# MSBA 7004
# Operations Analytics

## Class 9: Inventory Analysis (III)
## Review of Newsvendor Problem
## 2023

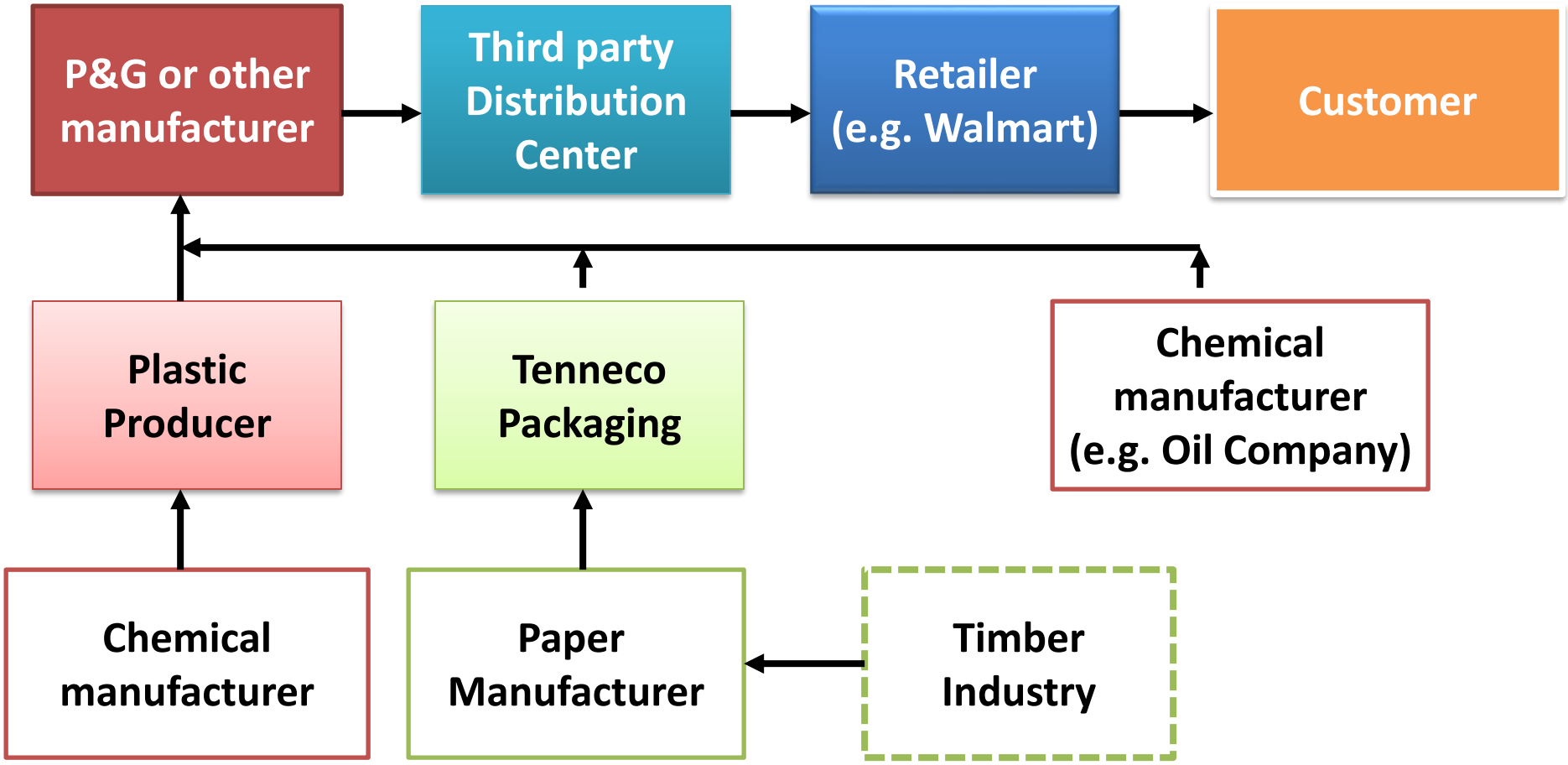
# Learning Objectives

- What is a supply chain?
- What are the challenges in managing a supply chain?
- How can we solve the challenges?

# Supply Chain Example: Detergent


What firms are involved in the supply chain of a detergent?

# Example: Detergent Supply Chain

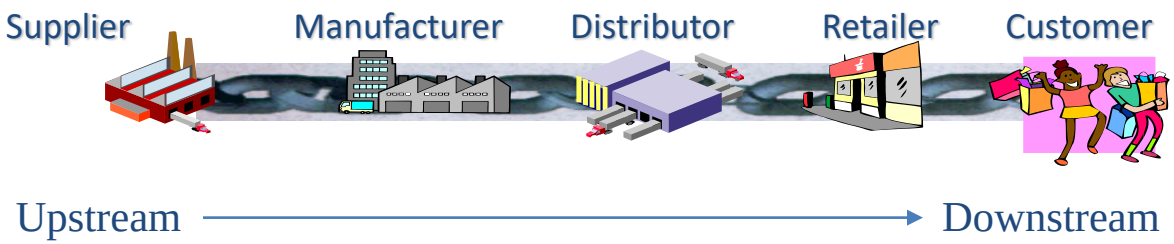


# Supply Chain is a..

- Complex system of organizations, resources, and information involved in transforming raw materials to final products, and supplying the final products to customers
- Supply chain is composed of..
  - suppliers, manufacturers, transportation, distributors, and vendors (function)
  - Raw material, work-in-process, and finished goods (FG) in **inventory**
  - Information, capital, and people associated with the system
- Supply chain is also called: the value chain, the logistics network, the distribution network

