DIS STUDY ABROAD IN SCANDINAVIA

Bullwhip Effect and Postponement

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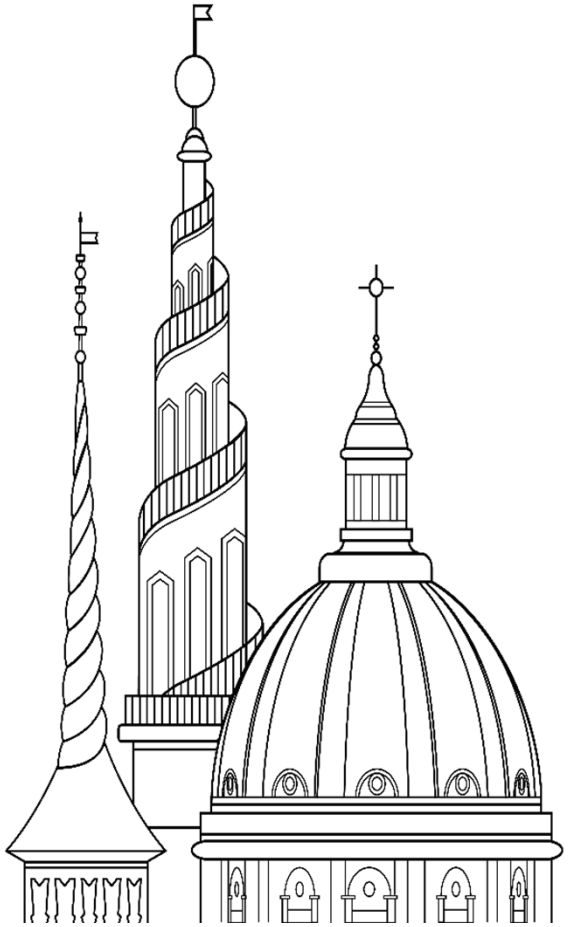


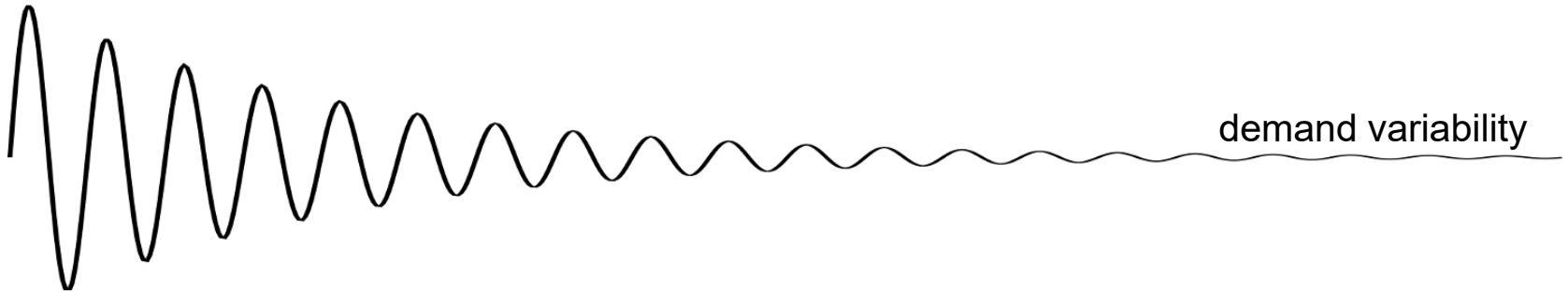
DIS STUDY ABROAD IN SCANDINAVIA

Outline

1. Bullwhip Effect
2. Postponement

Degree of Variability Cannot be Explained by Customer Demand Fluctuations Alone

- Procter & Gamble examined order patterns for one of their best-selling products, Pampers.
- Its sales at retail stores were fluctuating, but the variabilities were certainly not excessive.
- However, as they examined the distributors' orders, the executives were surprised by the degree of variability. When they looked at P&G's orders of materials to their suppliers, such as 3M, they discovered that the swings were even greater.
- Procter & Gamble called this phenomenon the "bullwhip" effect.



