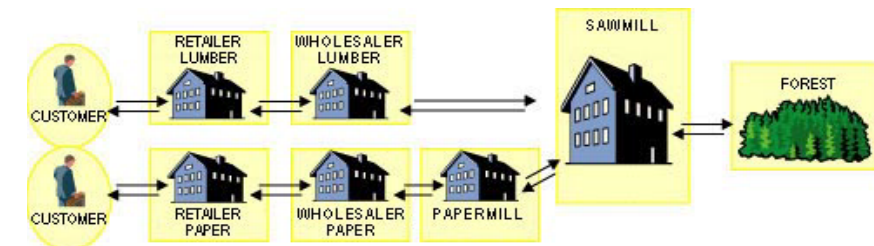
AGENDA

1. Introduction Supply Chain Management
2. Coordination in a Supply Chain
3. Assignment: The Wood Supply Game

How to participate?

Click on the projected screen to start the question

Copy participation link

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INTRODUCTION

HEALTH

Coronavirus raises fears of U.S. drug supply disruptions

Many pharmaceuticals' active ingredients are made in China

By Laurie McGinley and Carolyn Y. Johnson
February 26, 2020 at 12:23 p.m. EST

Washington Post, 26-2-2020
https://www.washingtonpost.com/health/2020/02/26/coronavirus-raises-fears-us-drug-supply-disruptions/

U.S. Food Supply Chain Is Strained as Virus Spreads

Disruptions are expected in the production and distribution of products like pork, and localized shortages could occur.

New York Times, 13-04-2020
https://www.nytimes.com/2020/04/13/business/coronavirus-food-supply.html

Crisis Management

Coronavirus Is a Wake-Up Call for Supply Chain Management

by Thomas Y. Choi, Dale Rogers, and Bindiya Vakil

March 27, 2020

Harvard Business Review, 27-03-2020,
https://hbr.org/2020/03/coronavirus-is-a-wake-up-call-for-supply-chain-management

FINANCE · ECONOMY

75% of companies report coronavirus has disrupted their supply chains

BY **LANCE LAMBERT**
March 11, 2020 at 7:30 PM GMT+1

Fortune 11-03-2020, https://fortune.com/2020/03/11/75-of-companies-report-coronavirus-has-disrupted-their-supply-chains/

Article · Logistics

Ukraine war hits supply chain on oil, gas, cereals and CPG

By **Sean Ashcroft**
March 02, 2022 · 6 mins

SupplyChain 02-02-2022, https://supplychaindigital.com/digital-supply-chain/ukraine-war-leaves-supply-facing-hits-on-oil-gas-cereals-an

Operations And Supply Chain Management

How the War in Ukraine Is Further Disrupting Global Supply Chains

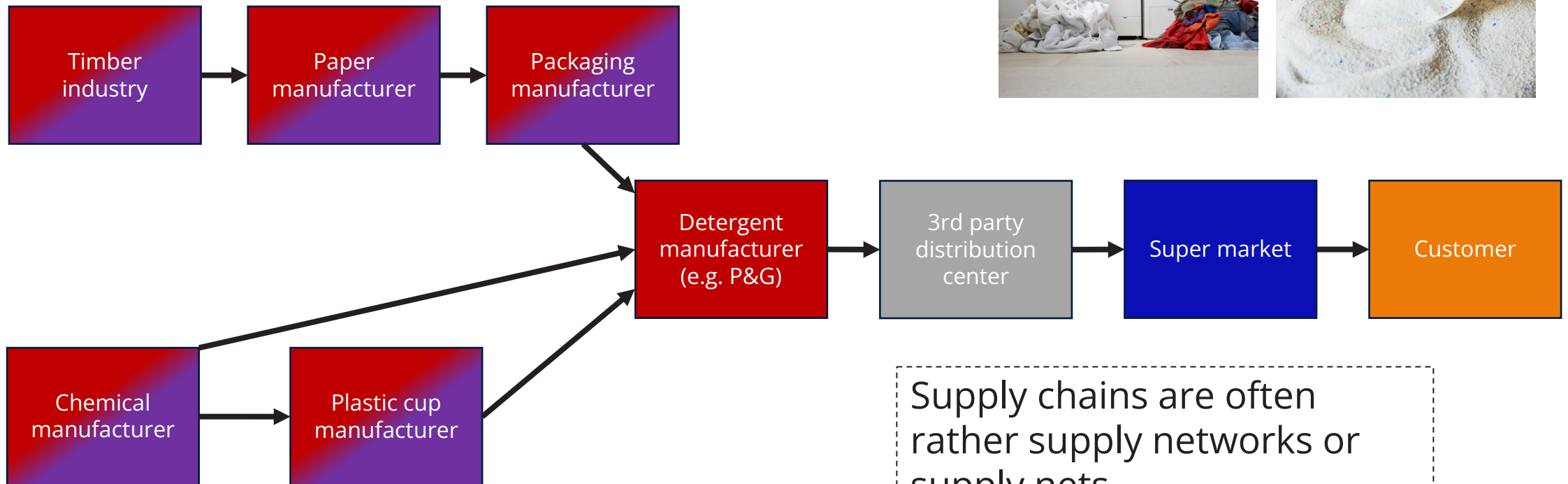by David Simchi-Levi and Pierre Haren

March 17, 2022

Harvard Business Review, 17-03-2022
https://hbr.org/2022/03/how-the-war-in-ukraine-is-further-disrupting-global-supply-chains

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WHAT IS A SUPPLY CHAIN (SC)?

- A supply chain contains **all parties** involved, directly or indirectly, in **fulfilling a customer request:**
  Suppliers, manufacturers, wholesalers / transporters, retailers and customers

- Example: Detergent supply chain


```
Timber industry → Paper manufacturer → Packaging manufacturer
                                              ↓
Chemical manufacturer → Plastic cup manufacturer → Detergent manufacturer (e.g. P&G) → 3rd party distribution center → Super market → Customer
```

Supply chains are often rather supply networks or supply nets.

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WHAT IS A SUPPLY CHAIN?

A supply chain contains **all functions in receiving and fulfilling a customer order**.