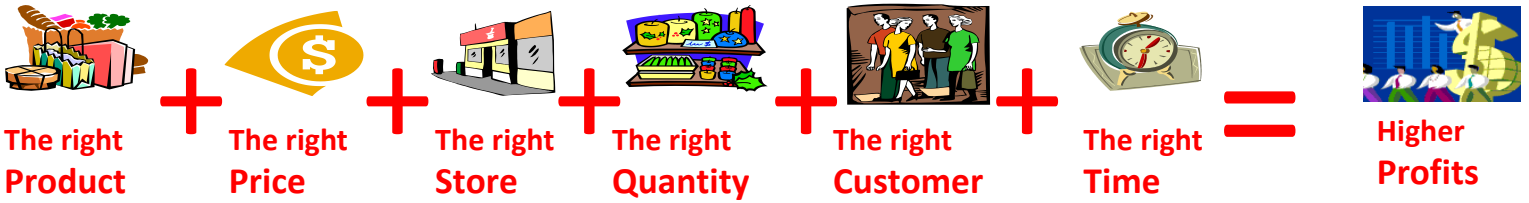
# Supply Chain: Structure and Objective

- Consists of

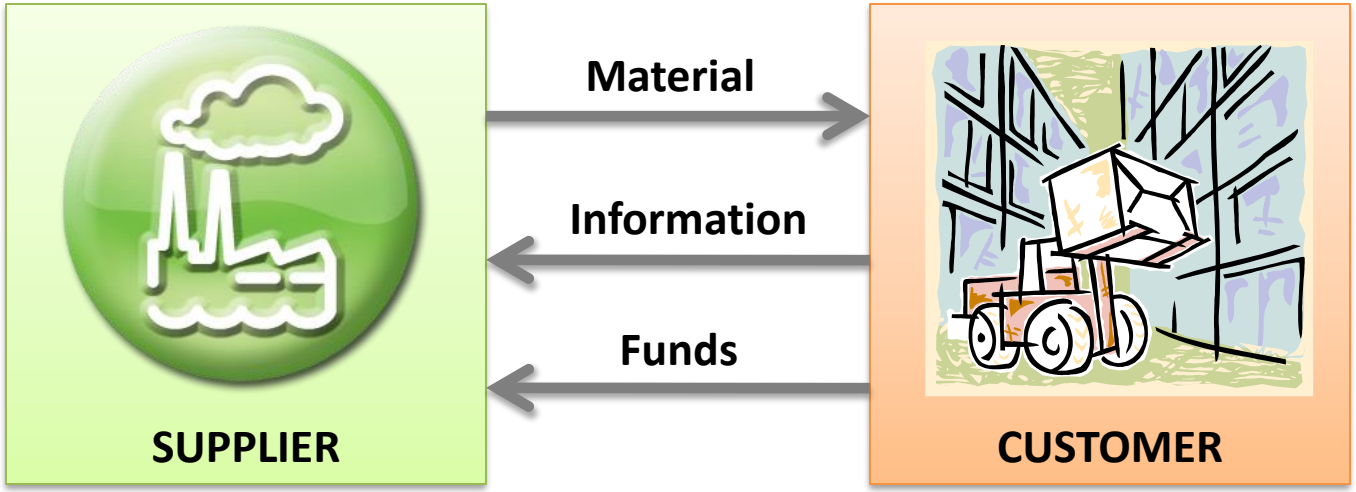



- Aims to match supply and demand (to generate profit for products and services)

- Achieved by..



# Flows in a Supply Chain




- The flows resemble a chain reaction

# Challenges in Supply Chain

Material Scarcity (insufficient inputs) becomes severe due to COVID

High inventories throughout the chain

Low order fill rates
High Stockout


supplier | factory | distributor | retailers | customers

Frequent supply shortages

Inefficient logistics (port congestion), High transportation costs (Increasing freight prices)

Difficult demand forecasting

# Source of Challenges: Conflicting Objectives

**Purchasing / Suppliers**

Supplier wants: Stable volume requirements, Flexible delivery time

**Warehousing**

Retailer wants: Low inventory, Reduced transportation costs
Distributer needs: Quick replenishment capability


supplier | factory | distributor | retailers | customers

**Manufacturing**

Long run production
High quality
High productivity
Low production cost

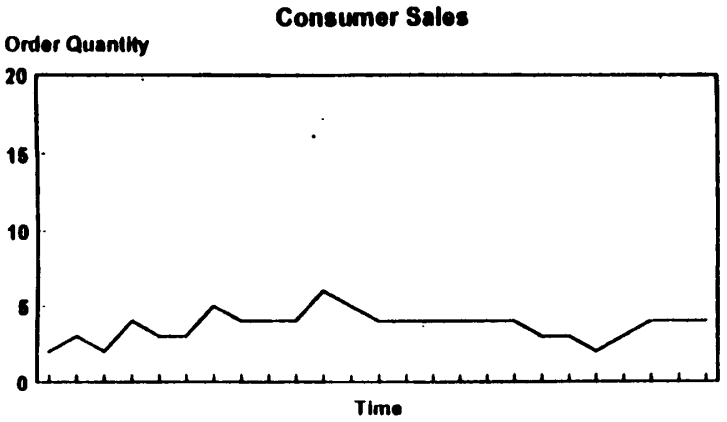
**Customers**

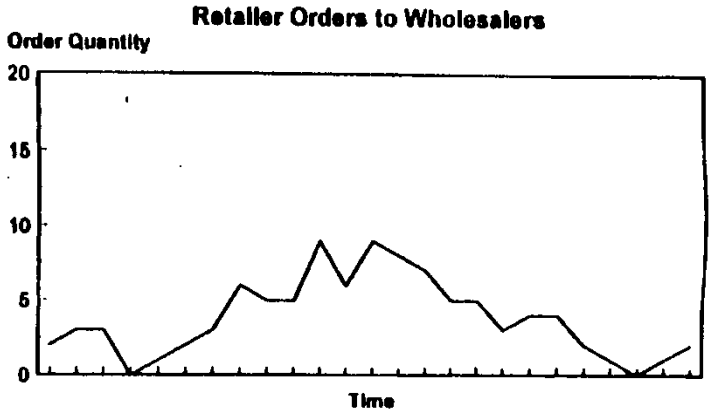
Customer wants: Enormous variety of products, Low prices
Retailer needs: Short order lead time
High in stock

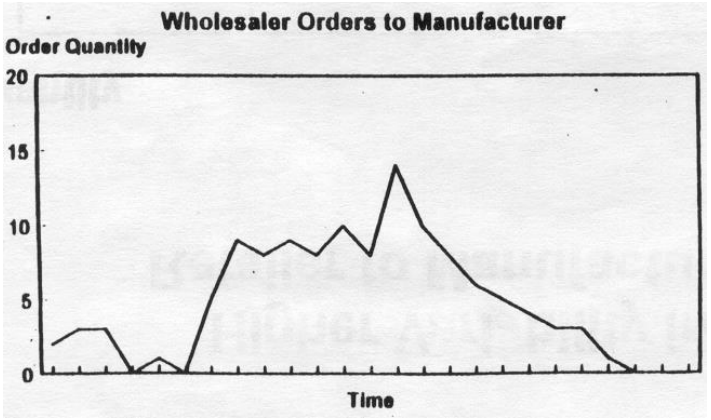
# Challenges in Supply Chain

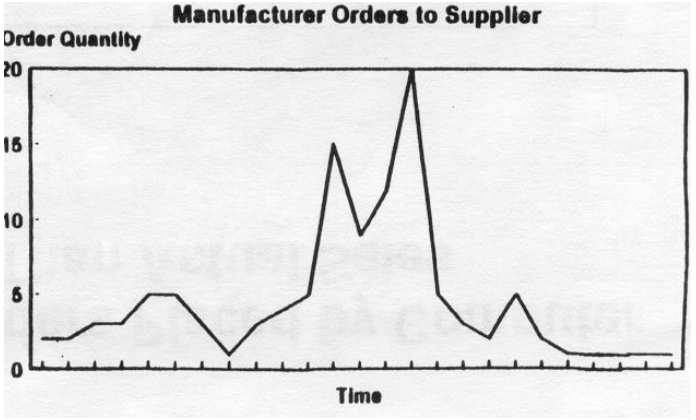
- Indeed, in many cases there are adversarial relationships between supply chain partners, as well as dysfunctional industry practices (e.g., price promotions), which lead to challenges in coordination of the supply chain.
- These main challenges are:
  - Bullwhip effect – demand variability increases as we move up the supply chain (from downstream to upstream)
  - Incentive conflicts