Source: Lee et al. (2004), https://doi.org/10.1287/mnsc.1040.0266

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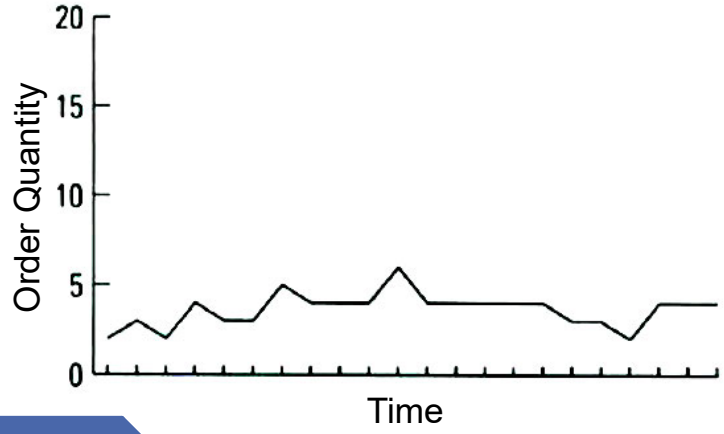
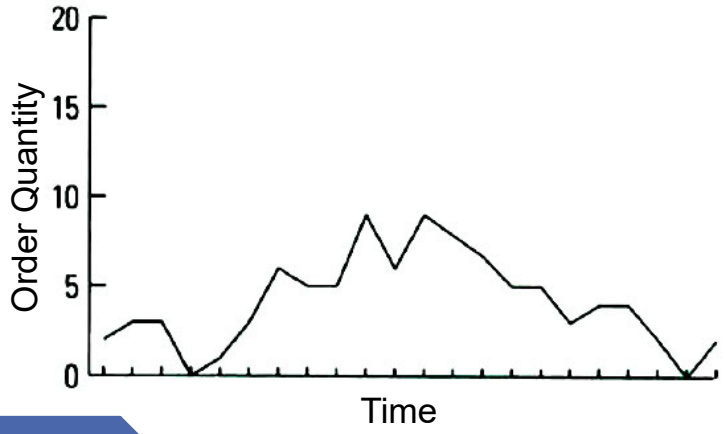
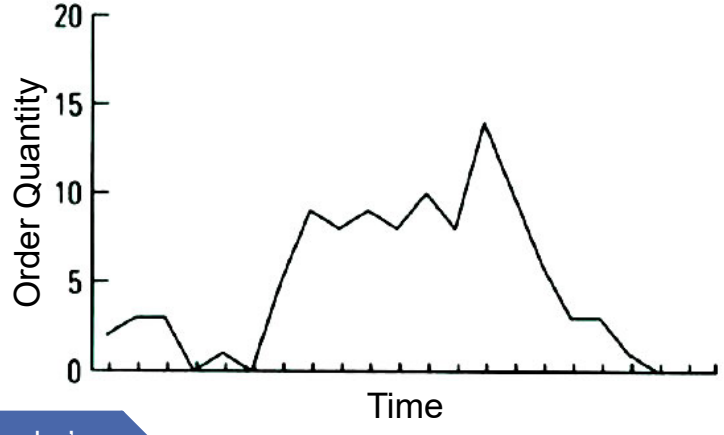
Increasing Variability of Orders up the Supply Chain



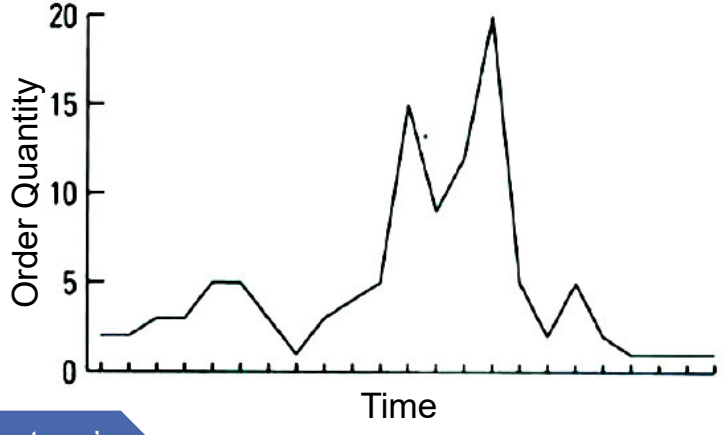
Customer sales



Retailer's orders



Wholesaler's orders



Manufacturer's orders

Source: Lee et al. (2004), https://doi.org/10.1287/mnsc.1040.0266

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The Bullwhip Effect has Serious Cost Implications

Bullwhip Effect (= Whiplash Effect)

"phenomenon where orders to the supplier tend to have larger variance than sales to the buyer (i.e., demand distortion), and the distortion propagates upstream in an amplified form (i.e., variance amplification)" Lee et al. (2004), https://doi.org/10.1287/mnsc.1040.0266

The distortion of demand information implies that the manufacturer who only observes its immediate order data will be misled by the amplified demand patterns, and this has serious cost implications, e.g.,

- manufacturer incurs excess raw materials cost due to unplanned purchases of supplies,
- additional manufacturing expenses created by excess capacity,
- inefficient utilization and overtime,
- excess warehousing expenses and additional transportation costs due to inefficient scheduling, and
- premium shipping rates.

Source: Lee et al. (2004), https://doi.org/10.1287/mnsc.1040.0266

Interpretations of the Bullwhip Effect

	Forrester (1961)	Sterman (1989)	Lee et al. (2004)
Behavior of supply chain members	time varying behaviors of the members are assumed	members lack full rationality and are prone to misperceptions	members are rational and optimizing
Mitigating the bullwhip effect	modify behavioral practice	modify individual education	modify institutional and inter-organizational infrastructure and related processes

Source: Lee et al. (2004), https://doi.org/10.1287/mnsc.1040.0266

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Causes of the Bullwhip Effect

Members react to market dynamics

Rationing Game

Strategic ordering behavior of buyers when supply shortage is anticipated. Rationing is common during the growth phase of the product life-cycle when demand outstrips supply.

Price Variations

Purchase prices of products are typically non-constant, e.g., if price promotions are conducted in the maturity phase of a product to increase market share.

