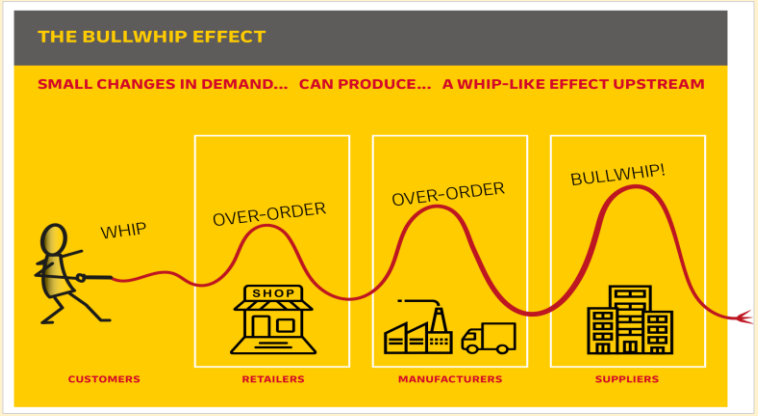
Lecture 5- Matching Demand and Supply



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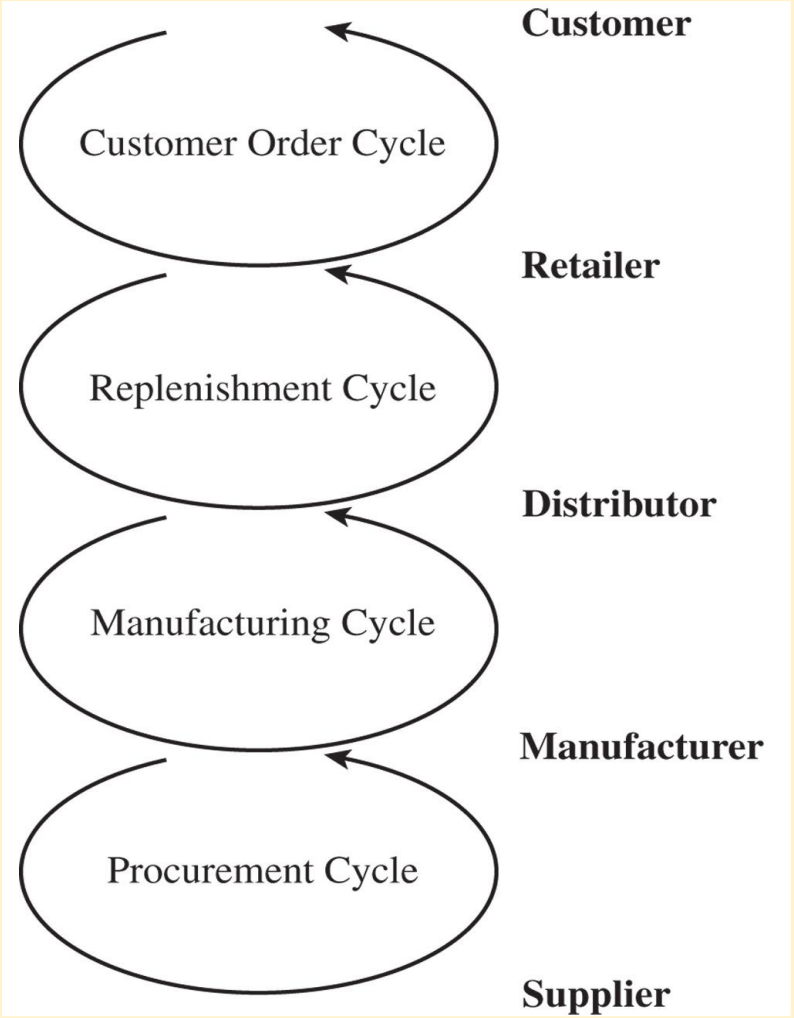
Recap

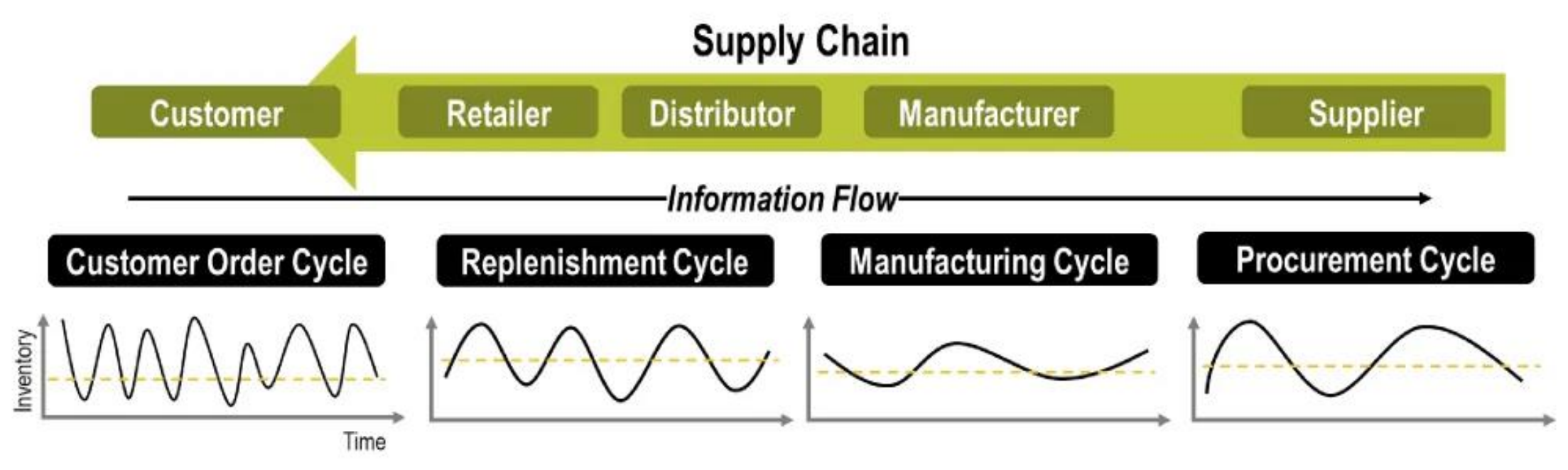
Cycle View of Supply Chain Processes

- The processes in a supply chain are divided into a series of cycles
- Each cycle occurs at the interface between two successive stages of a supply chain
- Not every supply chain will have all four cycles clearly separated
- For Example:
  - A Grocery supply chain is likely to have all four cycles separated.
  - Dell, in contrast, bypasses the retailer and distributor when it sells directly to customers.



Chopra and Meindl (2013, p. 8)

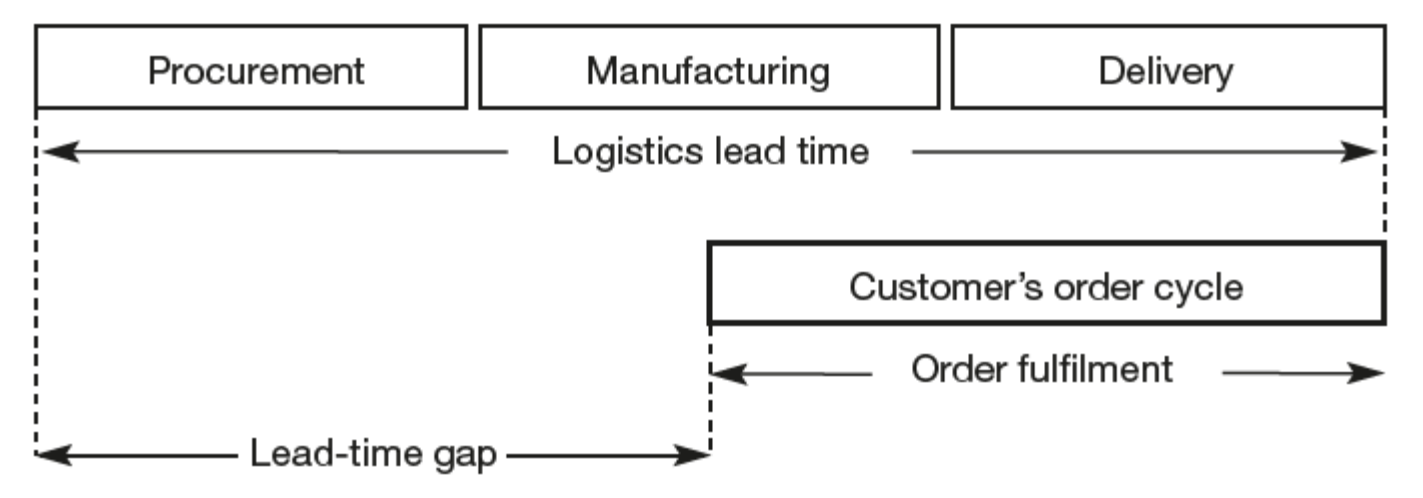
Supply Chain and its Cycles



Rodrigue (2020)

The lead-time Gap Problem

- The time it takes to procure, make and deliver the finished product to a customer is longer than the time the customer is prepared to wait for it.