# Increasing Variability of Orders Up the Supply Chain – Bullwhip effect



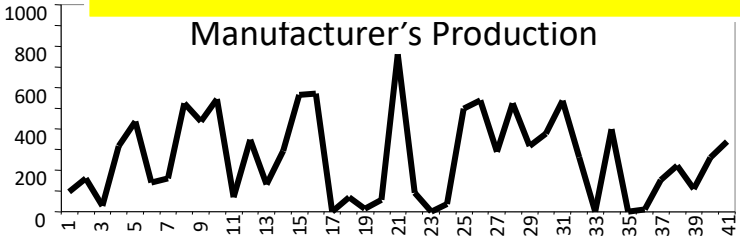




Lee, H, P. Padmanabhan and S. Wang (1997); (Disposal Baby Diapers SC)

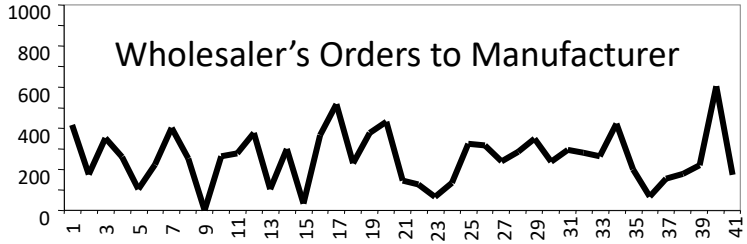
# The Bullwhip Effect

The variance of orders is greater than that of sales, and the distortion increases as one moves upstream in the supply chain