Members optimize internal operations of inventory management

Order Batching

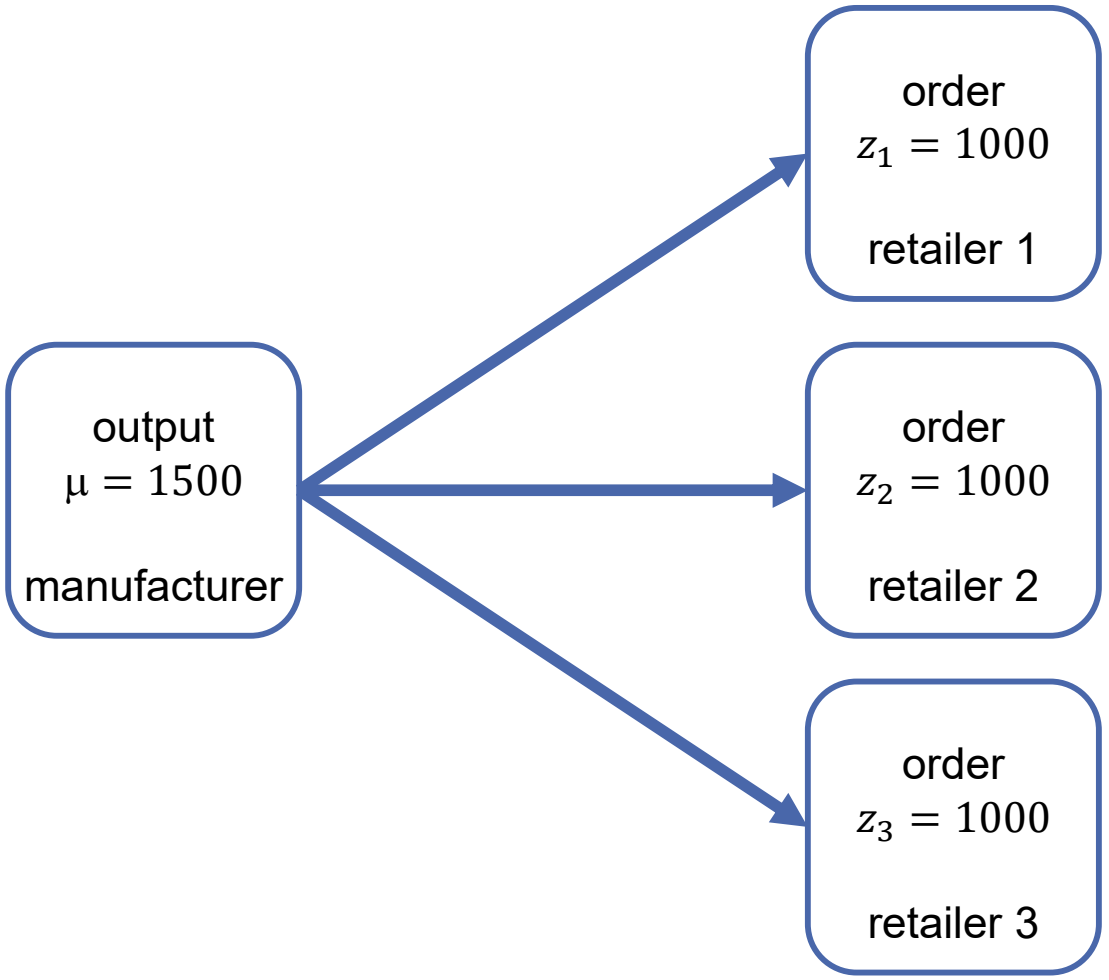
When the fixed order cost is nonzero, ordering in every period would be uneconomical, and batching of orders would occur. Order batching is a routine part of buyers' decision process.

Demand Signal Processing

Let us assume that demand is non-stationary and past demand information is used to update forecasts. Retailers routinely use demand realizations as signals/predictors of future demand.

Source: Lee et al. (2004), https://doi.org/10.1287/mnsc.1040.0266

Rationing Game



$$\mu = 1500 < Q = \sum_{j=\{1,\dots,3\}} z_j = 1000 + 1000 + 1000 = 3000$$

$$\rightarrow z_1 \cdot {}^{\mu}/_{Q} = 1000 \cdot {}^{1500}/_{3000} = 500$$

→ retailers will order more than they actually need

Source: Lee et al. (2004), p. 1879, https://doi.org/10.1287/mnsc.1040.0266

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Rationing Game Counter-measure: Contract that Restricts the Buyer's Flexibility

- A contract could restrict the buyer's flexibility, since an unrestricted choice of order quantities, free return and generous order cancellation policies all contribute to gaming.
- This method of sharing forecast information, risk and flexibility is observed in computer and retail companies like Hewlett-Packard, SUN, and Lands' End with their suppliers.
- Also some companies like Seagate reserve the supplier's capacity or intermediate goods well ahead of time, so that the buyer and the supplier share risk and demand information.

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1. Buyer starts transmitting its demand forecast 18 weeks ahead of delivery.
2. Buyer updates initial forecast in four weeks, but is only allowed to change up to 30% of initial forecast.
3. Four weeks later, buyer updates forecast one more time, but up to 15% of second forecast.
4. Third forecast becomes binding order to supplier.

Source: Lee et al. (2004), p. 1884, https://doi.org/10.1287/mnsc.1040.0266

Price Variations Counter-measure: Every Day Low Price

- The frequency as well as depth of manufacturer's trade promotions (i.e., wholesale price discounts) could be reduced.
- Major manufacturers (e.g., P&G, Kraft, Pillsbury, etc.) pursue the Every Day Low Price (EDLP) strategy in spite of the resistance by several grocery chains.

Source: Lee et al. (2004), p. 1884 f., https://doi.org/10.1287/mnsc.1040.0266; Image: LateNameGuys, CC 3.0 Unported