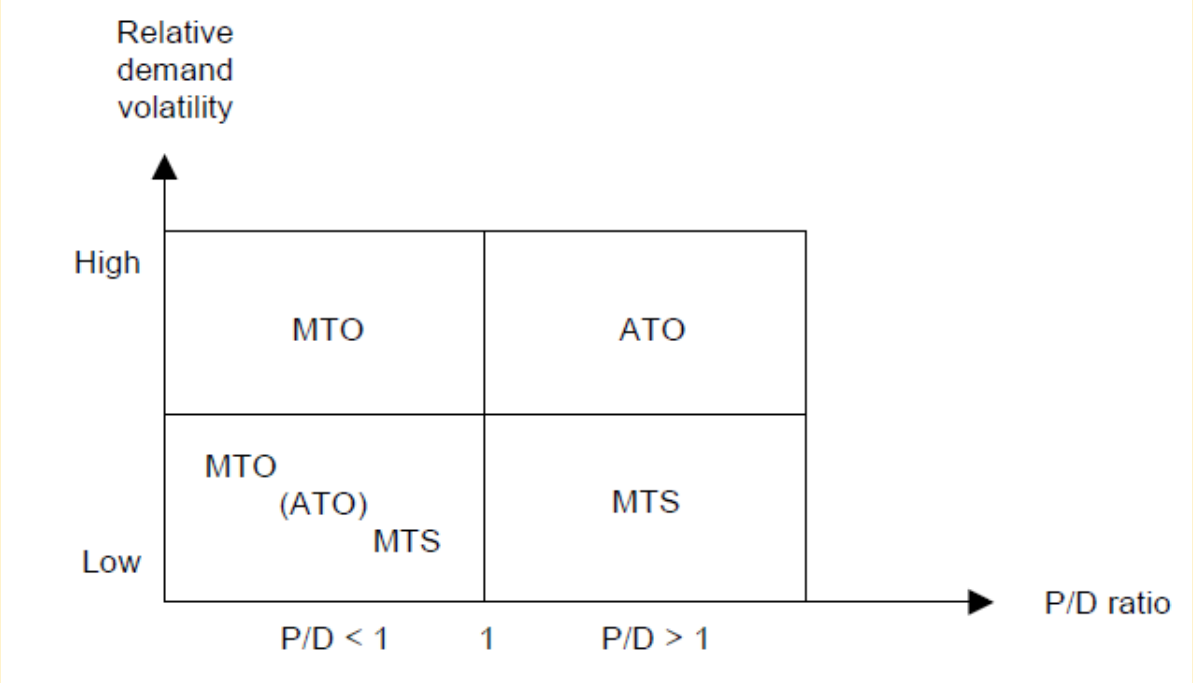
Source: Christopher (2016)

A model for choosing the right Product Delivery Strategy

- P/D ratio is the production lead time to delivery lead time ratio

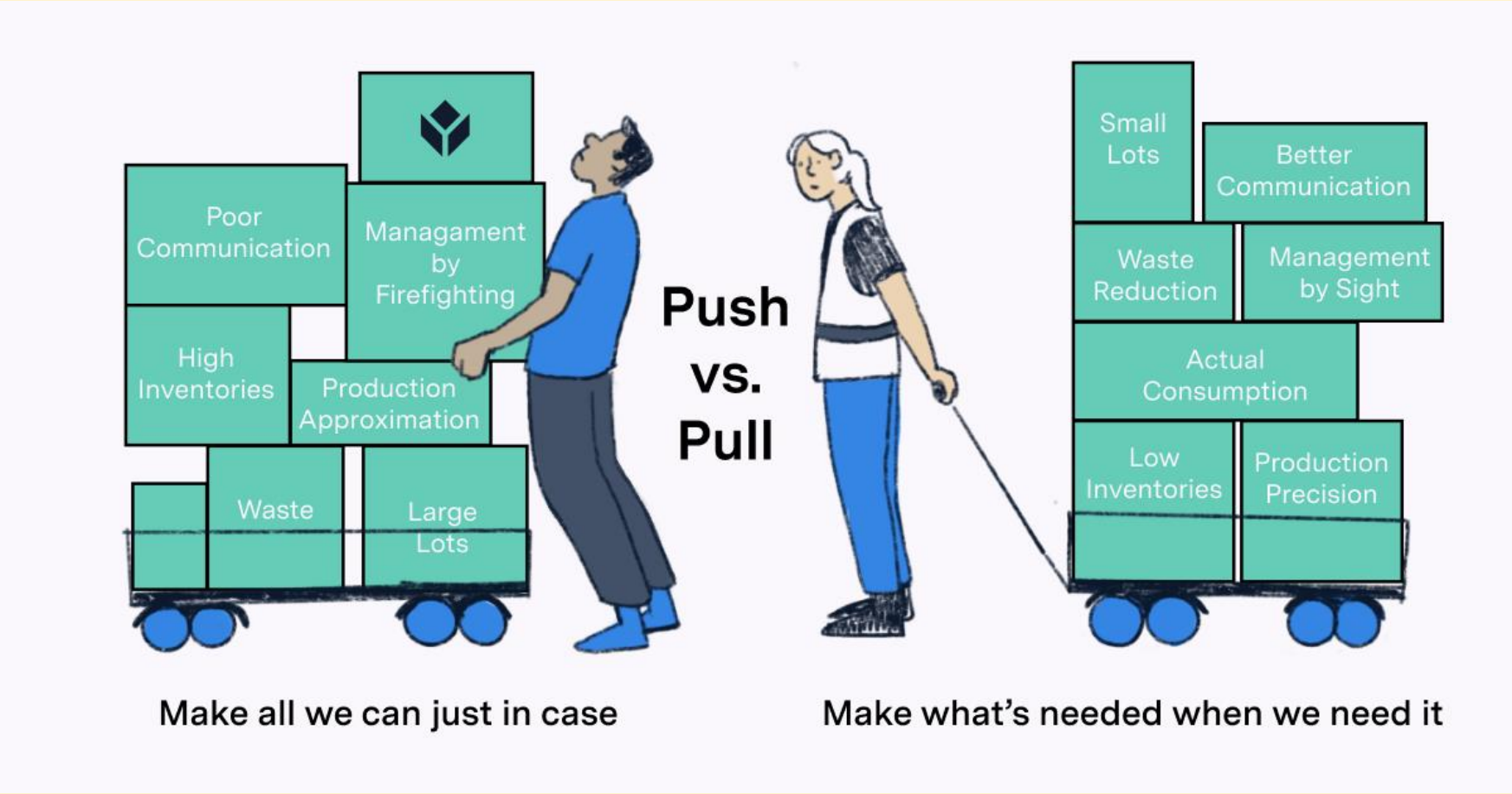
- Generally:
- IF P:D > 1- Push/MTS

- IF P:D < 1- Pull/MTO/ATO



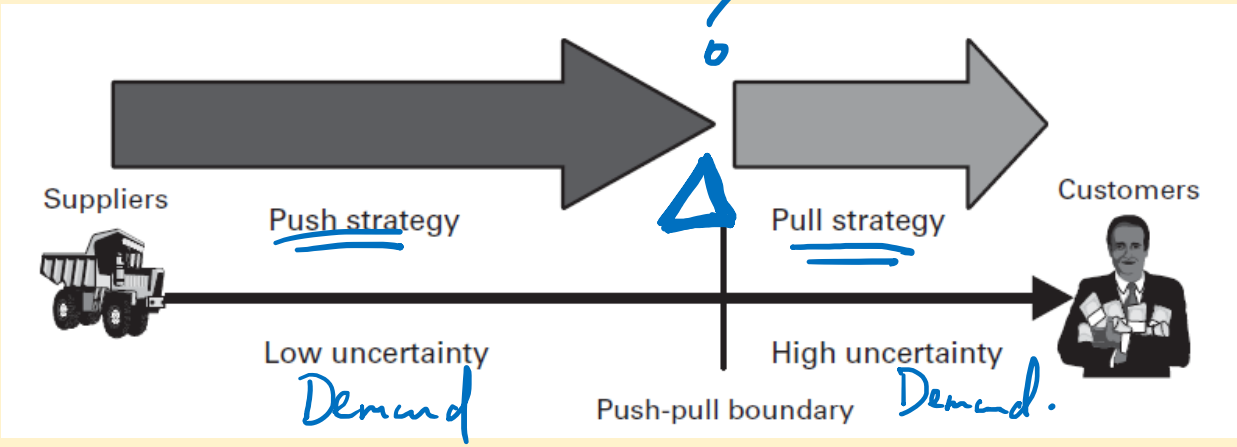
Olhager (2003)

Push vs Pull


Poor Communication
Managament by Firefighting
High Inventories
Production Approximation
Waste
Large Lots
Push vs. Pull
Small Lots
Better Communication
Waste Reduction
Management by Sight
Actual Consumption
Low Inventories
Production Precision
Make all we can just in case
Make what's needed when we need it

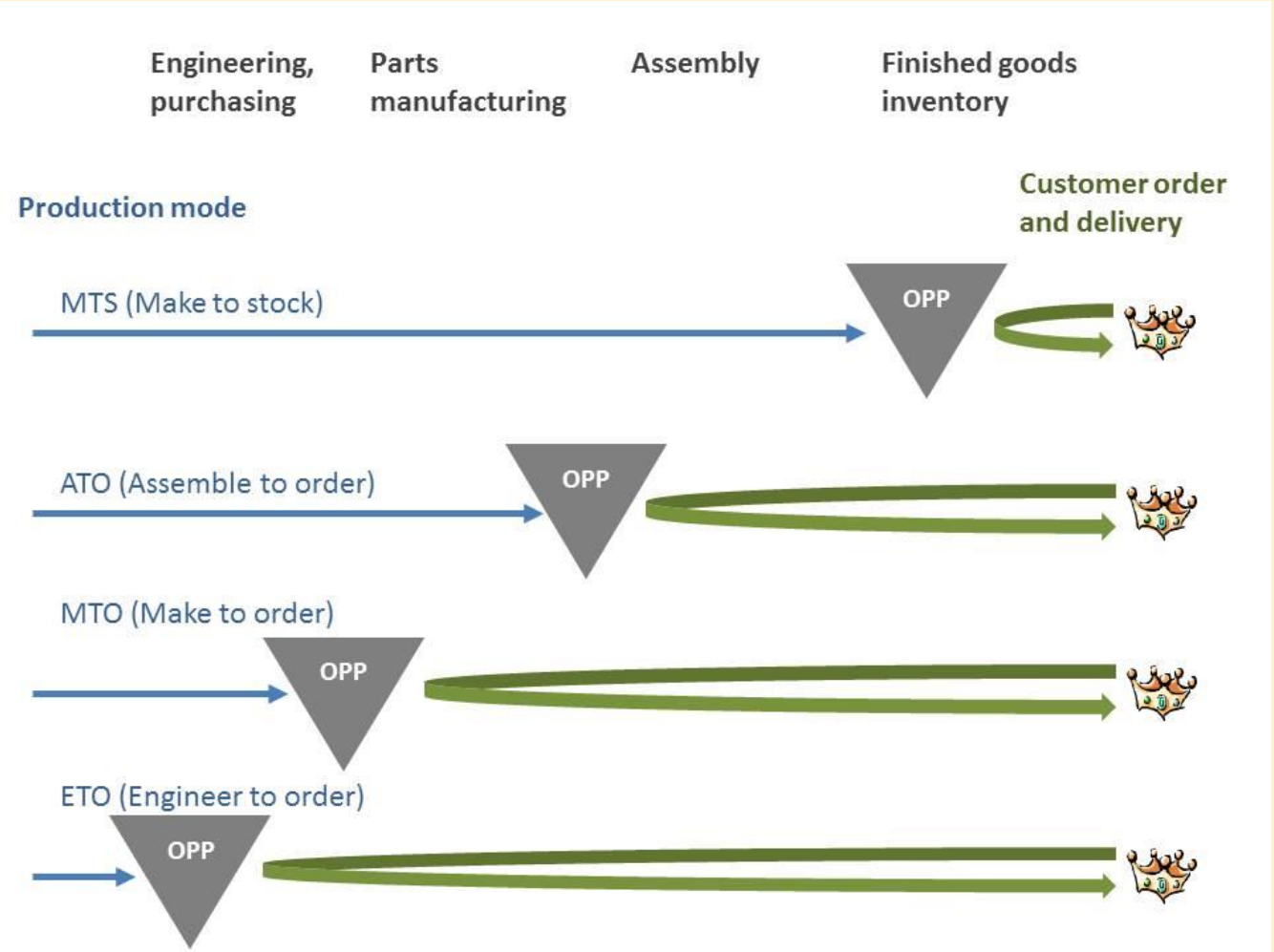
Implementing a Hybrid- Push Pull Strategy