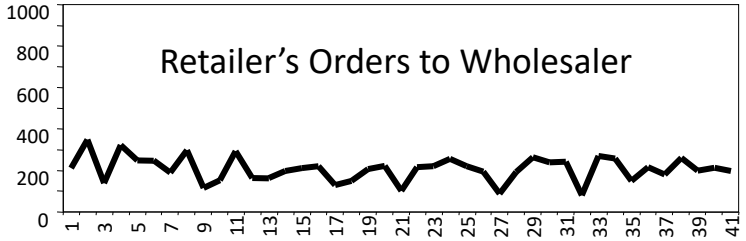

Delivery

Order



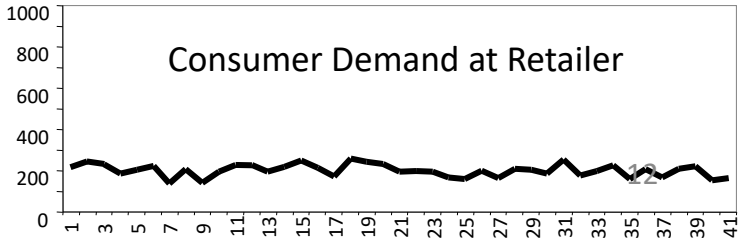

Delivery

Order




Delivery

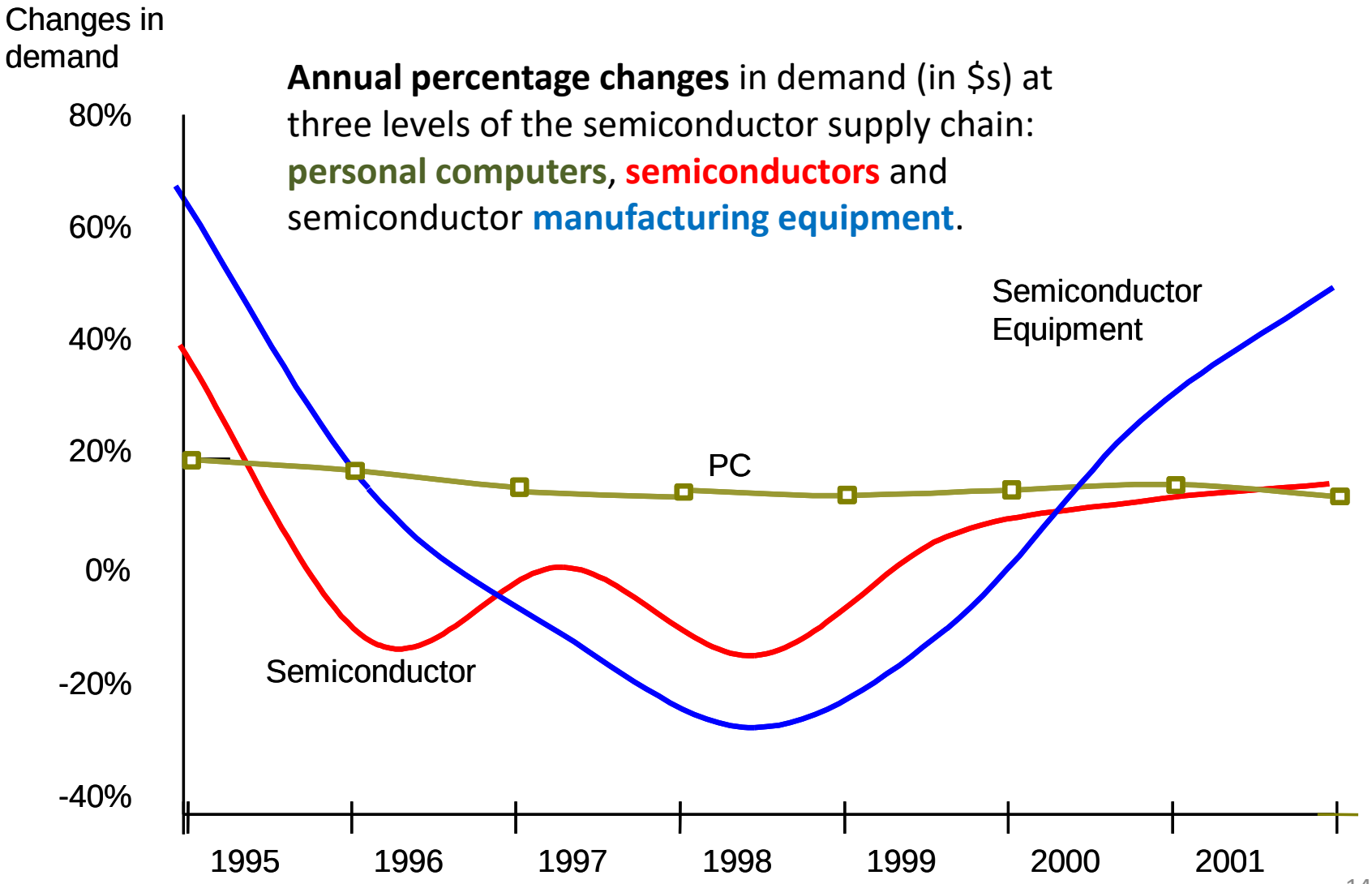
Order




Large swings at the tip

Small perturbation at the handle

# Another Bullwhip Effect Example: US PC Supply Chain



# Why is the bullwhip effect bad?

- Inefficient production or excessive inventory
- Necessity to have capacity far exceeding average demand
- Poor customer service due to stock outs

What causes the bullwhip effect?

# Forecasting Updates and Lead Time Delays

- **Every company forecasts its demand myopically**
  - The company sees fluctuations in demand caused by the bullwhip effect from downstream, company orders accordingly, creating further swings for the upstream suppliers.
- **Lead Time Delays and Variation**
  - Upstream companies may overreact to demand variations.

# Forecasting Updates and Lead Time Delays

- **Avoid misleading forecast updates**
  - Share demand info throughout SC (EDI, electronic data interchange)
  - Increase visibility of inventory throughout SC (VMI)
  - Develop trust and good working relationships
- **Reduce Lead Times**

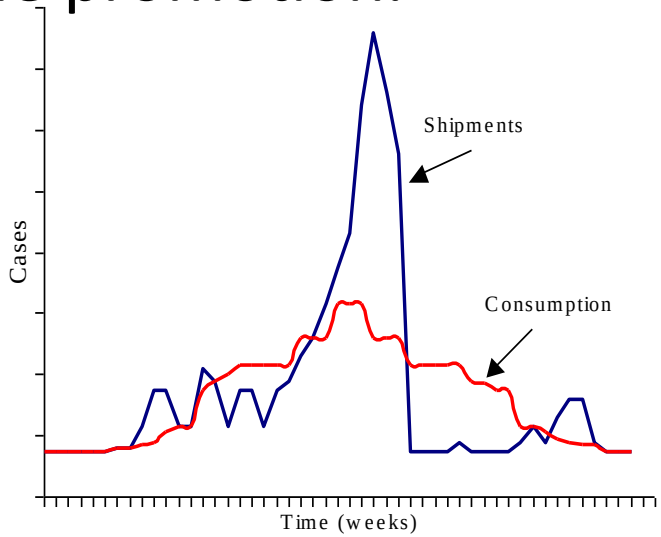
# Order batching

- To reduce ordering cost (transaction cost, fixed transportation cost), upstream suppliers order in batch. (EOQ)

- Reduce/Eliminate fixed costs (EOQ quantity)
  - Reduce transaction costs through various forms of electronic ordering

# Price fluctuations (trade promotions) and forward buying

- Supplier gives retailer a temporary discount, called a **trade promotion.**
- Retailer purchases enough to satisfy demand until the next trade promotion.



Total shipments and consumption

- Stabilize prices; avoid trade or price promotions

# Rationing and Shortage gaming

- Setting (one supplier faces multiple buyers): Retailers submit orders for delivery in a future period. Supplier produces. If supplier production is less than orders, orders are rationed.
- To secure a better allocation, the **retailers inflate their orders**, i.e., order more than they need…
- … So retailer orders do not convey good information about true demand.

- Eliminate gaming and shortage situations
  - Encourage retailers to share demand information
  - Allocate orders based on past usage, not on present

# The Bullwhip Effect

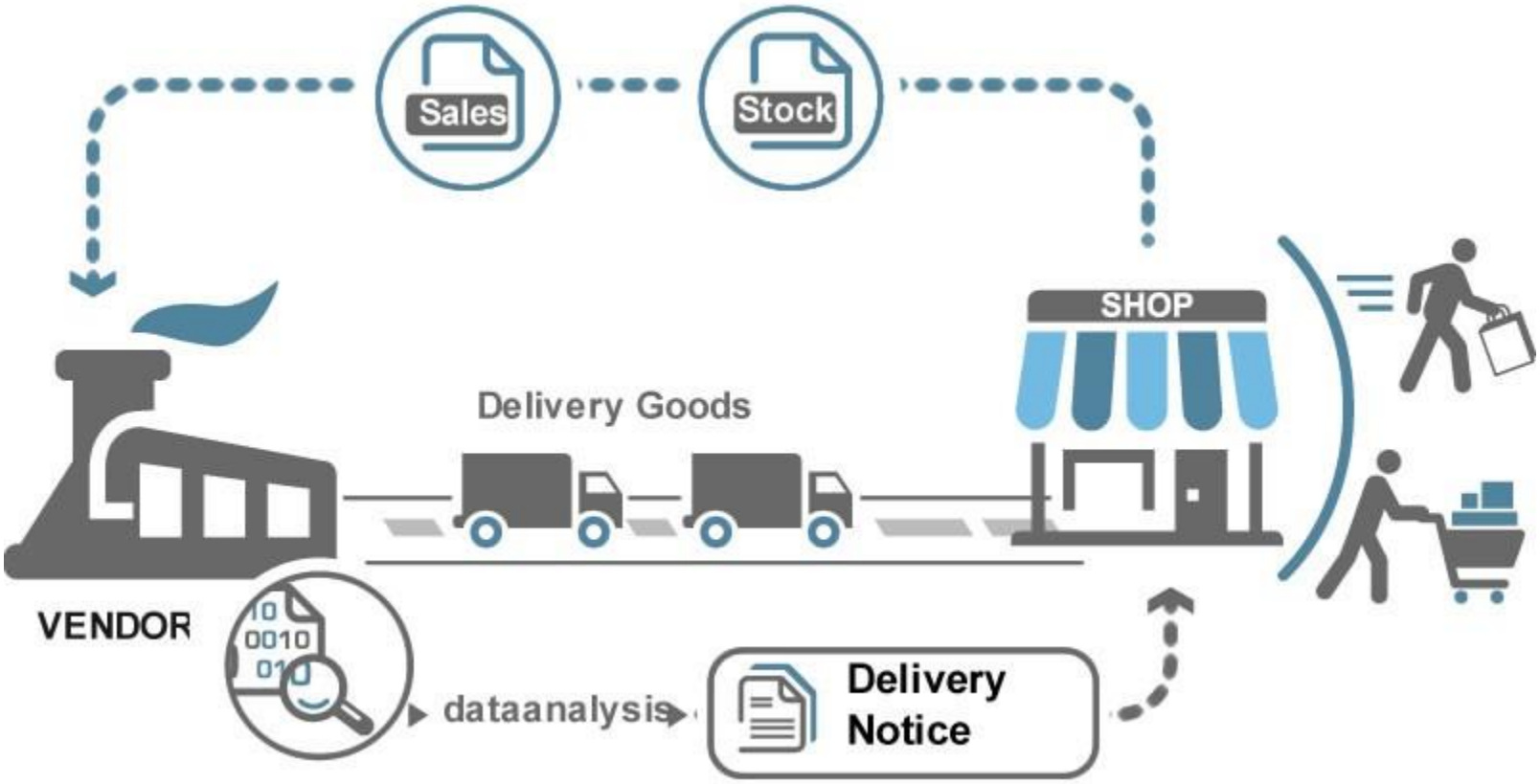
The variance of orders is greater than that of sales, and the distortion increases as one moves upstream in the supply chain