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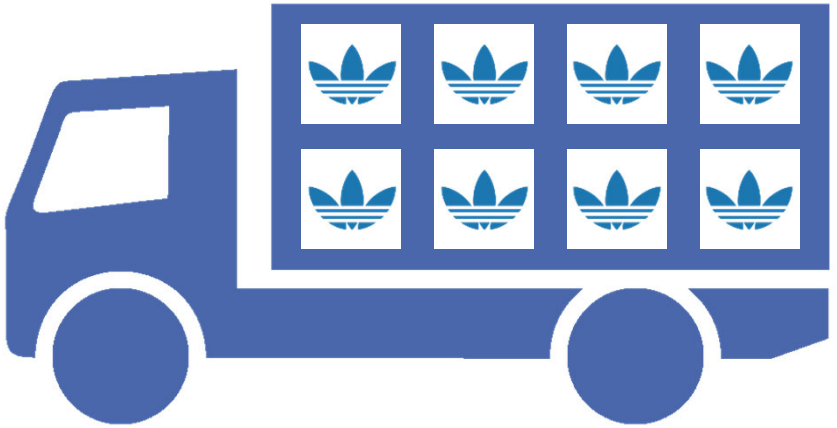
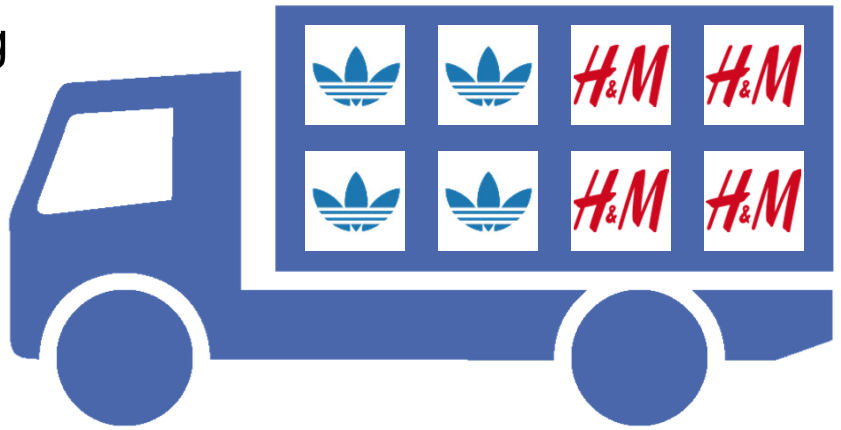
Order Batching Counter-measure: Third Party Logistics Providers

In-house Logistics

- No scale economies accessible in single buyer–seller relationships.
- Full truckload can only be created by filling truck with own goods.
- Each individual buyer could find it uneconomical to generate a full truckload order by herself.



- 3PL can exploit scale economies.
- Full truckload is created by consolidating orders from retailers who are in geographical proximity to one another.
- Consolidation enables retailers to order more often as there is no need to wait for a full truckload.



Third Party Logistics

Source: Lee et al. (2004), p. 1884, https://doi.org/10.1287/mnsc.1040.0266

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Demand Signal Processing Counter-measure: Access to Demand Data

- One clear solution is to grant the manufacturer access to the demand data at the retail outlet.
- The grocery industry is a good illustration of demand information sharing. Electronic data interchange systems between retailers and manufacturers have become fairly common. These systems facilitate quick and easy transmission of demand data to upstream members of the channel.
- The computer industry is also making some progress in this regard. Manufacturers such as IBM, Hewlett-Packard and Apple are increasingly requesting sell-through data from their resellers.

Source: Lee et al. (2004), p. 1883, https://doi.org/10.1287/mnsc.1040.0266

Summary: Rational Behavior Causes the Bullwhip Effect

Cause	Contributing factors	Counter-measures	State of practice
Demand signaling	• No visibility of end demand • Multiple forecasts • Long lead-time	• Access sell-thru or POS data • Single control of replenishment • Lead-time reduction	• Sell-thru data in contracts (e.g., HP, Apple, IBM) • VMI (P&G and WalMart) • Quick Response mfg strategy
Order batching	• High order cost • FTL economics • Random or correlated ordering	• EDI & CAO • Discount on assorted truckload, consolidation by 3rd party logistics • Regular delivery appointment	• McKesson, Nabisco • 3rd party logistics in Europe, emerging in the US • P&G
Prices variations	• High-low pricing • Delivery & purchase asynchronized	• EDLP • Special limited over time, capacity reservation	• P&G (resisted by some retailers) • Under study
Rationing game	• Proportional rationing scheme • Ignorance of supply conditions • Unrestricted orders & free return policy	• Allocate based on past sales • Shared capacity & supply information • Flexibility limited over time, capacity reservation	• Saturn, HP • Scheduling sharing (HP, Motorola) • HP, Sun, Seagate

Source: Lee et al. (2004), p. 1883, https://doi.org/10.1287/mnsc.1040.0266

Group Work: Bullwhip Effect

During the first weeks of the COVID-19 pandemic, millions of people have been panicking about their household supply. Stores shelves have been emptied. Things were calming down after a buying spree in mid-March 2020. One reason was because people were hoarding. Some were stockpiling in advance of lockdown orders. For example, U.S. toilet paper sales rose 51% between February 24 and March 10, but sales finally rocketed a whopping 845% on March 11 and 12 as states announced lockdowns.

Please discuss how the four different causes of the bullwhip effect might have contributed to the bullwhip effect for various supply chains during the COVID-19 pandemic. Make own assumptions if needed.

Outline

1. Bullwhip Effect
2. Postponement

Postponement

- When decisions on the final configuration or pack have to be made ahead of demand there is the inevitable risk that the products that are available are not the ones the customer wants.
- Example: The customer may want a blue four-door car with air-conditioning but the dealer has a red, two-door with a sunroof.

Postponement

"Postponement refers to the process by which the commitment of a product to its final form [manufacturing postponement] or location [logistics postponement] is delayed for as long as possible."

Christopher (2005), p. 134

- The philosophy of postponement ideally would begin in the drawing board so that products are designed with late configuration in mind.
- The term was coined by Alderson (1950).

Source: Christopher (2005), pp. 234 f

Key Enablers of Manufacturing Postponement

Process Standardization

The initial steps in the process are standardized across the product line so that products are not differentiated at these steps, and distinct personalities of the products are added at a later stage.

Process Resequencing

The sequence is changed so that more common components are added at the beginning of the process. The components or features that create product differentiation are added later.

Component Standardization

Rather than to process design changes, postponement can relate to product design changes. This requires standardizing key components, or introducing parts commonality in the product structure.