- In a push-pull strategy , some stages of the supply chain, typically **the initial stages, are operated in a push-based** manner while the **remaining stages employ a pull-based strategy**
- The interface between the push-based stages and the pull-based stages is known as the **push-pull boundary**



Simchi-Levi (2010)

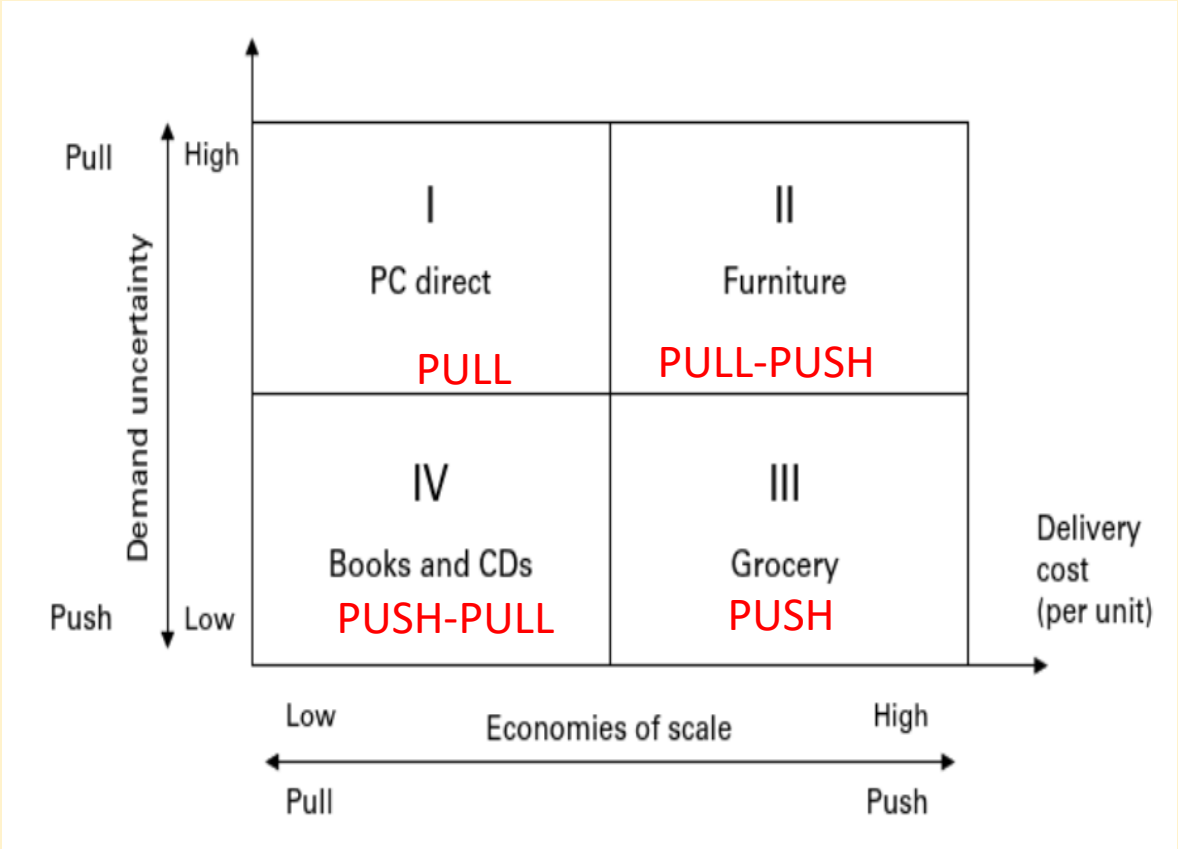
Manufacturing Strategy and OPP/CODP



Olhager (2003)

Matching SC Strategies with Products-
Effect of demand uncertainty and economies of scale

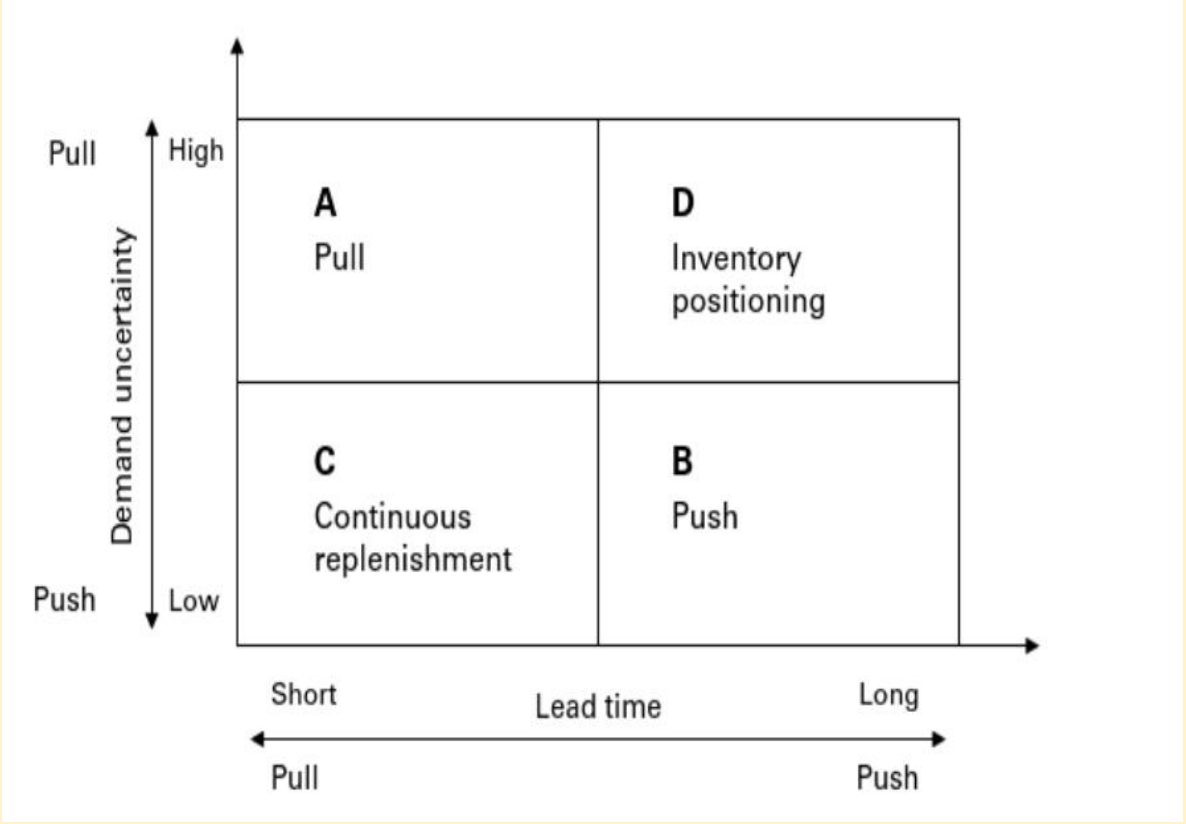
- **Box 1-** Pull-based SC Strategy
- **Box 3-** Push-based SC Strategy
- **Box 2 and 4-** Push-Pull SC Strategy



Simchi-Levi (2010)

Matching SC Strategies with Products-
Effect of Lead Time and Demand Uncertainty

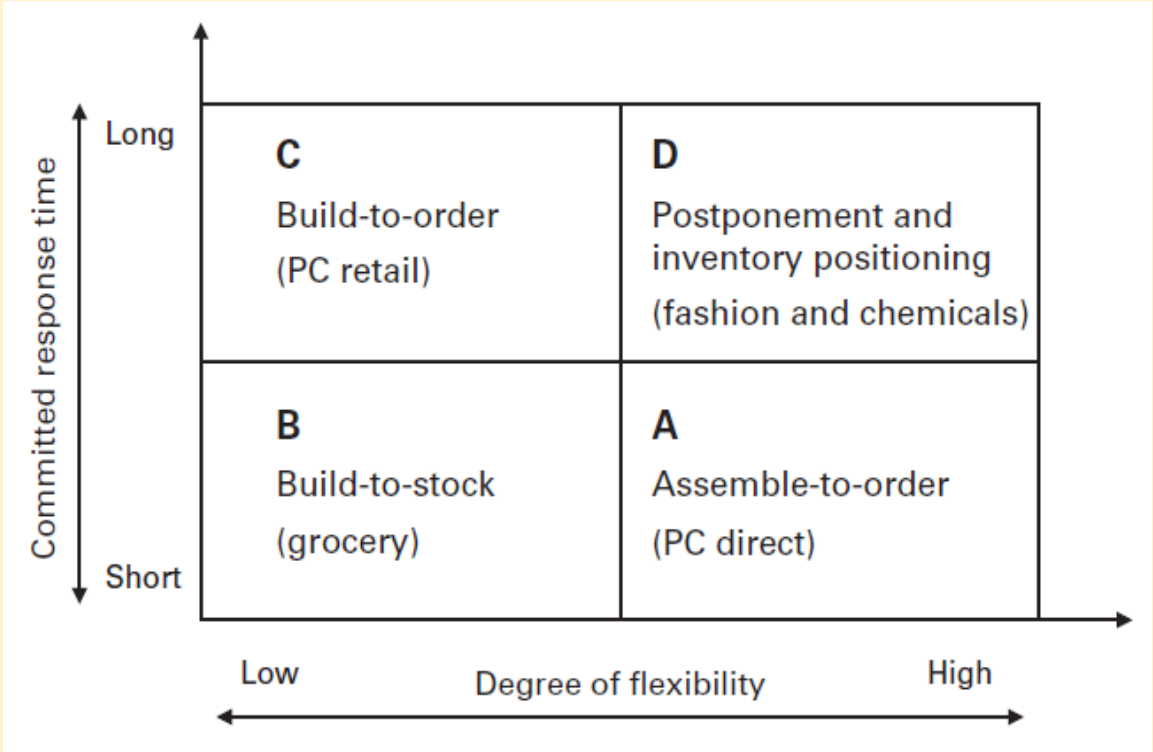
- Intuitively, the longer the lead time, the more important it is to implement a push-based strategy.