| Causes | |
|---|---|
| **Forecasting Updates and Lead Time Delays** | **Avoid misleading forecast updates**<br>– Share demand info throughout SC<br>– Increase visibility of inventory throughout SC<br>– Develop trust and good working relationships |
| | **Reduce lead times** |
| **Order Batching** (Fixed Costs) | **Reduce/Eliminate fixed costs** |
| **Price Fluctuations** ("Forward Buying") | **Stabilize prices; avoid trade or price promotions** |
| **Rationing and Shortage Gaming** | **Eliminate gaming and shortage situations** |

# Reducing the Bullwhip Effect

- Campbell Soup (CS) established electronic data exchange links with its retailers
- After CS started to receive demand information electronically, the retailers' weeks in inventory decreased from 4 weeks to 2 weeks
- This led to decrease in retailers' inventory costs and they became more incentivized to carry CS products

# Information sharing: Vendor Managed Inventory



# Vendor Managed Inventory : Success Story


https://www.datalliance.com/writable/resources/CGT_Datalliance_PG.pdf

# Reducing the Bullwhip Effect (cont.)

- In a VMI, or Continuous Replenishment
  - The retailer no longer decides when and how much inventory to order.
  - The retailer and supplier jointly agree on objectives (e.g., service levels), and the supplier "manages" the retailer's inventory
  - Relevant sales data is shared
  - Supplier and retailer eliminate trade promotions

# Vendor Managed Inventory: Failure Story

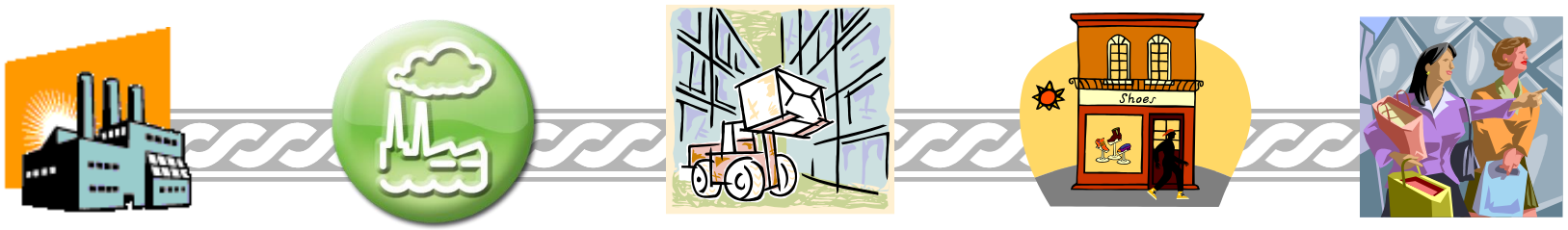
- Spartan Stores (now SpartanNash), a grocery chain, shut down its VMI effort about one year after its inception.


- Buyers
  - didn't trust the suppliers enough
  - Stop carefully monitor inventories and intervene at the slightest hint of trouble
- Suppliers
  - didn't do much to allay buyers' fears
  - didn't do as effective a job as buyers


The buyer and supplier do not have a jointly agreed objectives

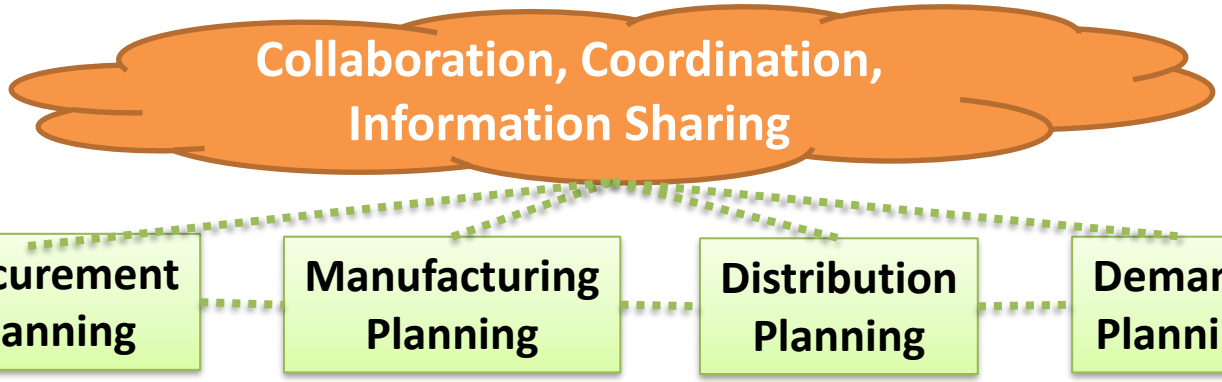
# Remedy of Bullwhip Effect: Global Planning

- Sequential Planning




- Global Planning

Zara, and Amazon




Corporate strategy: Vertical Integration

# Other Supply Chain Challenge: Incentive Conflicts

- Notwithstanding improved information sharing in the supply chain, there may be incentive conflicts among supply chain members

- Solution?
  - Profit sharing

# Incentive Misalignment:


- Rent DVD/VCDs from Blockbuster store to watch movies.
- In the summer of 1997, movie fans flocked to their local Blockbuster, only to find that all ten copies had already been checked out.
- At $60 a copy, Blockbuster couldn't afford to stock the number of movies it needed. (At $3 per rental, Blockbuster had to rent a movie at least 20 times!)
- Its suppliers, the movie studios, had to charge $60 to earn enough revenue themselves.
- No one – not the suppliers, not the retailer, nor the customers – was happy.