Source: Swaminathan & Lee (2003)

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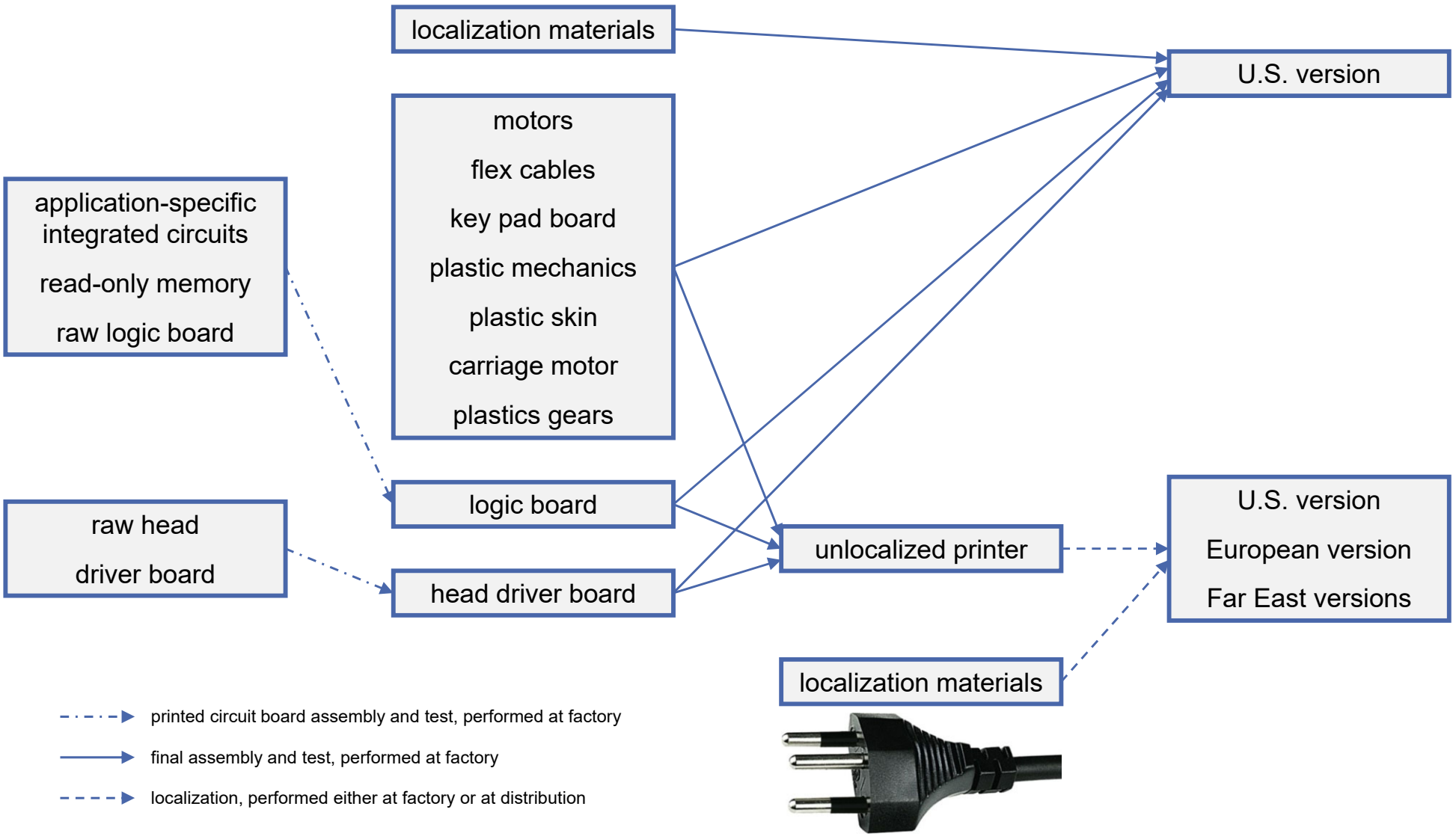
HP's Deskjet-Plus Printers as an Example for Process Standardization

- In the 1990s, Hewlett-Packard's Deskjet-Plus printers were manufactured at the Vancouver, Washington division of the company.
- To localize the printer for different countries, HP packages the appropriate power supply module and the appropriate manual with the printer.

Old Process	New Process
▪ Distribution centers in the U.S., Europe, and Asia/Pacific ▪ U.S. factory produced finished printers for all other countries ▪ U.S. factory sorted printers into three groups for the three DCs ▪ Transit time (1 month) to non-U.S. DCs creates uncertainties	▪ Distribution centers in the U.S., Europe, and Asia/Pacific ▪ U.S. factory produces finished printers for the U.S. only ▪ It produces generic printers (no manual, power supply module) for the two other regions ▪ Risk pooling effect, less stock