Simchi-Levi (2010)

Flexibility and the manufacturing strategy

- **Build-to-stock strategy-**
  - inventory is built based on forecast-
  - Push strategy.
  - Focus on cost reduction and effective forecast
- **Assemble-to-order strategy-**
  - individual products are assembled based on customer configuration
  - Pull strategy
- **Build-to-order strategy-**
  - Pull-Push strategy
  - lot sizes are produced after receiving a customer order
  - focuses on efficiency or cost reduction through economies of scale

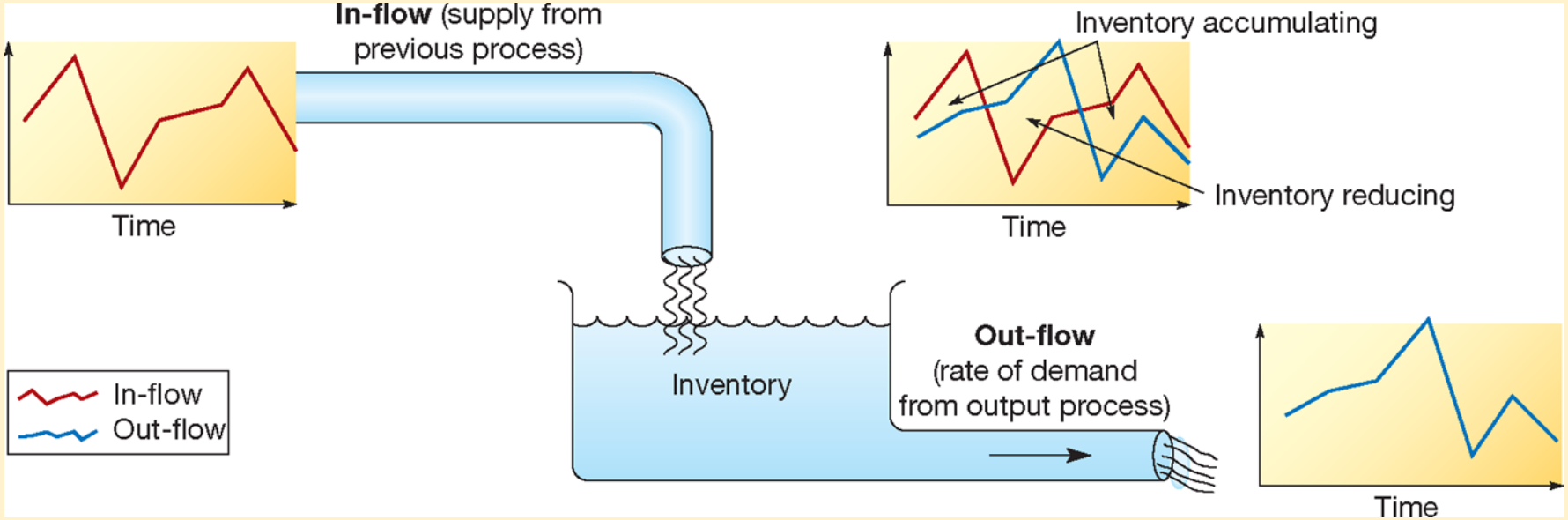


Simchi-Levi (2010)

Inventory Management

Inventories are often the result of uneven flows

- If there is a difference between the timing or the rate of supply and demand at any point in a process or network then accumulations will occur



Slack et al 2013

- **IF** supply exceeds the rate of demand,
  - **THEN** inventory increases;
- **IF** demand exceeds the rate of supply,
  - **THEN** inventory decreases

- AIM: Match supply and demand rates, it will also succeed in reducing its inventory levels
- Challenge: Most organizations must cope with unequal supply and demand, at least at some points in their supply chain

Why have inventory?

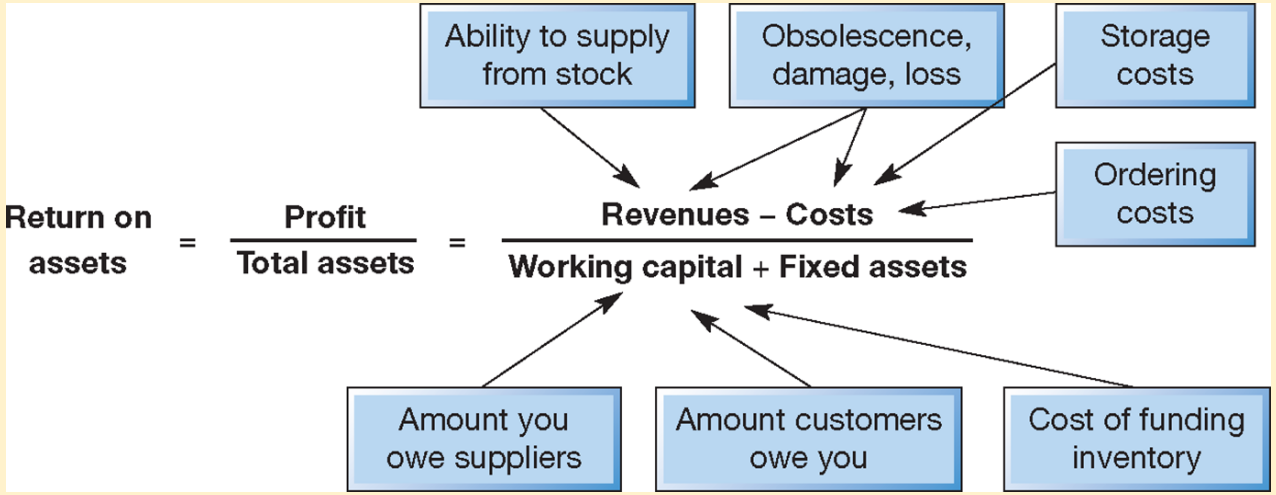
Reason for holding inventory	*Example*	*How inventory could be reduced*
As an insurance against uncertainty	Safety stocks for when demand or supply is not perfectly predictable	• Improve demand forecasting • Tighten supply, e.g. through service level penalties
To counteract a lack of flexibility	Cycle stock to maintain supply when other products are being made	• Increase flexibility of processes, e.g. by reducing changeover times (see Chapter 11) • Using parallel processes producing output simultaneously (see Chapter 7)
To take advantage of relatively short-term opportunities	Suppliers offer 'time limited' special low-cost offers	• Persuade suppliers to adopt 'everyday low prices' (see Chapter 13)
To anticipate future demands	Build up stocks in low demand periods for use in high demand periods	• Increase volume flexibility by moving towards a 'chase demand' plan (see Chapter 11)
To reduce overall costs	Purchasing a batch of products in order to save delivery and administration costs	• Reduce administration costs through purchasing process efficiency gains • Investigate alternative delivery channels that reduce transport costs
To fill the processing 'pipeline'	Items being delivered to customer	• Reduce process time between customer request and dispatch of items • Reduce throughput time in the downstream supply chain (see Chapter 13)

Some reasons to avoid inventories

	'Inventories'		
	Physical inventories	***Queues of customers***	***Digital information in databases***
Cost	Ties up working capital and there could be high administrative and insurance costs	Primarily time-cost to the customer, i.e. wastes customers' time	Cost of set-up, access, updating and maintenance
Space	Requires storage space	Requires areas for waiting or phone lines for held calls	Requires memory capacity. May require secure and/or special environment
Quality	May deteriorate over time, become damaged or obsolete	May upset customers if they have to wait too long. May lose customers	Data may be corrupted or lost or become obsolete
Operational/ organizational	May hide problems (see lean synchronization – Chapter 15)	May put undue pressure on the staff and so quality is compromised for throughput	Databases need constant management; access control, updating and security

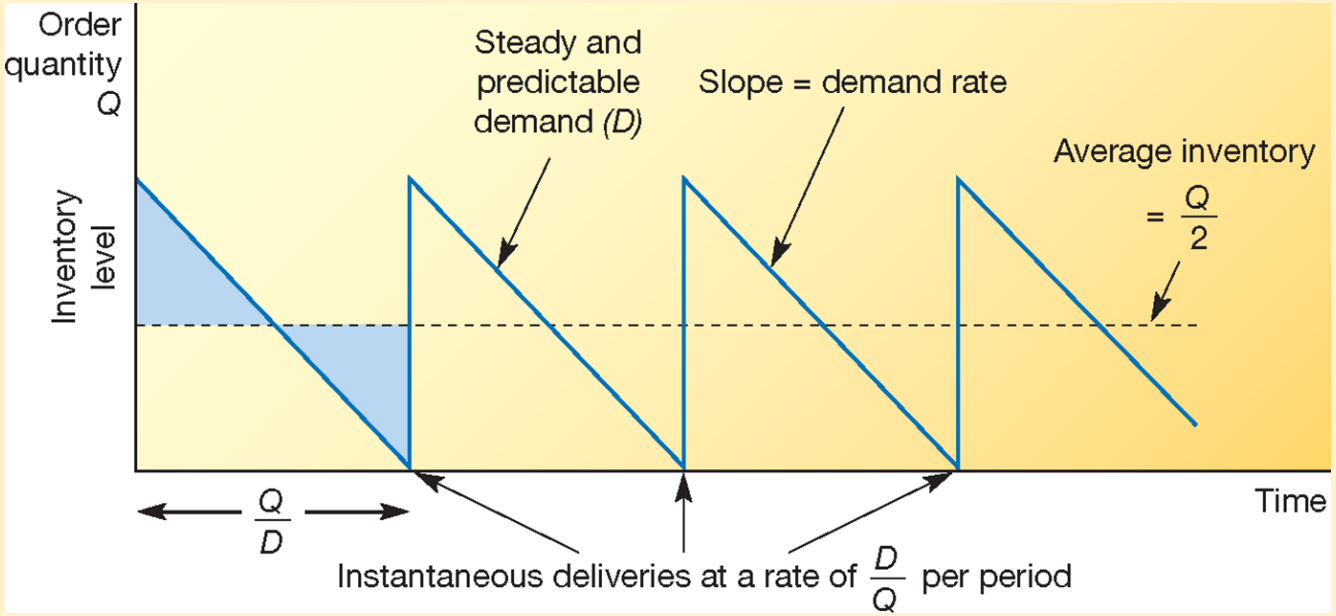
Reducing physical inventory

- The objective is to reduce the overall level (and/or cost) of inventory whilst maintaining an acceptable level of customer service.
- Since Inventory management impact on ‘return on assets:



Inventory profiles chart the variation in inventory level

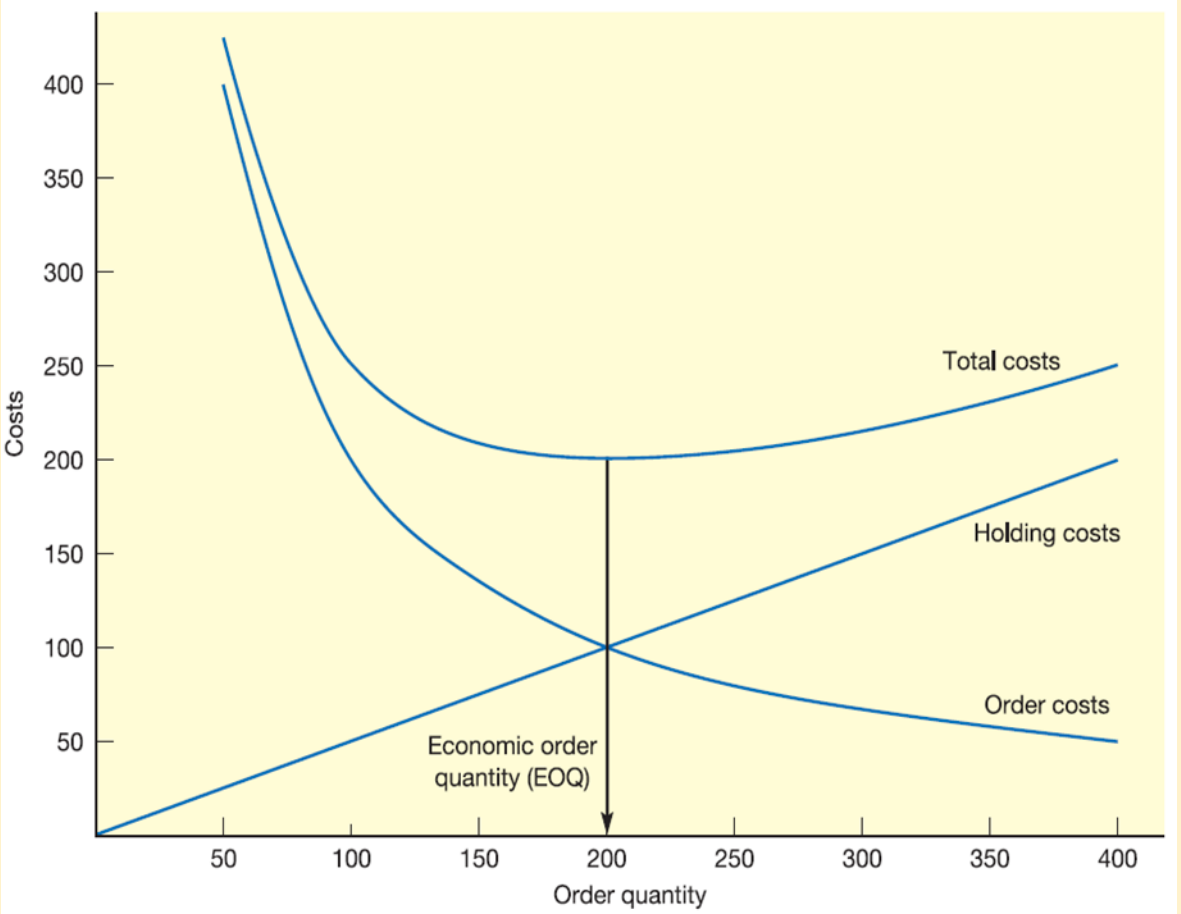
- Every time an order is placed, **Q** items are ordered
- Demand for the item is then steady and perfectly predictable at a rate of **D** units per period
- When demand has depleted the stock of the items entirely, another order of Q items instantaneously arrives, and so on



How Much to Order- Volume Decision?

- In making this decision we are balancing two sets of costs:

1. the costs associated with ordering
2. the costs associated with holding the stocks



The economic order quantity (EOQ)

- The most common approach to deciding how much of any particular item to order when stock needs replenishing is called the economic order quantity (EOQ) approach.

- This approach attempts to find the best balance between the advantages and disadvantages of holding stock

The Total Cost of stocking the item

- Information Needed:
  - The total cost of holding one unit in stock for a period of time (C_h)
  - The total costs of placing an order (C_o)

$$\text{Holding costs} = \text{holding cost/unit} \times \text{average inventory} = C_h \times \frac{Q}{2}$$

$$\text{Ordering costs} = \text{ordering cost} \times \text{number of orders per period} = C_o \times \frac{D}{Q}$$

$$\text{So, total cost, } C_t = \frac{C_h Q}{2} + \frac{C_o D}{Q}$$

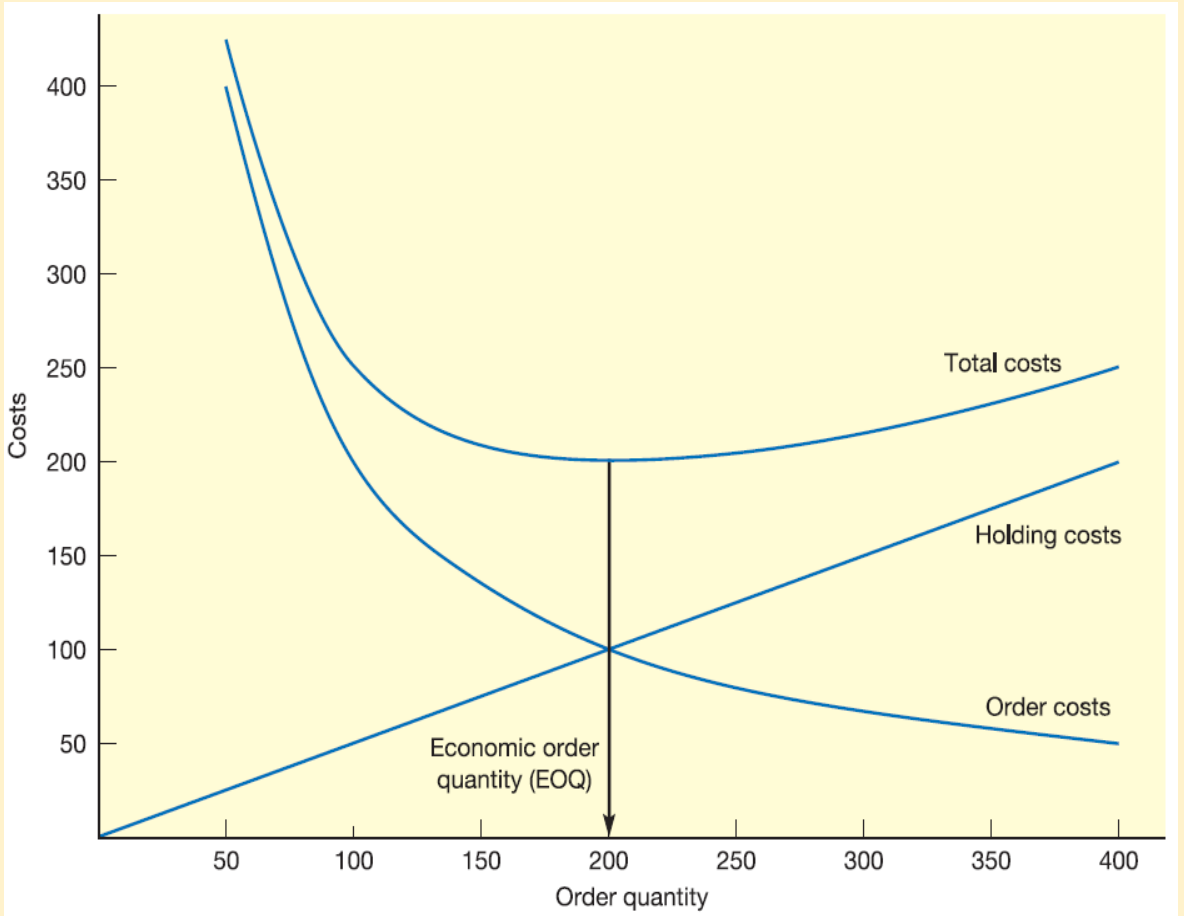
Costs of adoption of plans with different order quantities

Demand (D) = 1,000 units per year *Order costs (C_o) = £20 per order*			*Holding costs (C_h) = £1 per item per year*		
Order quantity (Q)	*Holding costs ($0.5Q \times C_h$)*	+	*Order costs ($(D/Q) \times C_o$)*	=	*Total costs*
50	25		$20 \times 20 = 400$		425
100	50		$10 \times 20 = 200$		250
150	75		$6.7 \times 20 = 134$		209
200	100		$5 \times 20 = 100$		200*
250	125		$4 \times 20 = 80$		205
300	150		$3.3 \times 20 = 66$		216
350	175		$2.9 \times 20 = 58$		233
400	200		$2.5 \times 20 = 50$		250

- As we would expect with low values of Q, holding costs are low but the costs of placing orders are high because orders have to be placed very frequently.
- As Q increases, the holding costs increase but the costs of placing orders decrease.
- Initially the decrease in ordering costs is greater than the increase in holding costs and the total cost falls.
- After a point, however, the decrease in ordering costs slows, whereas the increase in holding costs remains constant and the total cost starts to increase.