Optional reading: Turning the Supply Chain into a Revenue Chain, by Cachon and Lariviere, Harvard Business Review, March 2001.

# BB's solution: Revenue Sharing

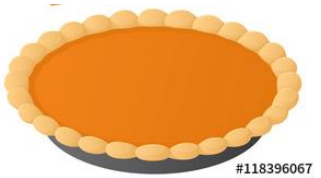
- In 1998, Blockbuster agreed to give the studios 50% of rental fees in return for $9 movie prices.

- How does revenue sharing affect Blockbuster?
  - Blockbuster keeps half of the revenue ($1.5 per rental), but it breaks even after each tape has been rented 6 times. Blockbuster purchase more tapes to satisfy more customers, which means higher profit.
- How does revenue sharing affect studio?
  - The studio also has higher profit from increased tape sales and the revenue share.
- Who wins?
  - Everyone: Blockbuster and Studio gain more revenue, and more customers are satisfied due to higher service level.

# Turning the Supply Chain into a Revenue Chain: Revenue Sharing Contract

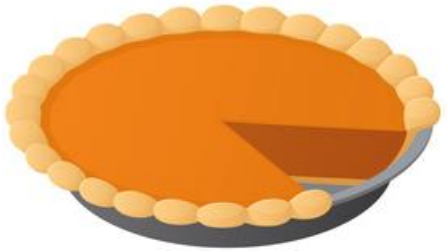
**FOR THE RETAILER**

| | Traditional Pricing | Revenue Sharing |
|---|---|---|
| A. Number of tapes purchased | 10 | 30 |
| B. Price per tape | $60 | $9 |
| C. Purchase cost | $600 | $270 |
| D. Number of rentals | 300 | 500 |
| E. Total rental revenue (D × $3/rental) | $900 | $1,500 |
| F. Retailer's share of rental revenue | $900 (100%) | $750 (50%) |
| G. Retailer's profit | $300 | $480 |
| H. Profit per dollar of inventory | $0.50 | $1.78 |




**FOR THE SUPPLIER**

| | Traditional Pricing | Revenue Sharing |
|---|---|---|
| I. Number of tapes purchased | 10 | 30 |
| J. Price per tape | $60 | $9 |
| K. Revenue from selling tapes | $600 | $270 |
| L. Number of rentals | 300 | 500 |
| M. Total rental revenue (L × $3/rental) | $900 | $1,500 |
| N. Supplier's share of rental revenue | $0 (0%) | $750 (50%) |
| O. Supplier's total revenues | $600 | $1,020 |
| P. Supplier's production and distribution cost (I × $10/tape) | $100 | $300 |
| Q. Supplier's profit | $500 | $720 |



# NetFlix: DVD Rentals and Streaming Video

- Netflix has a similar revenue-sharing agreement for its DVD rentals with most studios in exchange for the opportunity to purchase new releases at production cost:
  - Blockbuster (rent in store), Netflix (rent by mail)
  - Allows Netflix to purchase more copies on a title and better meet demand without substantial capital investment of full ownership
  - After revenue-share period expires, the agreement generally grants Netflix the right to acquire the units at low cost
  - **Subscription model: customer usually use less times than they expect. Netflix needs a large amount of movies, it helps them to get a better revenue sharing contract with movie studios.**

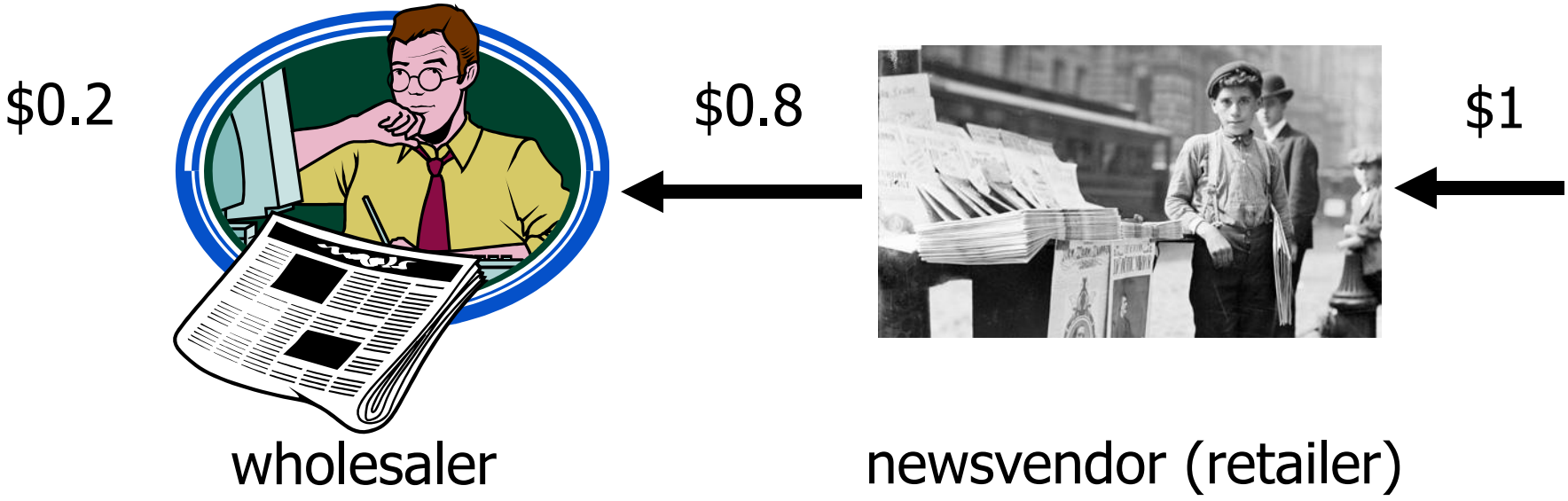
- However, for streaming movies and TV shows online Netflix pays a one-time licensing fee:
  - E.g. Netflix recently paid CBS $200M for the right to stream a large number of recent and classic TV shows
  - There is no stocking problem for streaming video, so a revenue sharing contract is not necessary.

# Newsvendor Logic in Supply Chain Incentive Conflict

- A newsvendor (retailer) stocks newspapers to sell that day
- Usual newsvendor tradeoffs:
  - If stocks too few newspapers, misses potential sales.
  - If stocks too many newspapers, money wasted on unsold newspapers.