Amongst others:
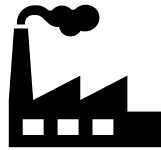
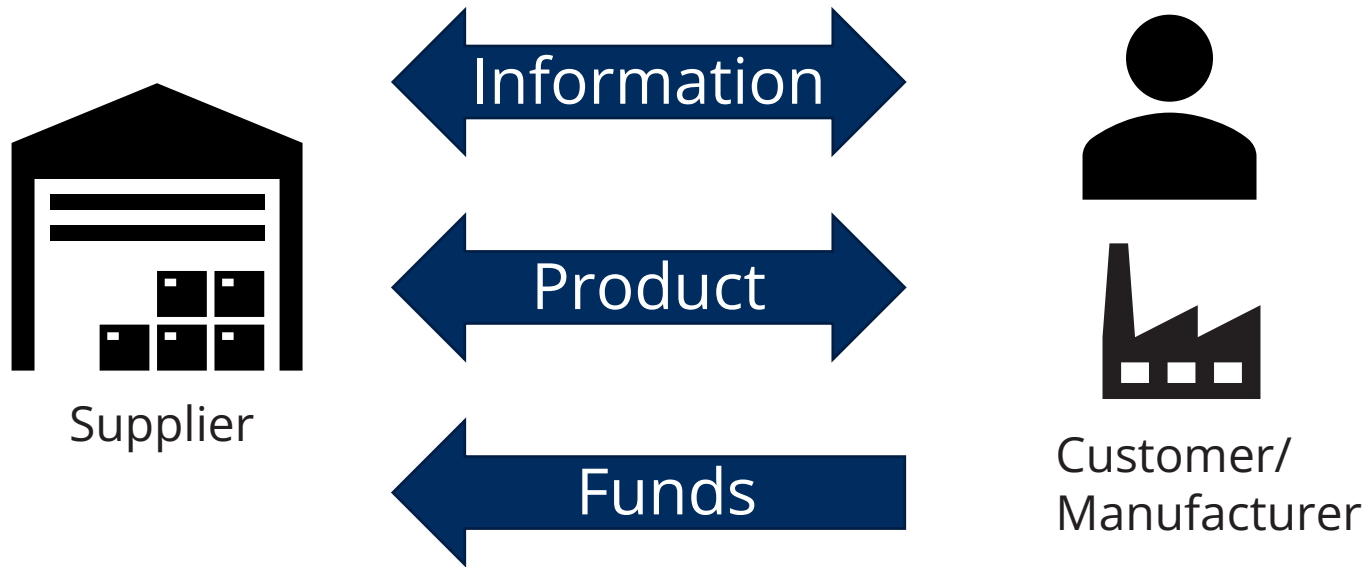Operations   Transportation   Customer service

Marketing   Finance   Product design

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WHAT IS A SUPPLY CHAIN?

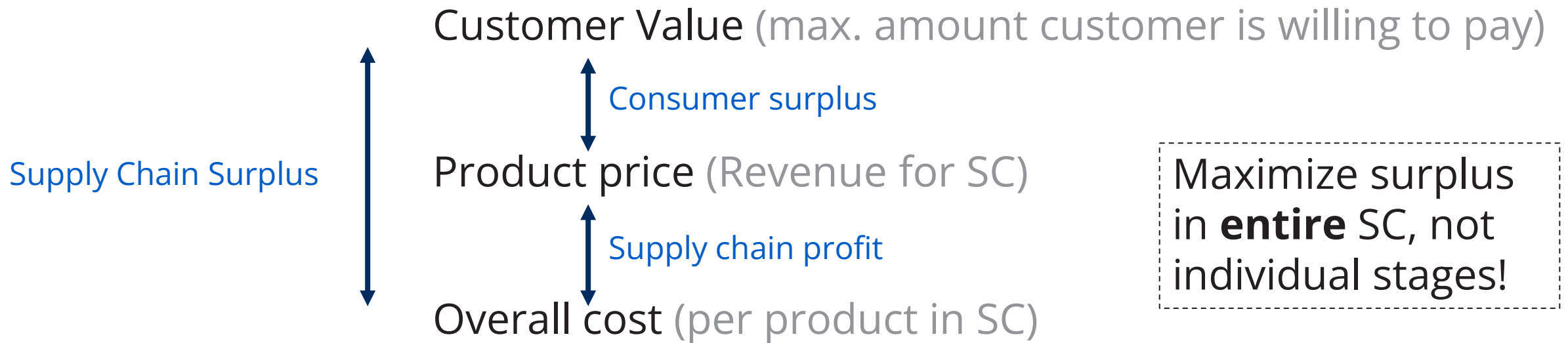A supply chain has **three types of flows** that constantly flow between different stages:

Information

Product

Funds

Supplier

Customer/
Manufacturer

Goal:
Structure the three flows such that they fulfill the customer needs in a cost-effective manner

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OBJECTIVE OF A SUPPLY CHAIN

A supply chain should maximize the net value generated measured by the **Supply Chain Surplus**

Supply Chain Surplus = Customer Value – Supply Chain Cost

Customer Value (max. amount customer is willing to pay)

Consumer surplus

Supply Chain Surplus

Product price (Revenue for SC)

Supply chain profit

Overall cost (per product in SC)

Maximize surplus in **entire** SC, not individual stages!

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EFFECTIVE SCM IS IMPORTANT FOR SUCCESS OR FAILURE

Walmart:

- Goal: low-cost, product availability
- Supply chain structure: Cluster of stores around distribution centers (DC) for frequent store replenishment (Match supply and demand more effectively)
- Invested heavily in transportation and information sharing
- Information sharing and supplier collaboration improved product availability and reduced costs
- Sales increase between 1980 and 2010: $1 billion $\rightarrow$ $408 billion (22% growth per year)
- SC structure not successful for small format stores and online sales

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EFFECTIVE SCM IS IMPORTANT FOR SUCCESS OR FAILURE

Borders:
- Superstore for books sales (greater variety at lower cost, compared to local bookstores)
- Lower operating cost due to larger stores
- Failed to adapt when Amazon grew (Amazon: even greater variety from a few distribution centers)
- Bankruptcy in 2010

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EFFECTIVE SCM IS IMPORTANT FOR SUCCESS OR FAILURE
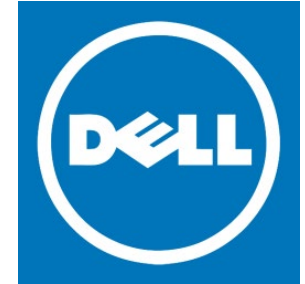
Dell
- Successful supply chain design, planning and operation
- Adaption to changing conditions