Source: Lee et al. (1993), https://doi.org/10.1287/inte.23.4.1

The Two-Stage Manufacturing Process for HP's Deskjet-Plus



Source: Lee et al. (1993), https://doi.org/10.1287/inte.23.4.1

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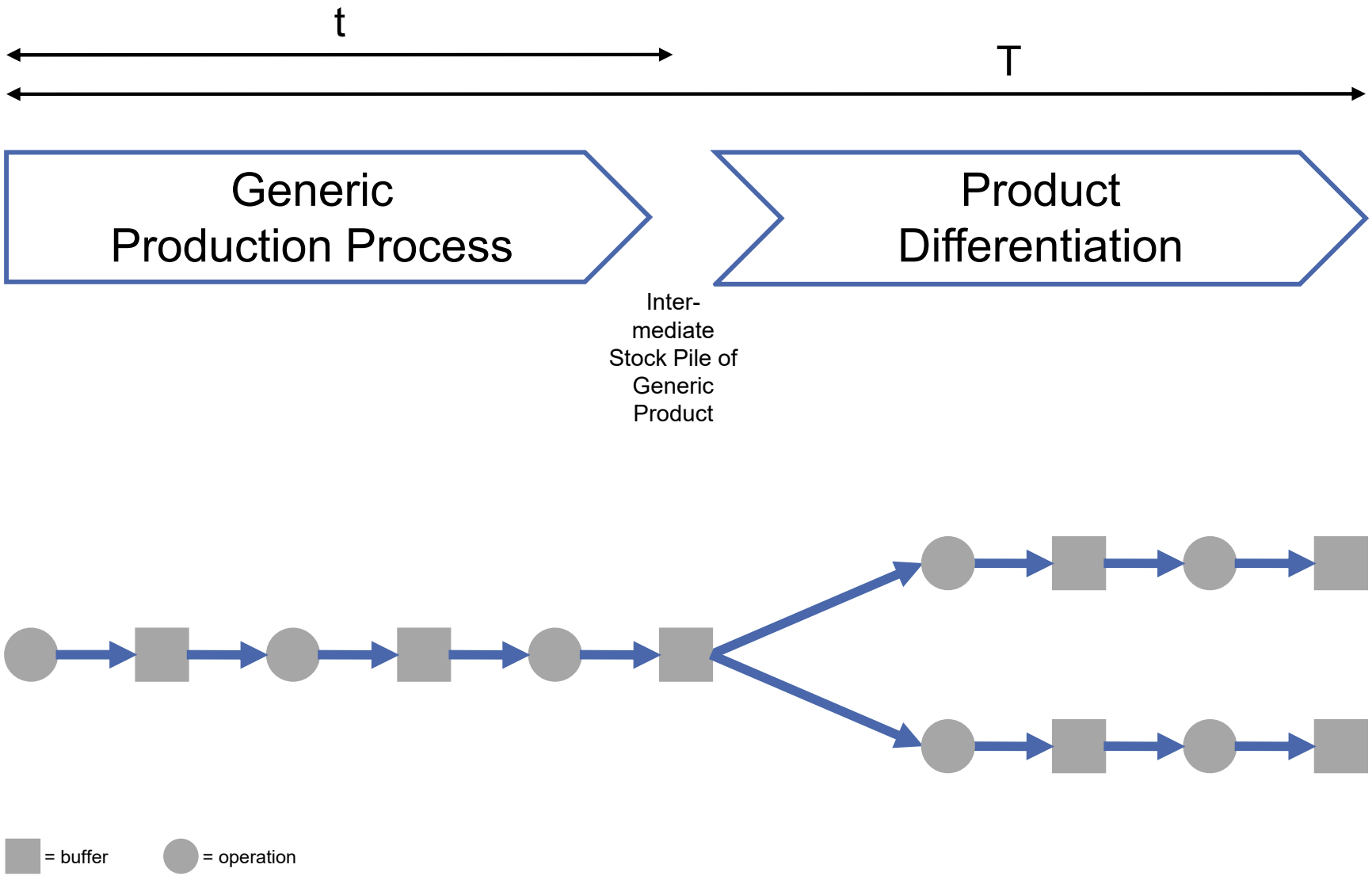
Postponement with a Single Point of Differentiation



Source: Swaminathan & Lee (2003)

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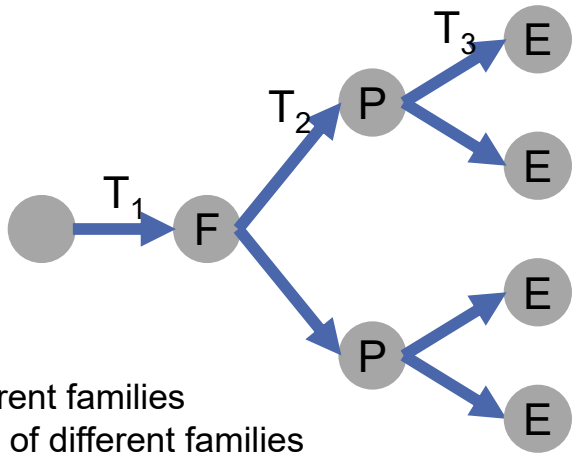
Postponement with Two Points of Differentiation



T_1 – lead time for producing generic products
T_2 – lead time for customizing the products into different families
T_3 – lead time for customizing different end products of different families

- **Family differentiation point (F):** This point occurs at the beginning of the second stage in the process where specific components are added to differentiate a generic product into different families.
- **Early postponement:** increase T_1 (e.g. by one week) and reduce T_2.
- **Product differentiation point (P):** This point occurs at the beginning of the third stage where specific components are used to customize semi-finished products into different end products of the family.
- **Late postponement:** increase T_2 and reduce T_3.