EOQ

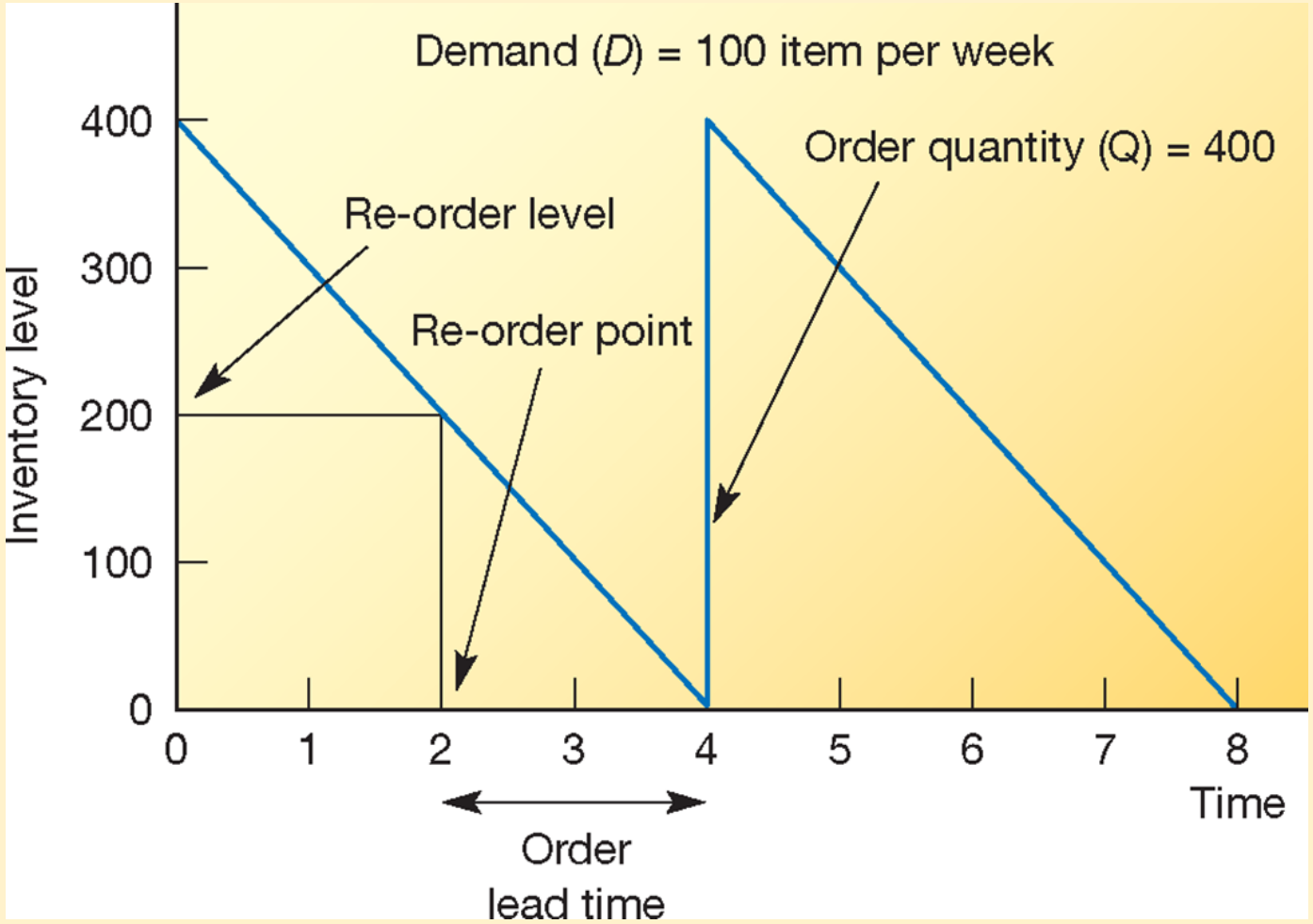
$$\text{EOQ} = \sqrt{\frac{2C_oD}{C_h}}$$



When to Place an Order- Timing Decision?

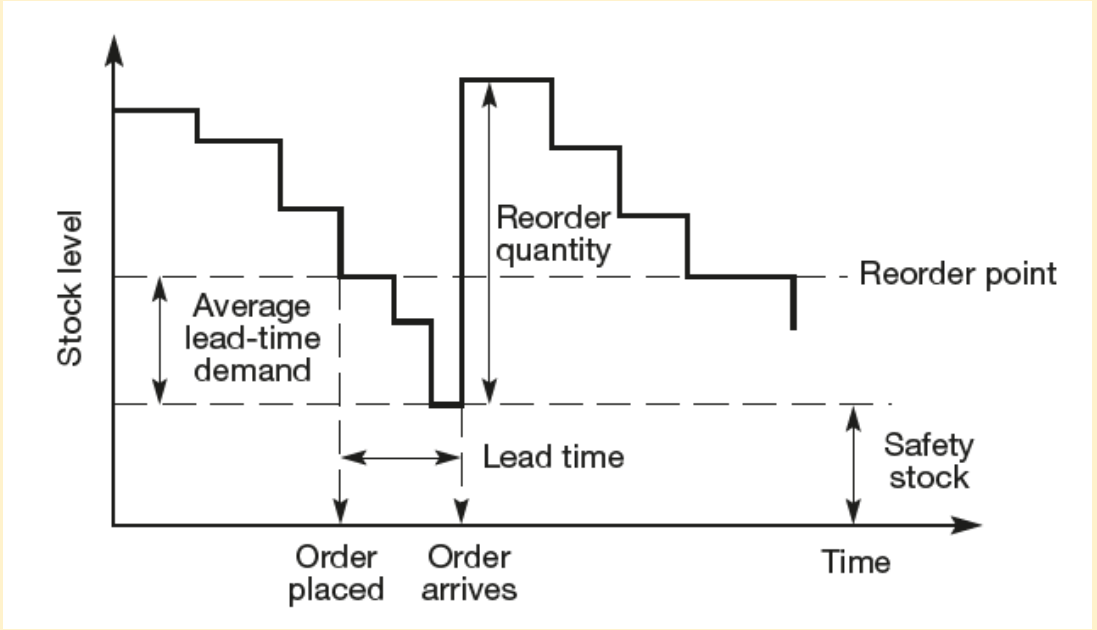
- If replenishment orders do not arrive instantaneously, but have a lag between the order being placed and it arriving in the inventory,
- Then we need to calculate the Reorder Point level
- So the Re-order point (ROP) is the point at which stock will fall to zero minus the order lead time
- Re-order level (ROL) the level of inventory when a replenishment order needs to be placed

Re-order level (ROL) and re-order point (ROP) are derived from the order lead time and demand rate



The reorder point method of stock control with Safety Stock

- A reorder point or **reorder level** is predetermined
- Based upon the expected length of the **replenishment lead-time**
- The amount to be ordered may be based upon **the economic order quantity** (EOQ)
- To balance the cost of holding inventory against the costs of placing replenishment orders.



Source: Christopher (2016)

The Bullwhip Effect

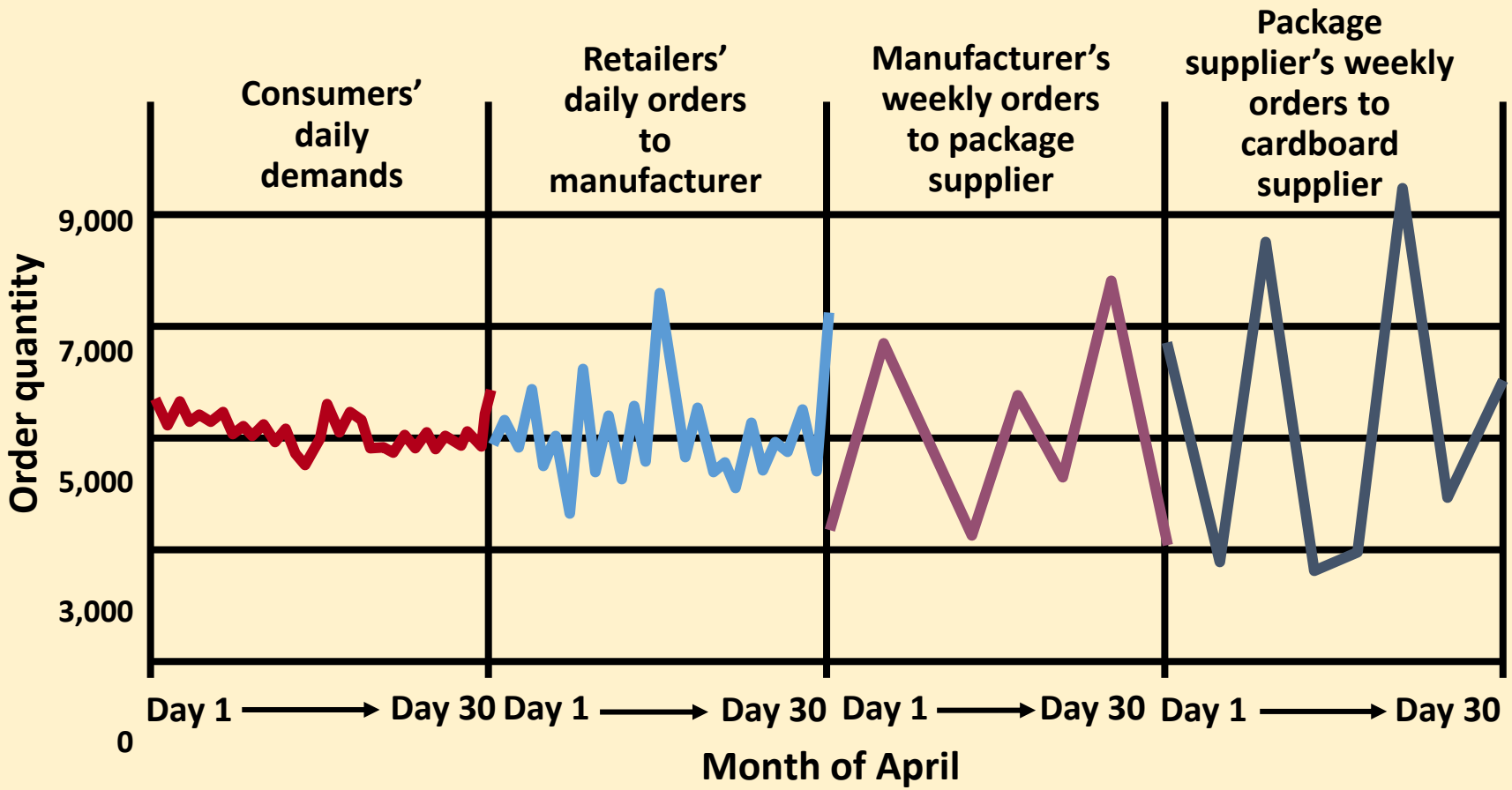
https://www.youtube.com/watch?v=JgLkDbiwTX0

Definition (Lee et al., 1997)

- Caused by:
  - **Demand distortion-** the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer
- Results in:
  - **Variance amplification-** the distortion propagates upstream in an amplified form