1993 – 2006:
- Strategy: Sell customized PCs quickly and at reasonable cost
- Decision: Sell directly to customers bypassing distributors and retailers
- Centralization of manufacturing and inventories in a few locations and final assembly is postponed until the customer order arrives

2006: Market shifted to low level customization (growing power of hardware, customers were satisfied with few models)
- Dell adapts its supply chain by operating two supply chains for two markets
- Additionally sell low-customized PCs through retailers
- Make-to-order for customized and make-to-stock for low customized

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SUPPLY CHAIN MANAGEMENT

Supply Chain Management (SCM):
Effective management of supply chain assets, products, information and funds to grow the SC surplus

Decisions in SCM can be divided in 3 stages (based on frequency):

Supply chain strategy or design

How to structure the supply chain over **several years**

Supply chain tactical planning

Decisions over a **quarter or year**

Supply chain operation

Daily or weekly operational decisions

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SUPPLY CHAIN STRATEGY OR DESIGN

Supply chain design decisions are **long-term and expensive to change on short notice**
→must consider uncertainty in market conditions over the following years

Goal: Increase supply chain surplus and fit strategic objectives

Example decisions:
- Locations and capacities of facilities (manufacturing, warehousing)
  Products to be manufactured (where to produce) and stored at various locations (where to store)
- …

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SUPPLY CHAIN TACTICAL PLANNING

Strategic decision are made and set constraints for decisions for tactical planning
→Planning starts with demand forecast for the coming year
→Demand uncertainty, exchange rates, competition over mid-time horizon need to be considered

Goal: maximize supply chain surplus

Example decisions:
- Which markets to supply from which locations (locations are fixed)
  Example: decisions regarding production quantities at each location for the next quarter
- Inventory policies for the warehouses
- Timing and size of market promotions
- ...

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SUPPLY CHAIN OPERATION

Supply chain strategy or design
How to structure the supply chain over **several years**
Supply chain tactical planning
Decisions over a **quarter or year**
Supply chain operation
Daily or weekly operational decisions

Goal: Handle incoming customer orders in the best possible manner
→Decisions regarding individual customer orders
→Supply chain structure and planning policies set constraints
→Less uncertainty, exploit this to optimize performance

Example decisions:
- Allocate an inventory item or release a production order for customer orders
- Set delivery schedules
- Replenishment orders
- …

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DECISION LEVELS

Supply chain strategy or design

How to structure the supply chain over **several years**

Supply chain tactical planning

Decisions over a **quarter or year**

Supply chain operation

Daily or weekly operational decisions

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DECISION LEVELS

Supply chain strategy or design
How to structure the supply chain over **several years**

Supply chain tactical planning
Decisions over a **quarter or year**

Supply chain operation
Daily or weekly operational decisions

Solution: Match each decision with the decision level that fits best

Which information system to install
→ Strategic (expensive to change, affects information flow in all business units)

Outsourcing of manufacturing
→ Tactical (no change of own assets, temporarily moving production to another company)

Generating lists of items to be picked for customer orders
→ Operational (links to specific orders)

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The structure of the world's supply chains is changing

The pandemic and war in Ukraine have speeded up the transformation

Briefing | Chain reaction

Jun 16th 2022 | NEW YORK AND SAN FRANCISCO

Yanking the chain
Global supply-chain leaders, % responding
March-April 2022

Implemented between:
- May 2020-Apr 2021
- May 2021-Apr 2022
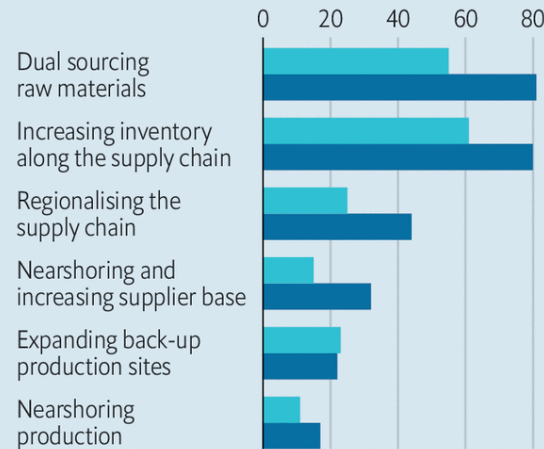
Source: McKinsey & Company
The Economist

Decisions need to be reevaluated and potentially revised in regular intervals.

The Economist, 16-06-2022, https://www.economist.com/briefing/2022/06/16/the-structure-of-the-worlds-supply-chains-is-changing

Supply Chain Management

Global Supply Chains in a Post-Pandemic World

Companies need to make their networks more resilient. Here's how. by Willy C. Shih

From the Magazine (September–October 2020)

Harvard Business Review, Issue Sep-Oct 2020, https://hbr.org/2020/09/global-supply-chains-in-a-post-pandemic-world

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CUSTOMER ORDER DECOUPLING POINT

Link to customer order

| Process 1 | Process 2 | Process 3 | ... | Process k | Process k+1 | ... | Process N-1 | Process N |
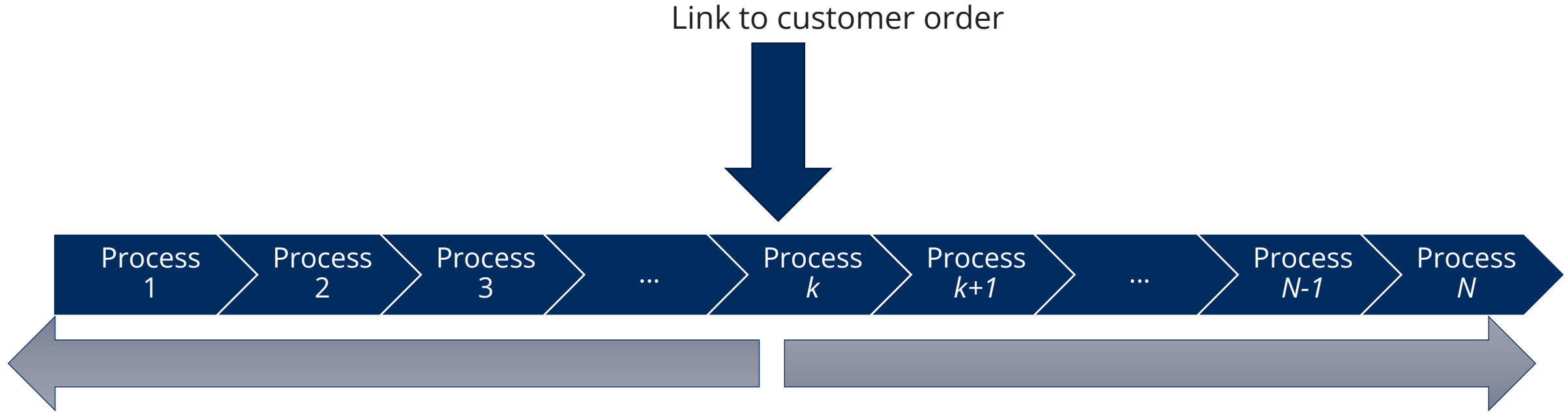
Processes start **before** customer order is linked.
- Processes in anticipation of customer orders (proactive)
- Upstream
- Forecast-driven planning
- Efficiency