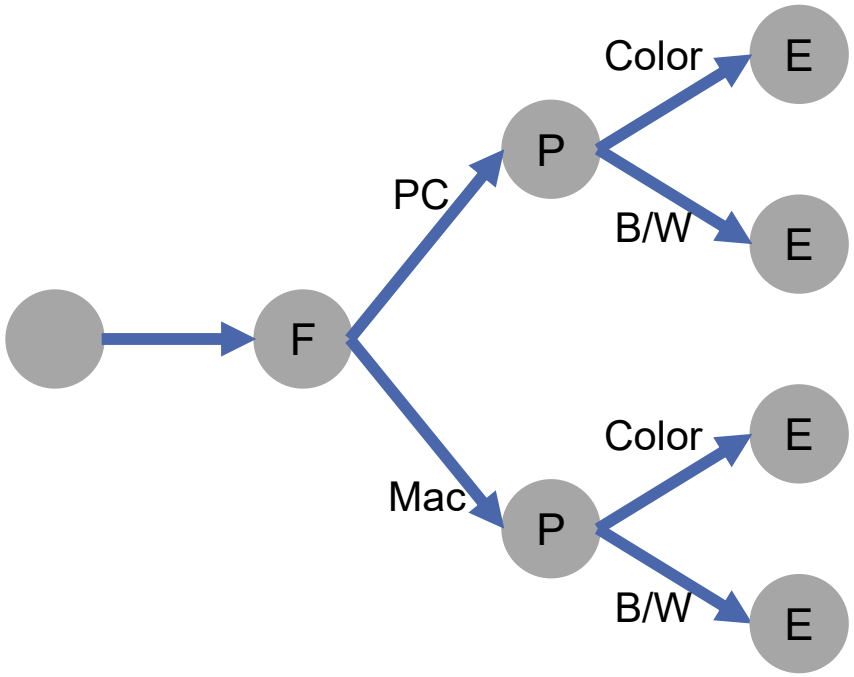
→ If $T_1 > T_2 > T_3$ then both early and late postponement are beneficial.

→ If T_2 is sufficiently smaller [larger] than T_1 and T_3, then early [late] postponement is beneficial.

Source: Eppen & Schrage (1981), Garg & Tang (1997), https://doi.org/10.1023/A:1018565917103

Postponement with two Points of Differentiation

Printer for PC and Mac



Source: Garg & Tang (1997)

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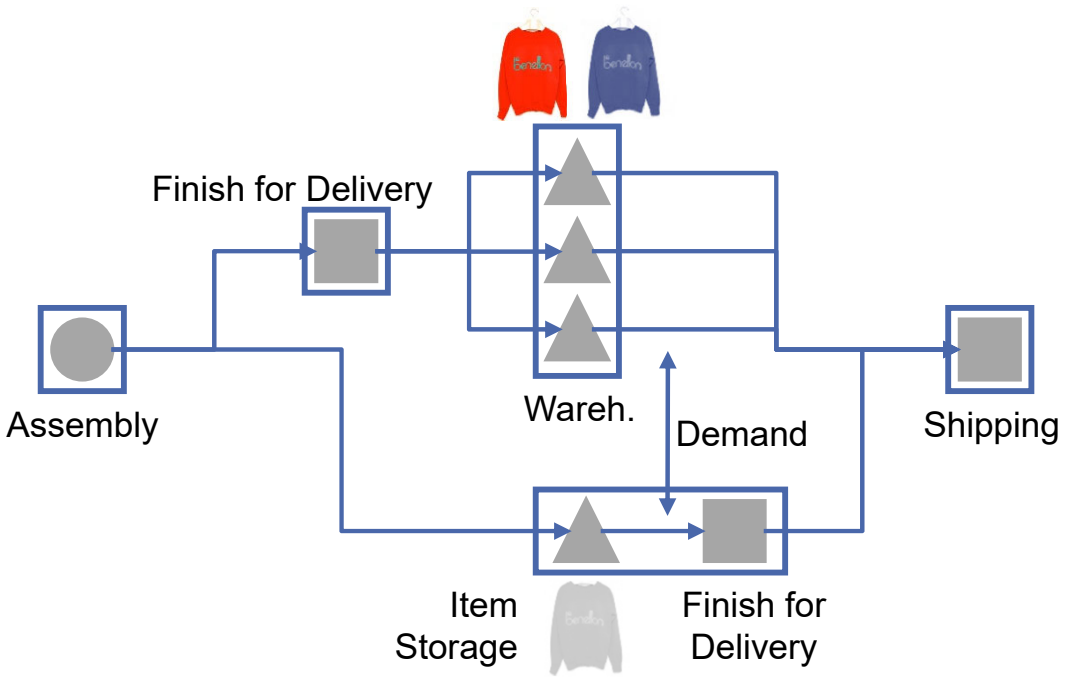
Partial Postponement as a Hybrid Between Speculation and "Complete" Postponement

Partial Postponement

"Some of the common generic item is completed as non-postponed products and […] some of the common item is kept as in-process inventory, thereby postponing the commitment to a specific product. When demand is realized, some combination of [both] inventories may be used to satisfy the demand." Graman & Magazine (2002)



Only a relatively small amount of postponement capacity is needed to achieve all of the benefits of completely delaying product differentiation for all demand.

Source: Graman & Magazine (2002)

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Partial Postponement: Example

- Let us consider the manufacturer of shirts. The shirts are only available in red or blue. Aggregate demand is stable (10,000 per year), but demand for red and blue shirts varies as follows:

Year	Demand red shirts	Demand blue shirts	Total demand
2015	5000	5000	10,000
2016	4000	6000	10,000
2017	5000	5000	10,000
2018	6000	**4000**	10,000
2019	4500	5500	10,000
2020	**3500**	6500	10,000
2021	4000	6000	10,000
2022	5000	5000	10,000

- The lowest demand for red and blue shirts was 3500 and 4000, respectively. It can therefore be speculated that at least 3500 red and 4000 blue shirts will likely be needed in 2023. They could be produced in a lean way (no postponement!).
- The rest amounting to 2500 shirt (= 10,000 − 3500 − 4000) could be produced without color and later dyed in an agile way depending on the actual demand (postponement!).

Benetton: Knit Now, Dye Later

- Benetton introduced postponement by interchanging "knit" and "dye" operations.
- Investments in improving the dyeing technology so that quality would not deteriorate due to the process changes.