A simplified example of the bullwhip effect

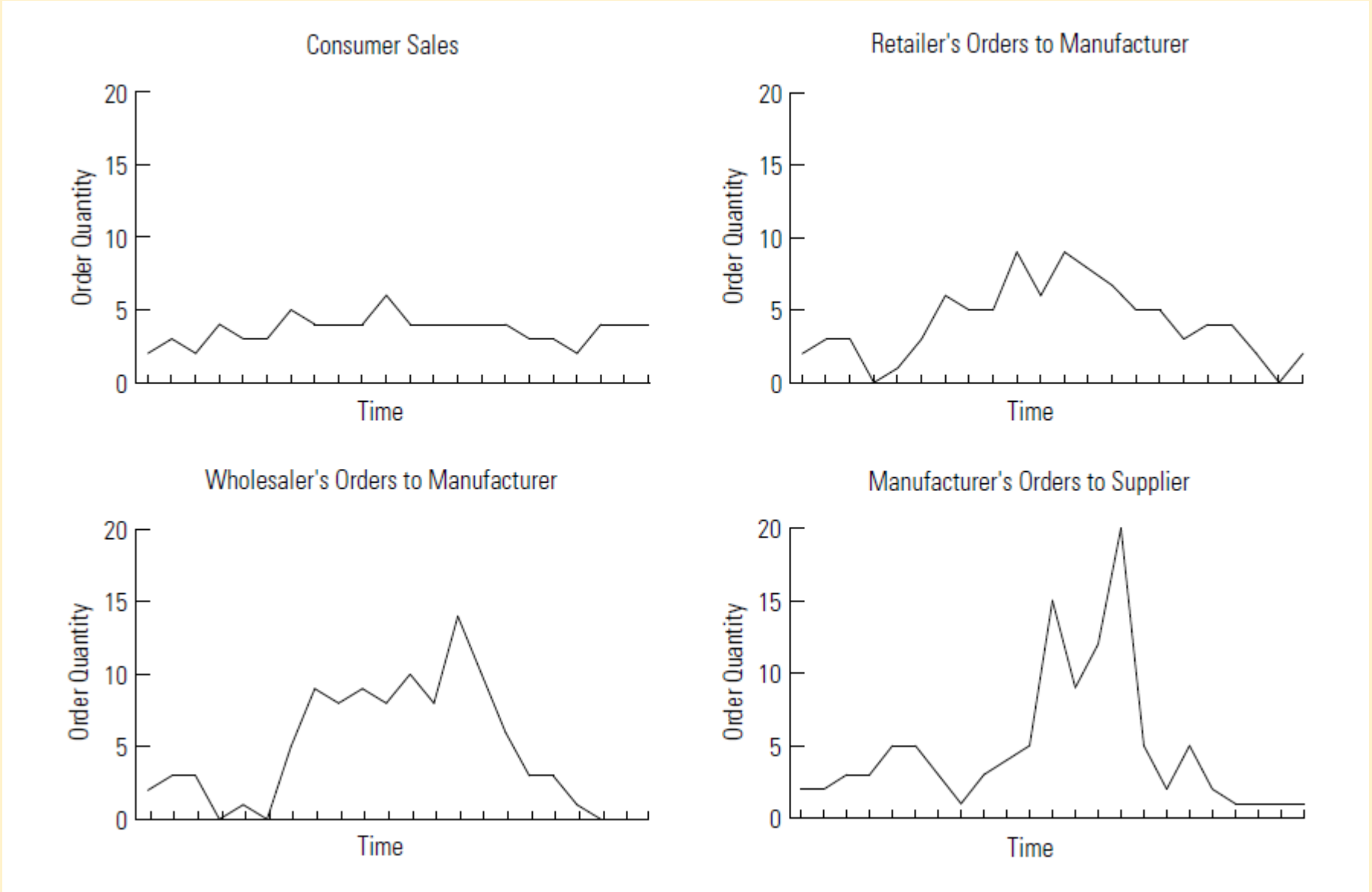
- A retailer typically keeps 100 six-packs of one soda brand in stock.
- If it normally sells 20 six-packs a day, it would order that replacement amount from the distributor.
- But one day, the retailer sells 70 six-packs and assumes customers will start buying more product, and responds by ordering 100 six-packs to meet this higher forecasted demand
- The distributor may then respond by ordering double, or 200 six-packs, from the manufacturer to ensure they do not run out.
- The manufacturer then produces 250 six-packs to be on the safe side.
- In the end, the increased demand has been amplified up the supply chain **from to 100 six-packs at the customer level to 250** at the manufacturer.



The Bullwhip Effect

Krajewski et al (2016)

Increasing Variability of Orders up the Supply Chain



Lee et al. (1997)