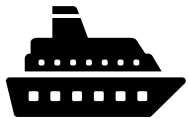Processes start **after** customer order is linked.
- Processes in response to customer orders (reactive)
- Downstream
- Order-driven planning
- Customer specific products
- Meet customer service levels
- Flexibility

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CUSTOMER ORDER DECOUPLING POINT

Engineer-to-order (ETO)

Make-to-order (MTO)

Assemble-to-order (ATO)

Make-to-stock (MTS)

Deliver from local stock (DFS)

Engineering → Manufacturing → Assembly → Distribution
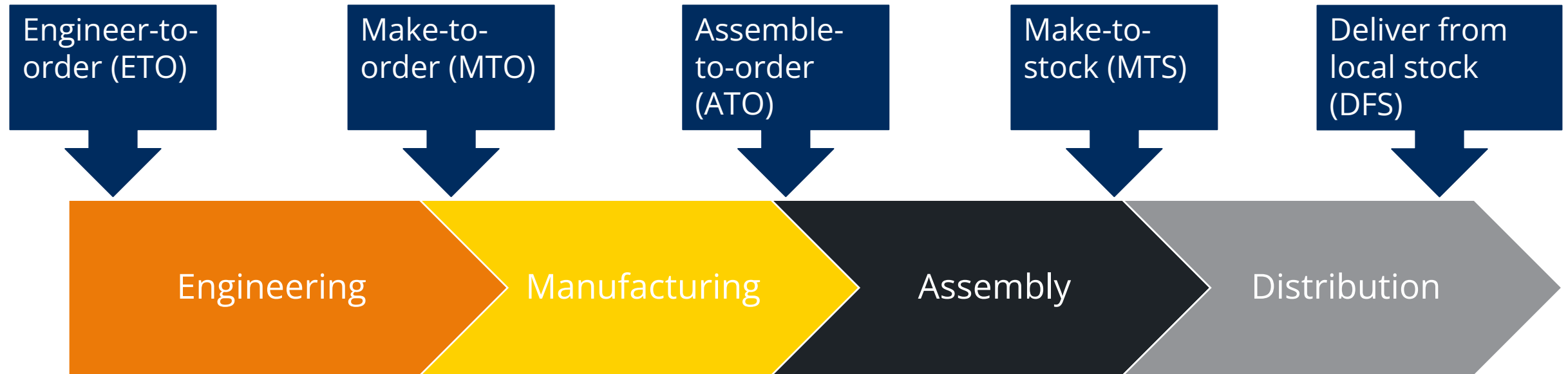
Examples:

Ship

Furniture

Car

Refridgerator

Food

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CUSTOMER ORDER DECOUPLING POINT

What kind of decision is the CODP?

CUSTOMER ORDER DECOUPLING POINT

Solution: What kind of decision is the CODP?

The COPD is a strategic decision, since it structures the processes in the supply chain and is the basis for many further decisions.

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EXAMPLE 1 OF CLEVER SUPPLY CHAIN MANAGEMENT:

Example: UNITED COLORS OF BENETTON. (see Chapter 12)

- Apparel company with production of garments in different colors

- Throughput time: up to 6 months

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EXAMPLE 1 OF CLEVER SUPPLY CHAIN MANAGEMENT:

The flows in the supply chain are more or less separated by color (different products):
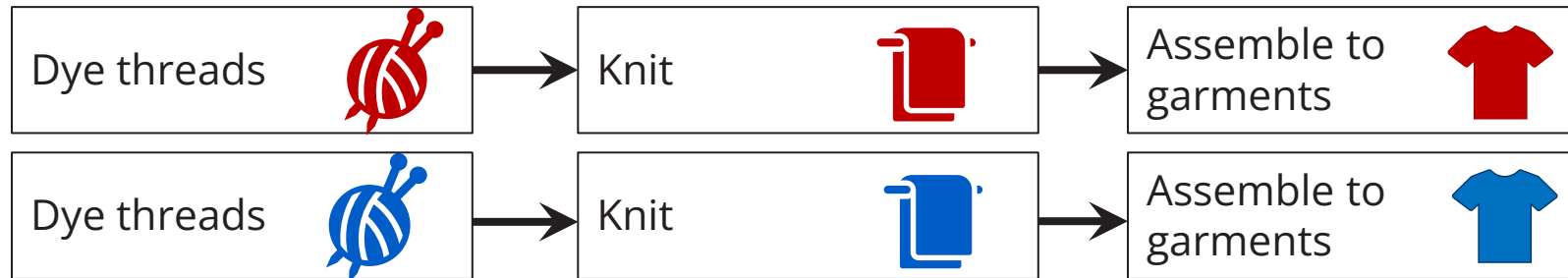
Demand used for planning: Forecast for each color 6 months ahead

What did United Colors of Benetton do to improve supply chain performance?

Postponement delays product differentiation or customization until closer to time of product sales.

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EXAMPLE 1 OF CLEVER SUPPLY CHAIN MANAGEMENT:

Postponement delays product differentiation or customization until closer to time of product sales.

UNITED COLORS OF BENETTON. rearranged the process steps to achieve postponement.