# Selling to Newsvendor

- Suppose you are a wholesaler
- Your cost is 20 cents /newspaper
- You charge the retailer 80 cents /newspaper
- Newsvendor sells to customers at $1/newspaper



# Supply Chain Incentives

- How many newspapers will the retailer purchase?
- Retailer figures out that

  $C_u$ = 1–0.8= $ 0.2

  $C_o$ = $ 0.8
- Retailer wants to maximize his own profit, so he purchase Q newspapers so that

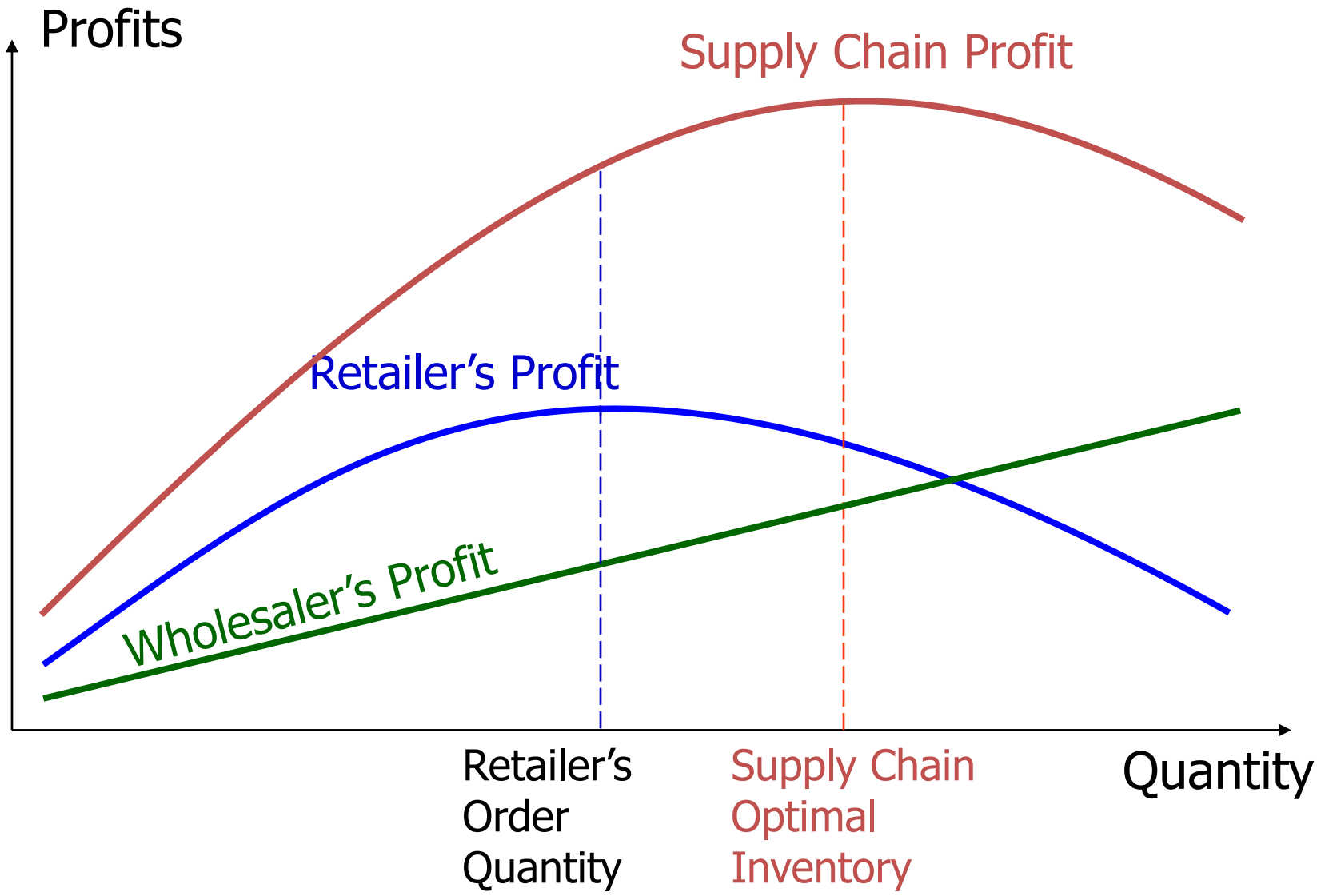
  $P(D \le Q) = C_u / (C_u+C_o)$ = SL* = 0.2
- What if the retailer and the wholesaler decide to maximize their total profit?

  $C_u$ = 1–0.2= $ 0.8

  $C_o$ = $ 0.2
- They should purchase $Q^*$ newspapers so that

  $P(D \le Q^*) = C_u / (C_u+C_o)$ = SL* = 0.8

# No Coordination vs. Centralization



# Coordinating the Supply Chain

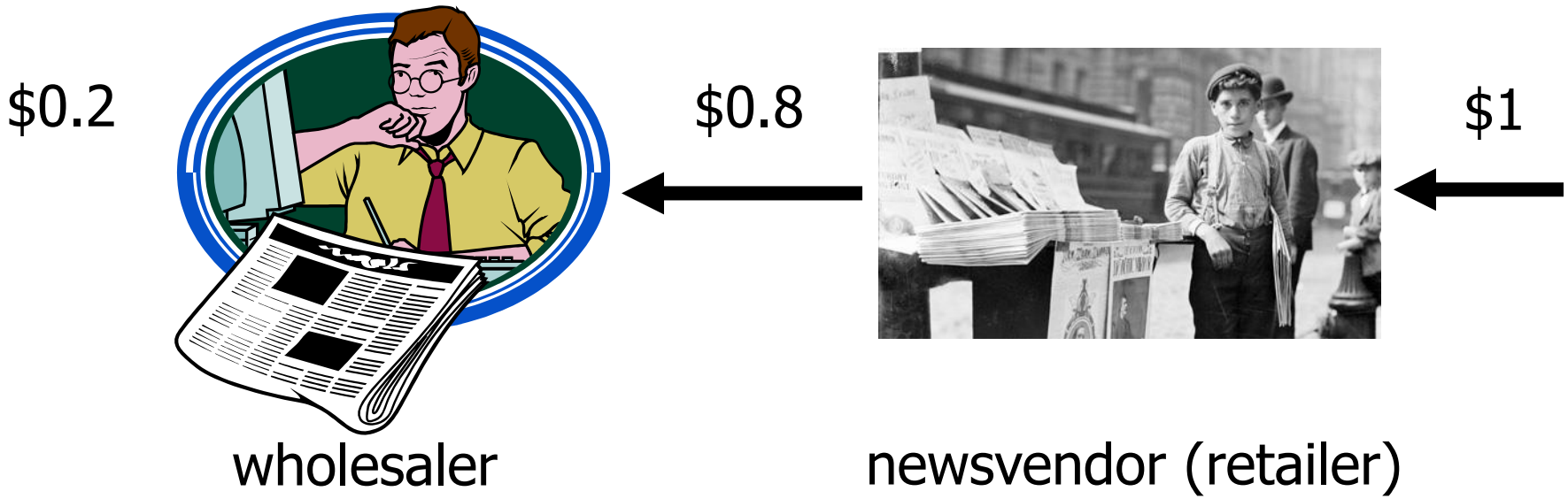
- Wholesaler wants to "induce" retailer to purchase more newspapers.
- Wholesaler agrees to "buy-back" unsold newspapers at price \$0.6/newspaper
- How many newspapers will the retailer purchase?
- Retailer figures out that