Old Process	New Process
▪ Yarn of sweaters is first dyed into different colors. ▪ Garments are then knitted. ▪ The garments are stored (finished goods) to be shipped. ▪ Demand variability due to uncertainty of customers' preference of colors.	▪ Interchange of knit and dye. ▪ Stock inventory of "greige" (uncolored) knit garments. ▪ Dyeing takes place once the seasonal demand is known. ▪ Introduction of process resequencing led to inventory reductions.

Source: Dapiran (1992), Swaminathan & Lee (2003)

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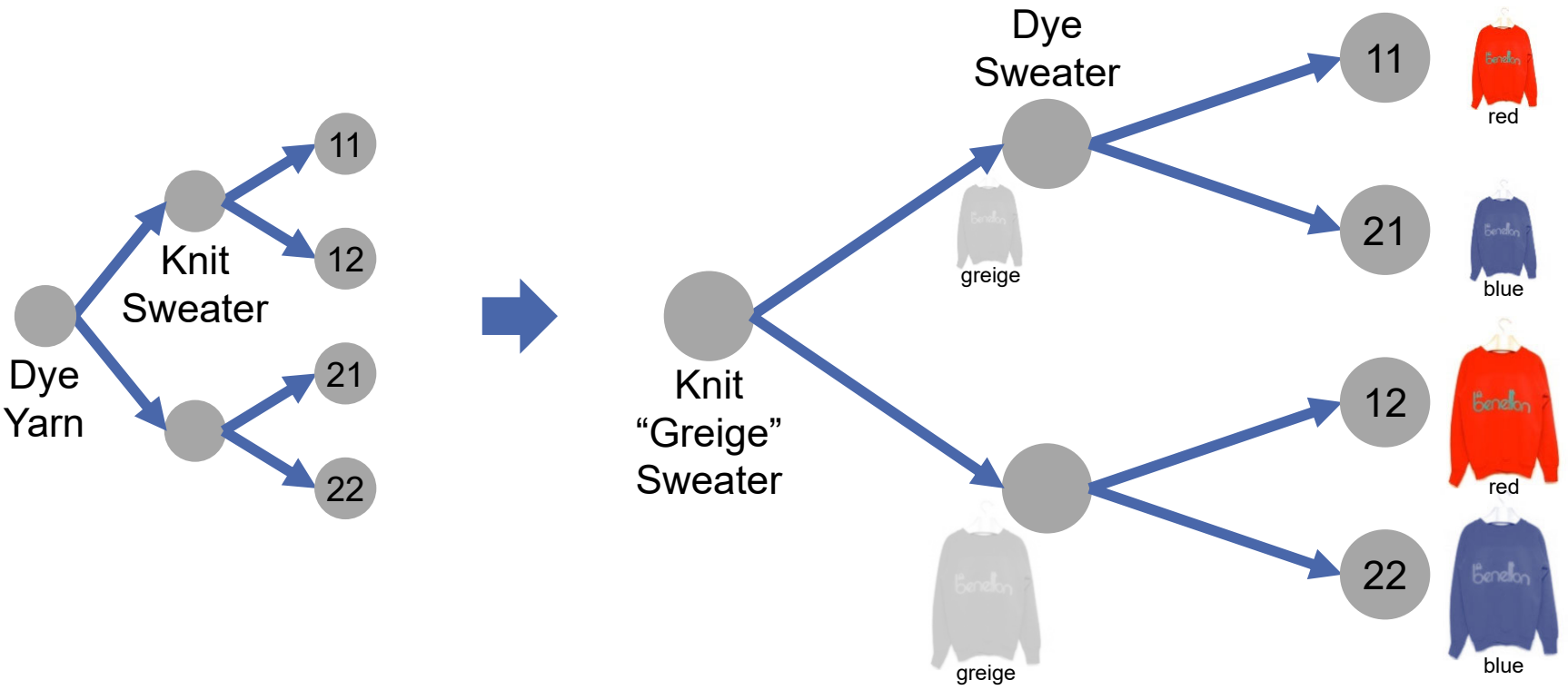
Linear Process Sequencing

- **Idea:** Consider a two-stage system where at each stage a distinct feature is introduced into the product. For example, there are four possible products available to a customer.
- **Example:** Garments can be dyed first and knitted later or garments can be knitted first and dyed later.



Source: Swaminathan & Lee (2003)

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Lucent Technology's Component Standardization Strategy

- Lucent's Tres Cantos plant was faced with a great sales potential in Saudi Arabia (millions of US$).
- The lead time required was much shorter than usual due to the Saudi government's desire to have all systems implemented prior to 2000 (Y2K).

Old Process	New Process
▪ Specific configurations can only be known after performing detailed site engineering work ▪ Much time needed for complete make-to-order process ▪ Much capacity needed in the Tres Cantos plant for big order ▪ Too much time needed!	▪ Redesigned products based on common building blocks ▪ Common building blocks built before site engineering tasks ▪ Utilize the U.S. plant in Oklahoma to help solve capacity limitation problem ▪ Company won contract!

Source: Hoyt & Lopez-Tello (2001), Swaminathan & Lee (2003)

Group Work: Postponement

Telecopenhagen produces routers and smart phones. Both products are available in two versions: white and red. When manufacturing these products in their plant in Thailand, Telecopenhagen has to consider regional differences for these two products, as its two sales markets, the European Union and the United States, use different electricity networks (220 vs. 110 V electricity supply) and languages (24 official languages in the European Union; English in the United States). Only for the U.S. market, they have introduced a pink version of the smart phone. The color preferences differ quite substantially throughout the year.

Please systematically discuss the different approaches that could be used here to implement postponement. Make your own assumptions, if needed.

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