Knit → Assemble to garments → Dye garments / Dye garments
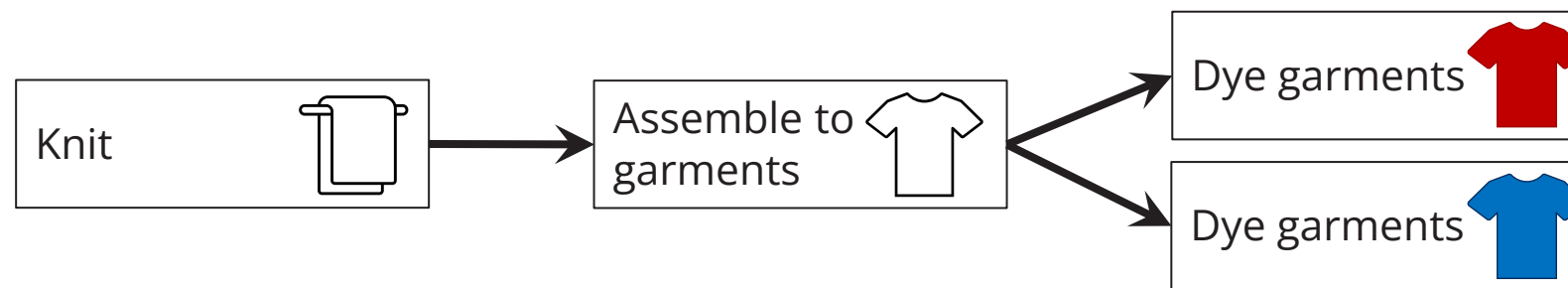
- Demand used for planning: Forecasted **aggregated** demand for all colors 6 months ahead
- Postpone dyeing until the selling season gets closer
- Less uncertainty → better planning

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EXAMPLE 2 OF CLEVER SUPPLY CHAIN MANAGEMENT

Example: ZARA

- Apparel manufacturing and retail company based in Spain

Apparel industry in general:
- Labor-intensive industry
- Many companies outsource production to low-cost countries
- Normal design-to-sales time in the apparel industry > 6 months
- Demand hard to predict

ZARA

- Design-to-sales time: **down to 4-6 weeks**

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EXAMPLE 2 OF CLEVER SUPPLY CHAIN MANAGEMENT

ZARA uses a **combination** of flexible and quick production in Europe and low-cost sources in Asia

- Low-cost sources (outsourced): Basic products with predictable demand
- Flexible sources: New designs with unpredictable demand
  - Divide 3-month sales season in three 1-month periods

    Month 1: Decide on production quantities for first period only, no sales data;
    Month 2: Production decisions based on first week of sales data
    Month 3: Production decisions based on first month of sales data
- Zara **responds** to trends rather than having to predict them
  - Much smaller forecasting error
  - Reduced inventories
  - Less discounts needed
- Higher manufacturing cost, but larger revenues in retail (ZARA is both, vertical integration)

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PUSH/PULL SYSTEM

Two approaches to control production/inventory based on Hopp and Spearman[1] (not book by Chopra)

Push:
- No limit on work-in-process
- Production based on external production schedule (based on forecasted or actual demand)
- Inventory can grow unlimited
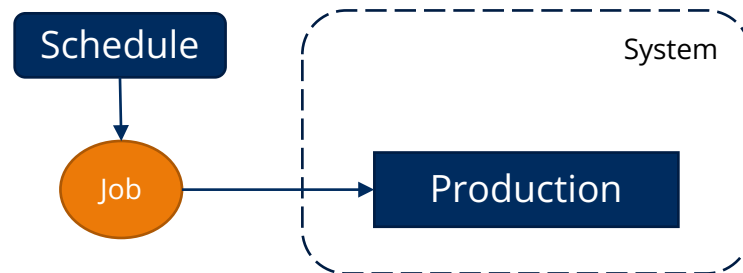
Pull:
- Limit on work-in-process (WIP)
- Production is released based on internal production/inventory status (actual consumption)
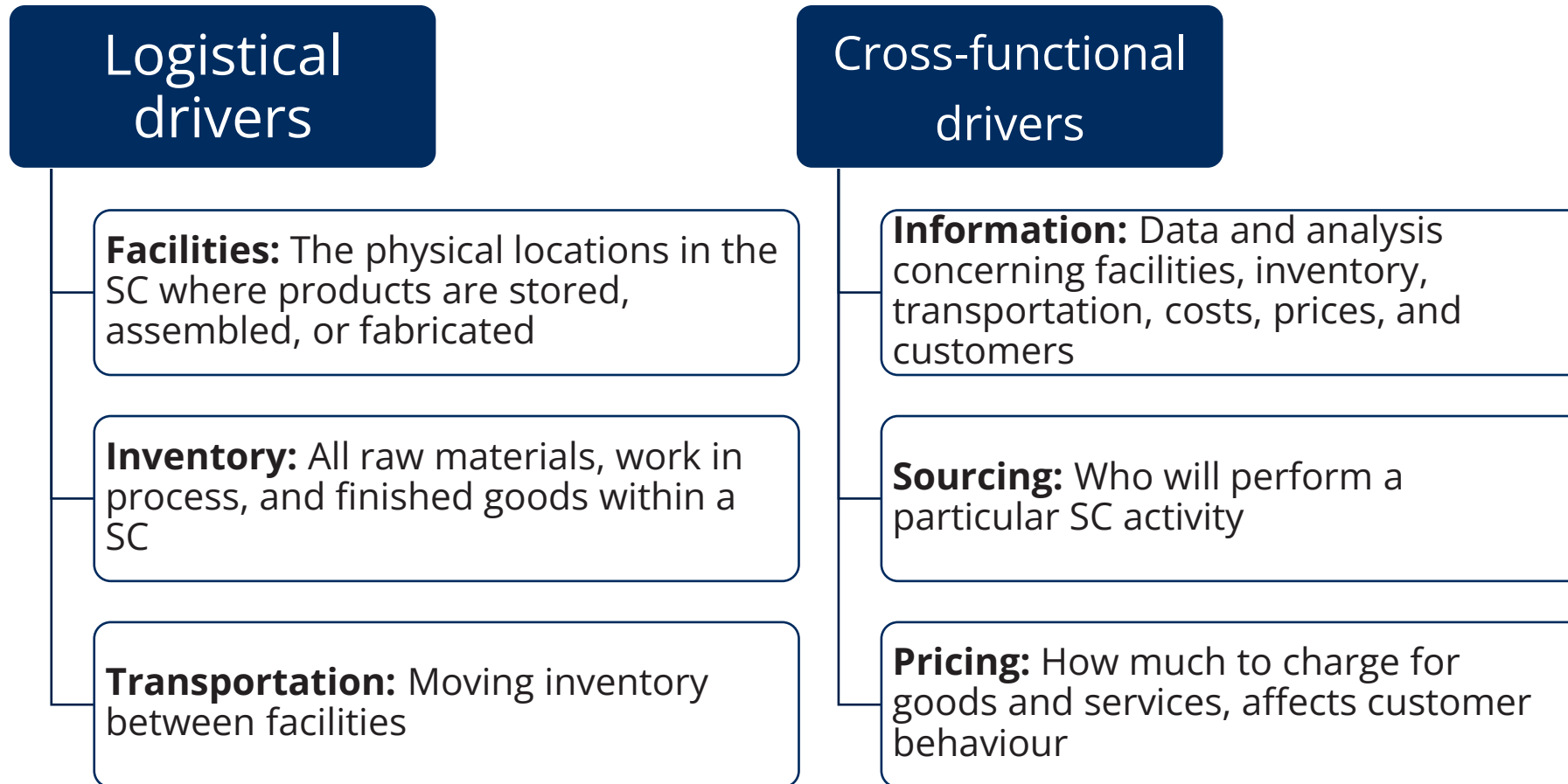- Prevents inventory from growing beyond a certain level
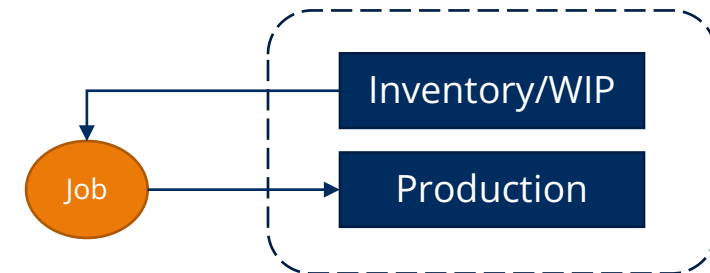
Strategic "pull" decision: Production based on actual consumption on the market (or not), production itself can still be "push"