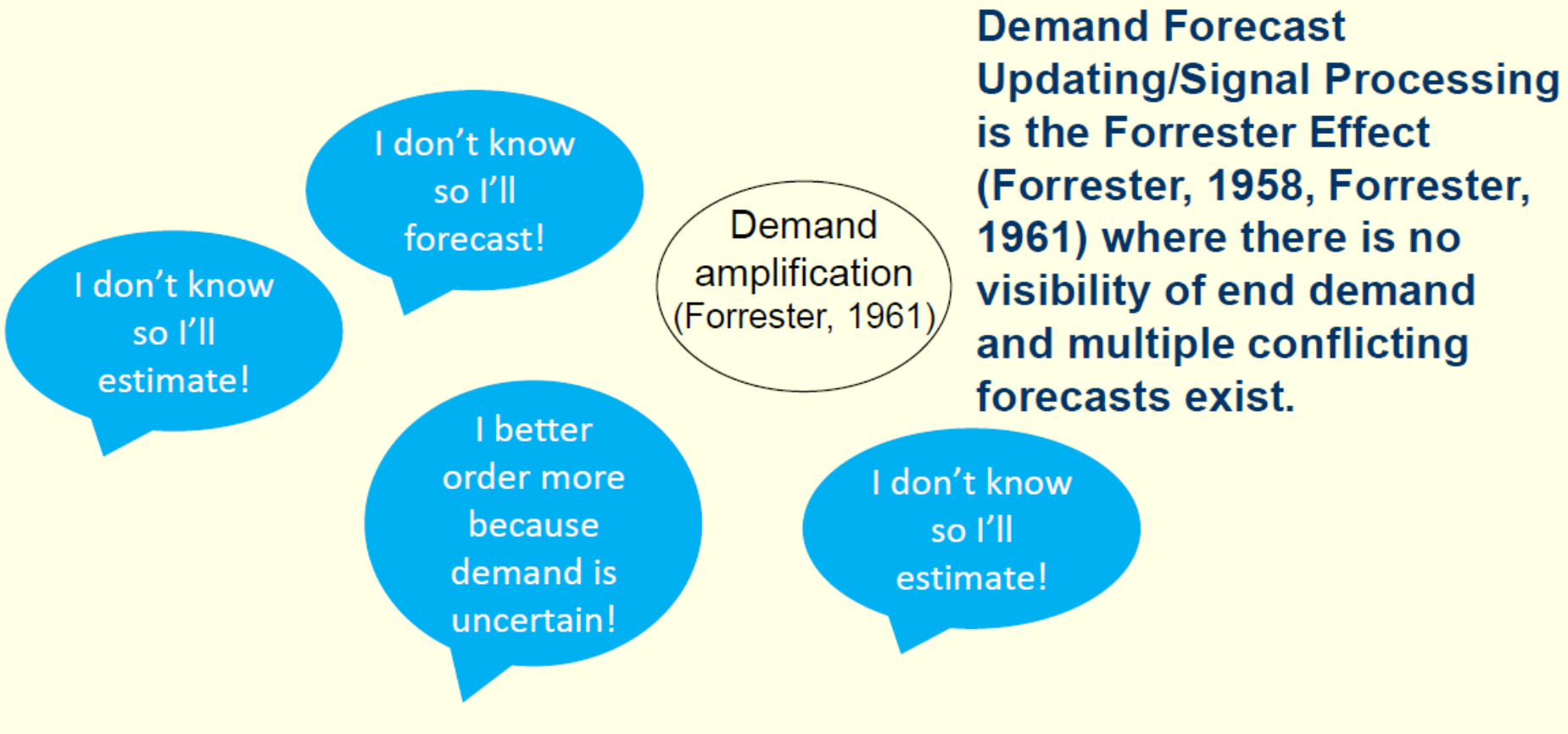
The Bullwhip Effect

https://www.youtube.com/watch?v=2nlmkTYZG5s

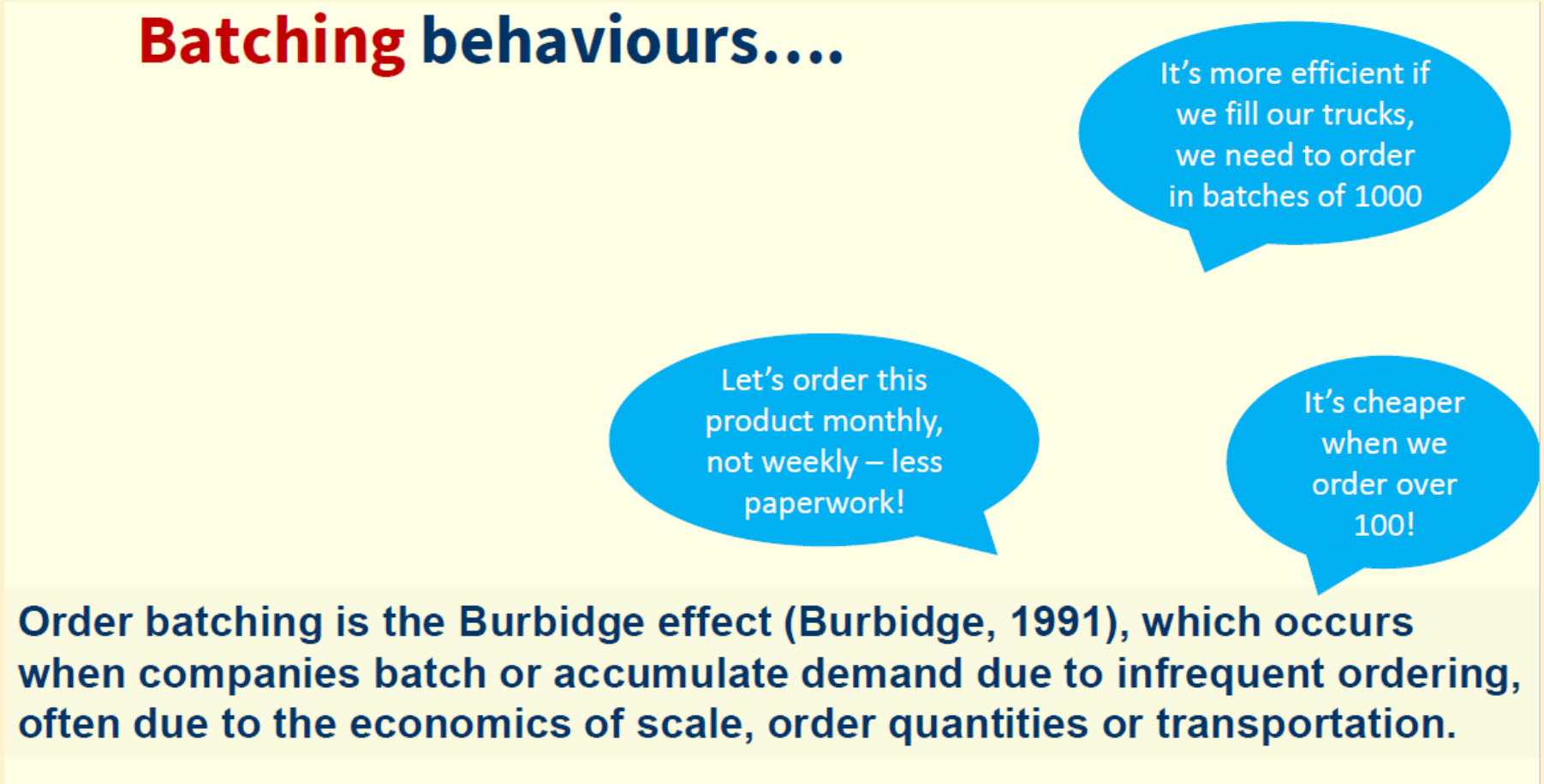
Causes of Bullwhip Effect

1. Demand forecast updating
2. Order batching
3. Price fluctuation
4. Rationing and shortage gaming

Demand Forecast Updating/Signal Processing



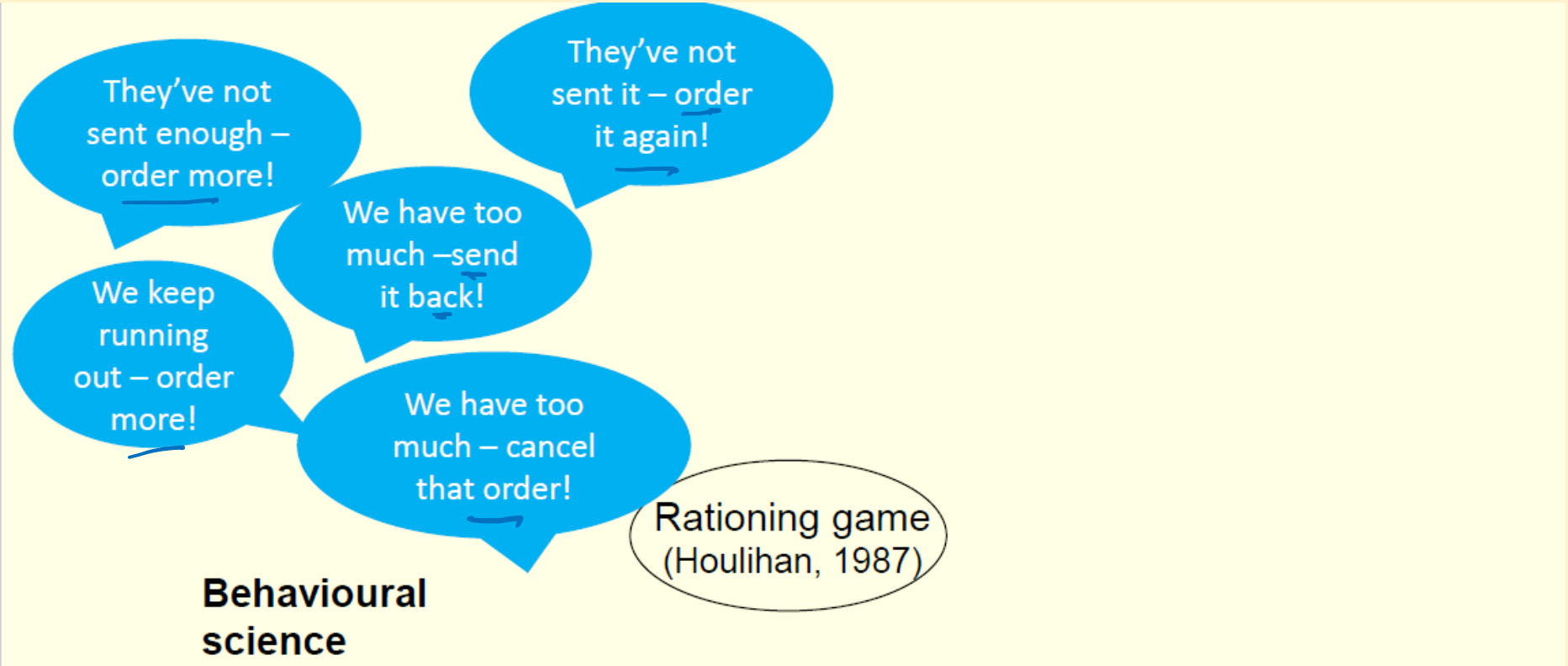
Order Batching



Price Fluctuations

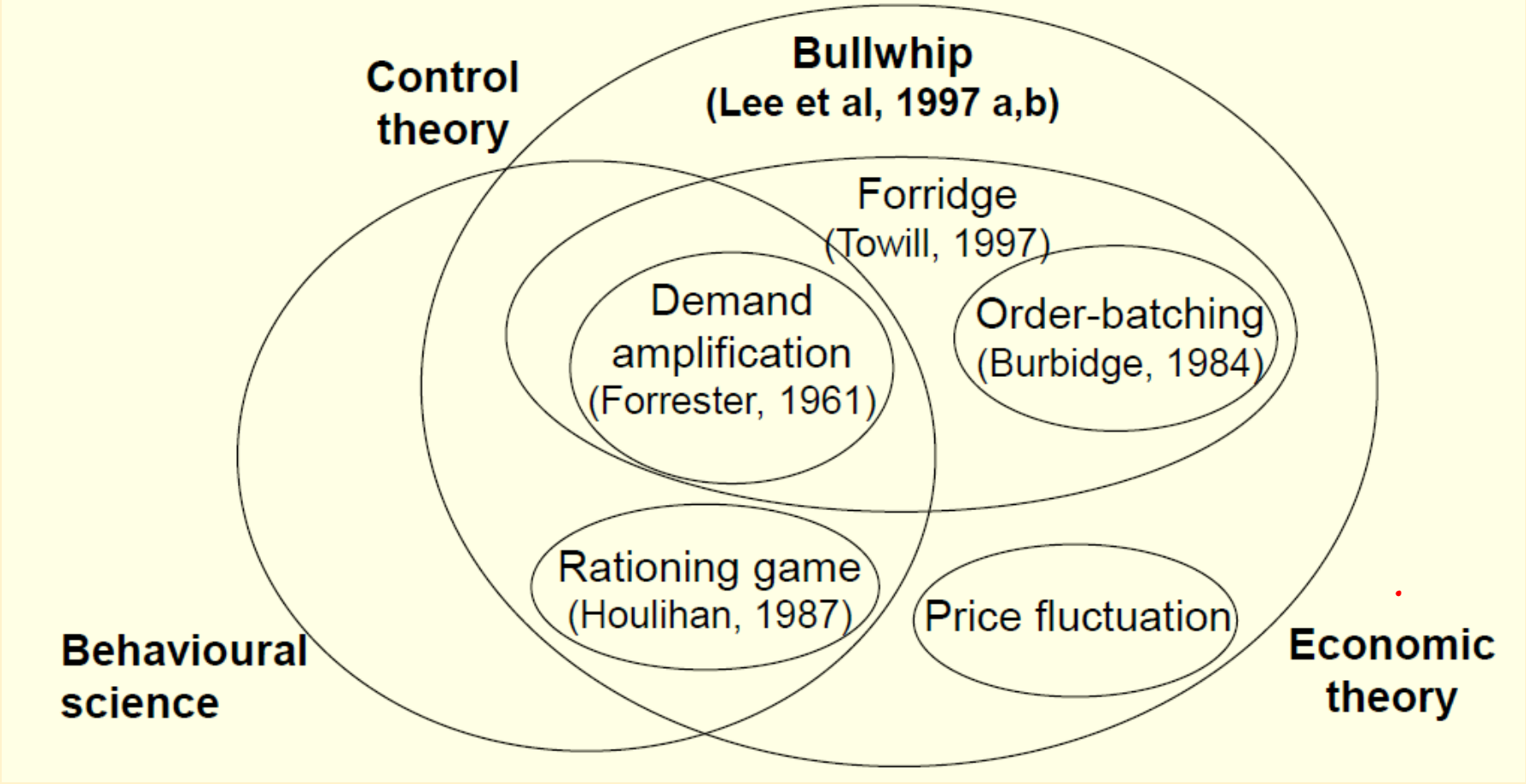
Price fluctuation causes manufacturers and distributors to "forward buy" usually due to an attractive price offer. The result is the consumer buys in bulk and then stops buying until their inventory is depleted; Holweg (2002) links this to economic theory.

Rationing and Short Gaming



Rationing and Shortage Gaming is the Houlihan effect (1987) which occurs when demand exceeds supply so customers get less than they ordered. Therefore they then over order to compensate for the rationing and then orders will disappear or be cancelled due to an overreaction in anticipation by customers.

Summary- What Caused the Bullwhip Effect?



Impact of the Bullwhip Effect

- Leads to **inefficient resource utilization**
- Because planning and managing are difficult
- It is not clear **how a manufacturer should determine production capacity**
- Should it be based on peak demand, which implies that most of the time the manufacturer has expensive resources sitting idle,
- Or should it be based on average demand, which requires extra — and expensive — capacity during periods of peak demand?
- Similarly, it is not clear how to plan transportation capacity — based on peak demand or average demand.
- Thus, in a push-based supply chain, **we often find increased transportation costs, high inventory levels, and high manufacturing costs**, due to the need for emergency production changeovers

Activity: Quiz

- Go to: https://forms.gle/HpfPyvZgV9C46Ccz8
- Post your score on the chat