Tactical "pull" decision: How to implement the limit on work-in-process

[1] *Hopp and Spearman (2008): Factory Physics, Chapter 10 – Push and Pull Production Systems, McGraw-Hill*

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DRIVERS OF SUPPLY CHAIN PERFORMANCE

Logistical drivers

Facilities: The physical locations in the SC where products are stored, assembled, or fabricated

Inventory: All raw materials, work in process, and finished goods within a SC

Transportation: Moving inventory between facilities

Cross-functional drivers

Information: Data and analysis concerning facilities, inventory, transportation, costs, prices, and customers

Sourcing: Who will perform a particular SC activity

Pricing: How much to charge for goods and services, affects customer behaviour

The **interaction** of those 6 drivers decides on the performance of a supply chain. Decisions need to **fit with the chosen supply chain strategy**.

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COORDINATION IN A SUPPLY CHAIN

INVENTORY

What is inventory?
All raw materials, work-in-process and finished assets within a supply chain

Why do we have inventory?
Mismatch between supply and demand
due to
- production processes take time
- economies of scale
- unknown future demand

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TYPES OF INVENTORY

TYPE	PURPOSE	TRADE-OFFS
Work-in-process (WIP)	All work-in-process assets	Always exists WIP = throughput x flow time
Cycle inventory	Amount of inventory to satisfy demand between supply shipments	Economies of scale vs. Inventory holding cost
Safety inventory	Amount of inventory to cover demand that exceeds expectations	Product availability vs. Inventory holding cost
Seasonal inventory	Built up to counter predictable seasonal variability in demand	Cost for flexible production vs. Inventory holding ost

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MANAGING INVENTORIES

We are selling sweaters.

5 sweaters on stock.

Suppose we sell on average 3 sweaters per week and it takes one week to get them from the supplier.

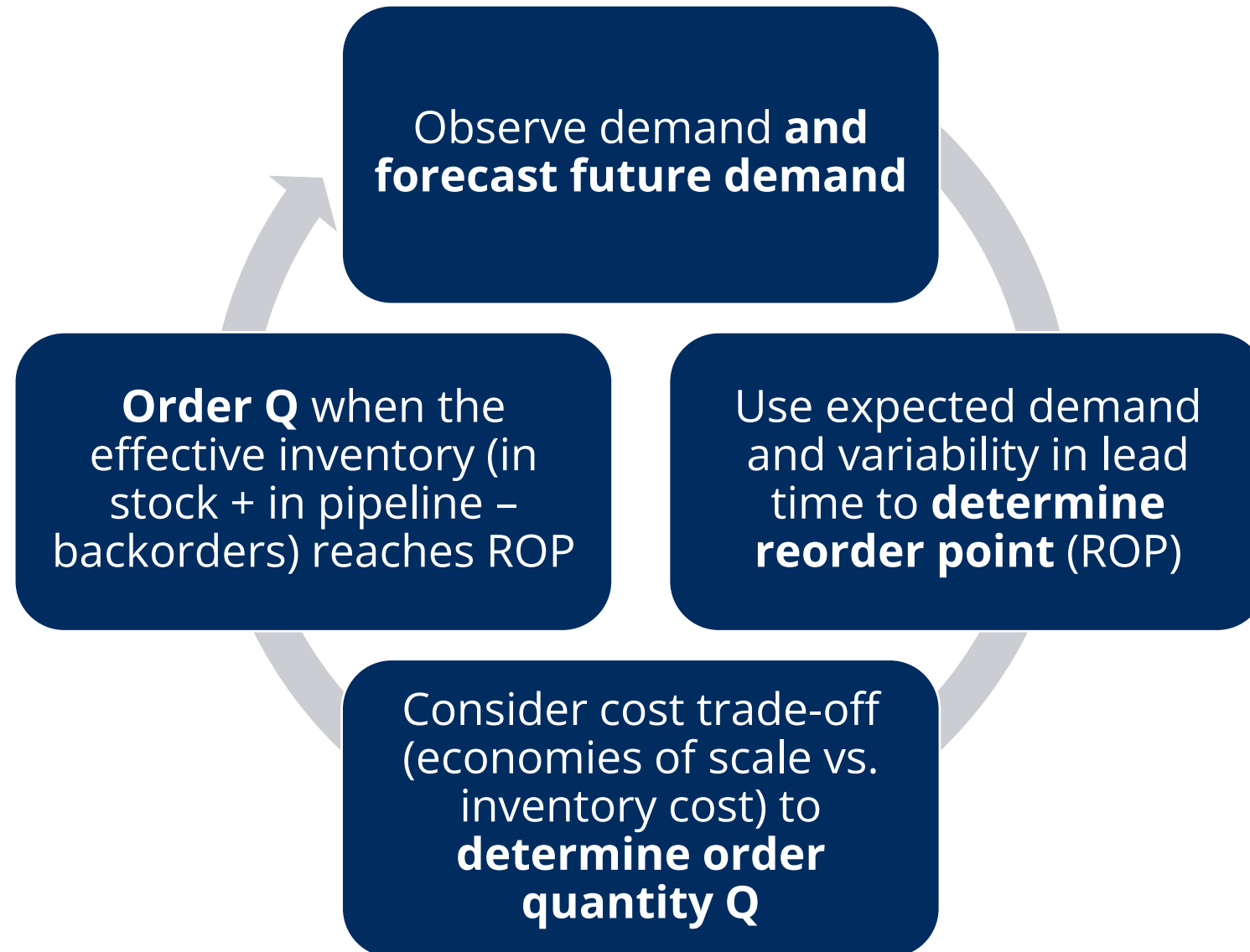When should we reorder latest? When **X** sweaters are in stock. (Possible answers for **X**: 0 to 5)

When should we reorder latest? When X ...

Top answers

1.	3	132
2.	4	19
3.	2	11
4.	5	6
5.	1	3

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MANAGING INVENTORIES

We are selling sweaters.

5 sweaters on stock.

Suppose we sell on average 3 sweaters per week and it takes one week to get them from the supplier.

When should we reorder latest?
When **X** sweaters are in stock.
(Possible answers: 0 to 5)

Solution:

Reorder latest when 3 sweaters are in stock.

But you add buffer for uncertainty (reorder already when 4,5,6,...? are in stock.)

and you consider orders already **in transit to you.**

MANAGING INVENTORIES

Observe demand **and forecast future demand**

Use expected demand and variability in lead time to **determine reorder point** (ROP)

Consider cost trade-off (economies of scale vs. inventory cost) to **determine order quantity Q**

Order Q when the effective inventory (in stock + in pipeline – backorders) reaches ROP

The suppliers observes the replenishment orders as their demand follow a similar procedure.

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DEMAND AT DIFFERENT STAGES

Figure 10-1 on page 259 in Chopra, Sunil. Supply Chain Management: Strategy, Planning, and Operation, Global Edition, Pearson Education, Limited, 2019.
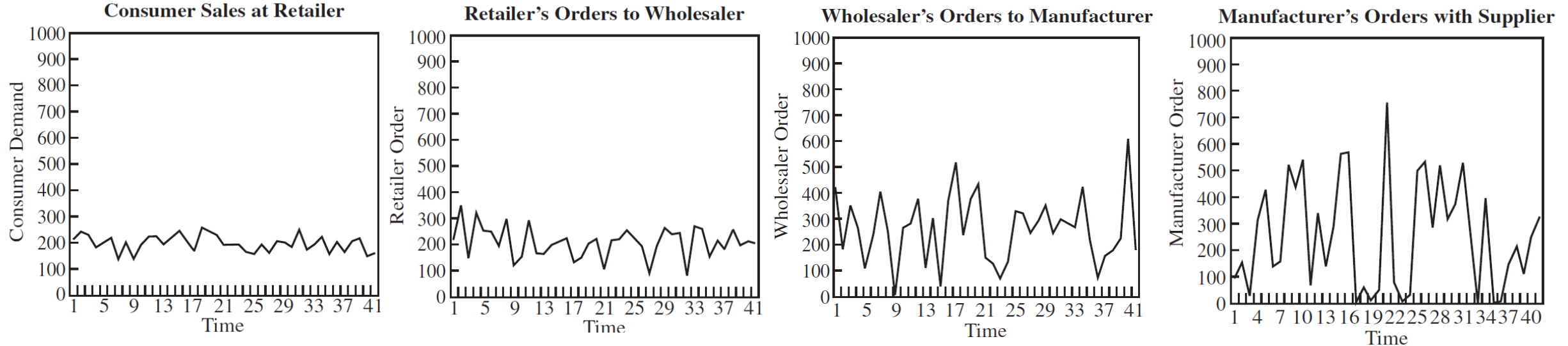
Fluctuations in orders increase as they move up the supply chain
from retailers to wholesalers to manufacturers and suppliers
→ Bullwhip effect

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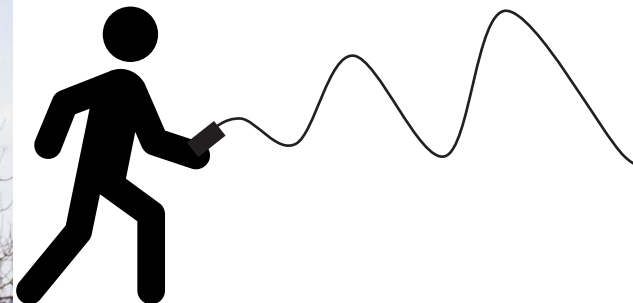
(LACK OF) COORDINATION IN A SUPPLY CHAIN

The bullwhip effect happens due to distorted demand information.

Lack of coordination in a SC happens, if...
- Information flows are missing, delayed and/or distorted
- Local objectives in different stages conflict

Lack of coordination leads **to increased cost and degraded responsiveness**.

Improve coordination:
- align goals and incentives of all functions and stages in the SC
- consider effects of actions on other stages
- share information and improve accuracy
- Improve synchronization of supply and demand (reduce lead times, lot sizes)

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GROUP ASSIGNMENT
THE WOOD SUPPLY GAME

THE WOOD SUPPLY GAME

Customer — Paper retailer — Paper wholesaler — Papermill — Sawmill — Forest

Customer — Lumber retailer — Lumber wholesaler
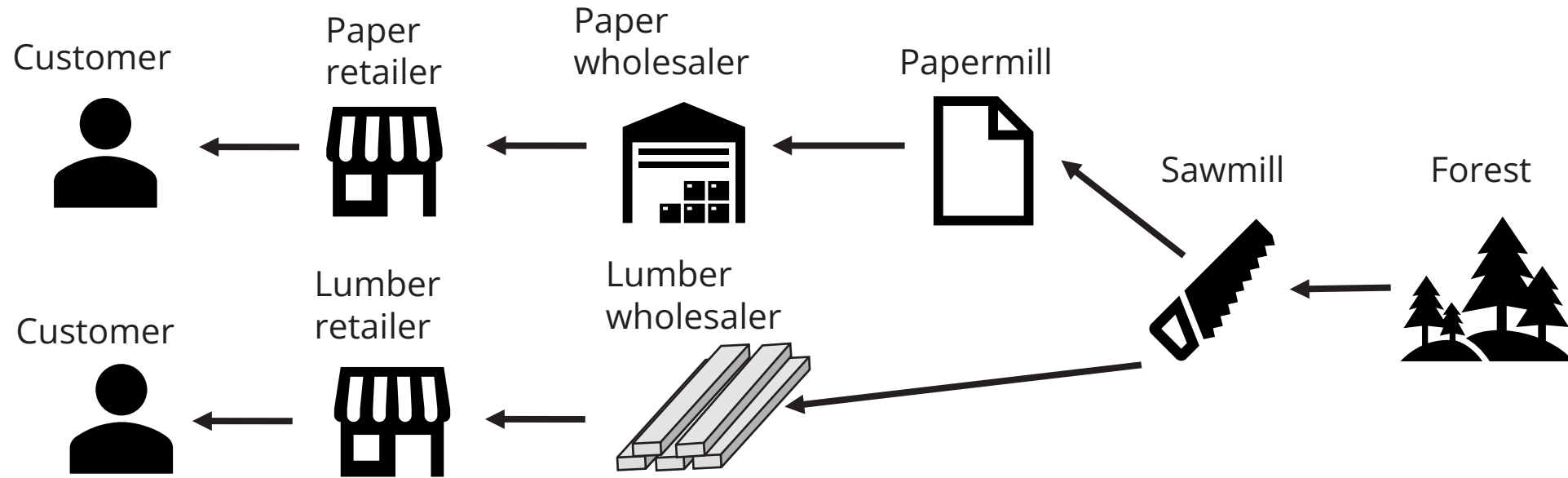
- **Mandatory** assignment
- Divergent supply chain with 7 roles
- Each role can be played by a student or by the computer (defined by the administator of the game) → Project groups as defined
- Appoint one student as administrator along with his/her role as a player

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PROCESS LOGIC IN WOOD SUPPLY GAME

The game proceeds in weeks.

Consider one order:

Order is submitted to supplier (predecessor in SC)

Receive products to fill demand

shipment lead time

order lead time

Receive demand from successor in SC:
- Take from inventory / backorder incl. cost calculation

Supplier takes product from inventory / backorder

Decision: Place a replenishement order to supplier

4 weeks lead time, the ordered products are in stock in the 5th week

w   w+1   w+2   w+3   w+4   w+5   w+6   Week

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HOW TO PLAY – LEARNING OBJECTIVES

Link:
http://forac-old.fsg.ulaval.ca/woodSupplyGame/AideJeuBois/EN/indexEN.htm
If there are issues opening the game, see if you need to allow Flash Player. Otherwise, try to change the internet browser e.g., use Microsoft Edge or Firefox.

Read the assignment instructions from Canvas very carefully and follow them.

Learning objectives:
- To experience the bullwhip effect (<u>individual</u>, <u>group</u>)
- To understand the causes of the bullwhip effect
- To experience how its affects different levels of the supply chain
- To learn how information mitigate the bullwhip effect

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USER INTERFACE

Demand side / Customer ⬅ ➡ Supply side / Supplier
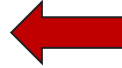
Demand /
Customer order:
Depleted automatically
from your inventory

Customer's
(incoming)
pipeline
order

Trade off: If you order more
than you sell, your inventory
costs will increase. If you
have insufficient products,
you face backorder
(shortage) costs

How much to
order
(only decision)

Your (previous)
pipeline orders

Information
Team : test_game
Week : 1 of 30

Lumber Wholesaler

Costs
Inventory cost :	0 $
Backorder cost :	0 $
Total cost :	0 $
Average cost :	0 $

Customer order
4

Satisfaction : 100%

Inventory and backorders : 12
Inventory
Backorders

Purchase order
2 weeks   0   Submit

In transit to customer
2 weeks   4   4

In transit from supplier
2 weeks   4   4

Team chat room
☒ Paper retailer
☒ Paper wholesaler
☒ Paper mill
☒ Lumber retailer
☒ Lumber wholesaler
☒ Sawmill
☒ Forest

network

history

This game does not allow chatting   Send

FORAC
FOREST TO CUSTOMER

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Two products: lumber and clips

Choose how to allocate incoming products between wood chips and lumber

USER INTERFACE - **THE FOREST**

Lead time is 1 week. You order in week 1 and get in week 3.

Min max amount that you can harvest

SETUP: THE ADMINISTRATOR

Set to 30

After setting the game, the game will be released when you press "RELEASE" button.

Remaining positions to computer. The administrator should do that by clicking on "COMPLETE" button.

"END" button is to finish the game earlier (stop in one week).

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WHAT MAY GO WRONG

The game automatically moves to the next week <u>once all decisions</u> have been submitted.

What could be the problem if the game does not proceed to the next week?
- Either there are players who did not enter their decisions yet.
- Or the administrator has not assigned the remaining roles to the computer.
  - Then, the computer expects another player to log on to the game and to take a decision.
  - Solution by administrator: click on COMPLETE on the admin screen

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WHAT SHOULD YOU DO

- **Scenario 1:** No coordination (inventories, backorders)
  - Comparison of performance (students, roles)
  - Which strategy worked best? How can you improve?
  - What is the SC performance (costs, customer satisfaction)?

- **Scenario 2:** No coordination, improve decisions, change role in the supply chain, (+ some randomness to compensate learning)
  - Did you improve? Why (not)? Impact of student/role?

- **Scenario 3:** Coordinate decisions
  - In advance: discuss and jointly design a coordination strategy

Report: Max 5 pages, excluding appendices (figures, tables)

Modify the parameters in each scenario according to the instructions!

Save graphs/take screenshots after each scenario.

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FURTHER INFORMATION

Estimated work load: 6 hours
- Two unsupervised self-study sessions (Tuesday and Thursday)
- Tutorial on Thursday at 8.45 in SP3, SP4 and SP5
- Check Rooster for details

Questions:
  - During tutorial, ask your class mates, use Slack, send an email to TAs or me

Grading: Pass/fail (+ Repair)

Deadline submission and details: **Check Canvas!**
        Deadline: Sunday, 10th September, 23:59
        Repair: Sunday, 17th September, 23:59

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WHAT KIND OF RESULTS MAY YOU EXPECT?

Some results from the past (under scenario 3 and a few outliers removed):

Average satisfaction retailers versus SC costs

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