  $C_u$ = 1 – 0.8 = \$0.2

  $C_o$ = 0.8–0.6 = \$0.2
- Retailer wants to maximize his own profit, so he purchase Q newspapers so that

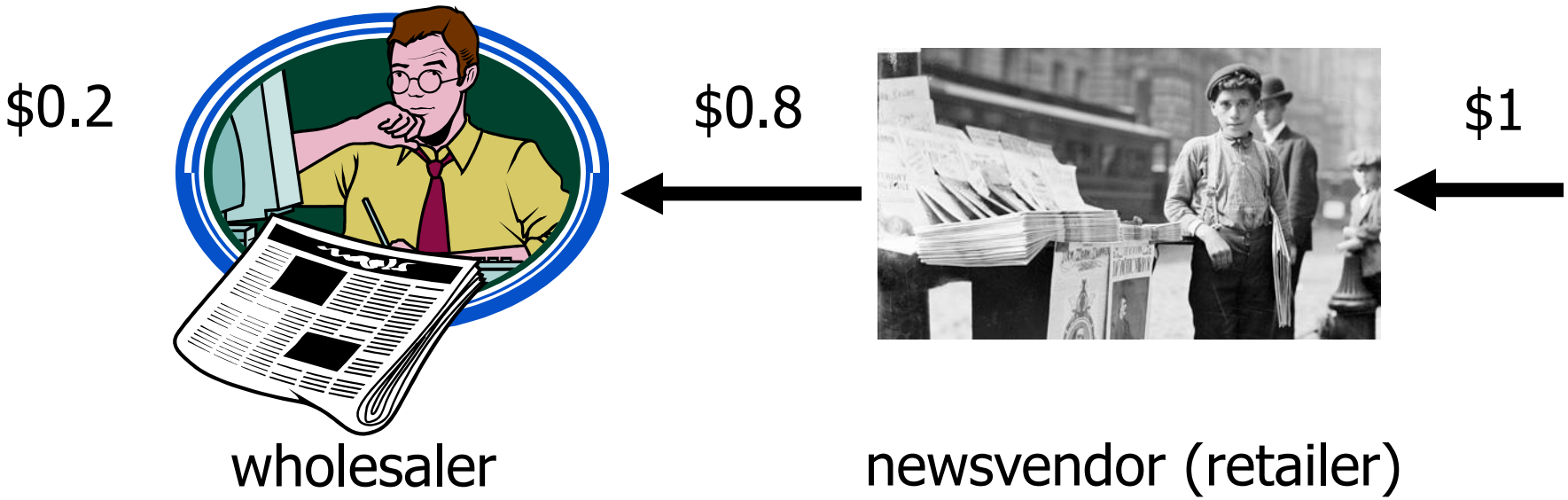
  $P(D \le Q) = C_u / (C_u + C_o)$ = SL* = 0.5

# Coordinating the Supply Chain




- Wholesaler agrees to "buy-back" unsold newspapers at price $b/newspaper
- Practice: Find a buy-back rate that induces the retailer to purchase $X = Q^*$ (optimal for the supply chain)

# Coordinating the Supply Chain




- Wholesaler agrees to "buy-back" unsold newspapers at price $b/newspaper
- Find a buy-back rate that maximize the wholesaler's profit.

# Example: Buy-back Contract

- Demand: Normally distributed, mean = 500, st dev = 100

| Buy-back Price | Q | Wholesaler Profit | Retailer Profit | Supply Chain Profit |
|---|---|---|---|---|
| **0** | **416** | **249.50** | **72.00** | **321.51** |
| 0.1 | 424 | 252.84 | 73.20 | 326.04 |
| 0.2 | 433 | 256.55 | 74.58 | 331.13 |
| 0.3 | 443 | 260.70 | 76.21 | 336.90 |
| 0.4 | 457 | 265.36 | 78.18 | 343.54 |
| 0.5 | 475 | 270.55 | 80.68 | 351.23 |
| 0.6 | 500 | 276.06 | 84.04 | 360.11 |
| 0.7 | 543 | 280.29 | 89.09 | 369.38 |
| 0.71 | 549 | **280.40** | 89.76 | 370.16 |
| 0.72 | 557 | 280.38 | 90.48 | 370.86 |
| 0.73 | 565 | 280.18 | 91.26 | 371.44 |
| 0.74 | 574 | 279.75 | 92.09 | 371.84 |
| 0.75 | 584 | 279.00 | 93.00 | **372.00** |
| 0.76 | 597 | 277.79 | 94.00 | 371.79 |
| 0.77 | 612 | 275.85 | 95.12 | 370.98 |
| 0.78 | 634 | 272.67 | 96.40 | 369.07 |
| 0.79 | 667 | 266.74 | **97.92** | 364.66 |

# Buyback Contract

- Advantages:
  - Affect supply chain inventory by reducing retailer overage costs (risk sharing)

- Limitations
  - Transaction cost (Negotiation for buyback contract)
  - Shipping cost (for returns)
  - Sales effort for retailer to sell more

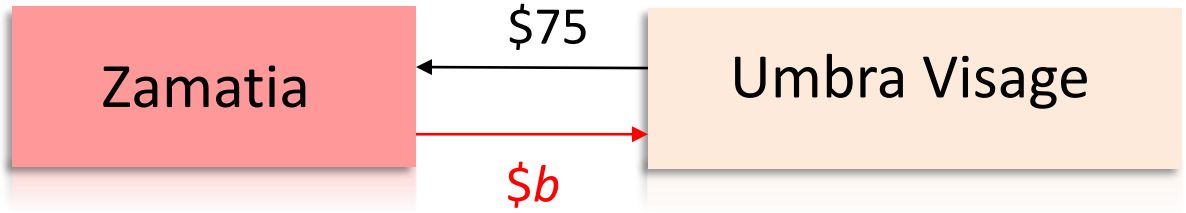
Zamatia ← $75 — Umbra Visage

Manufacturing cost = $35

Retail price = $115

Salvage value = $25

- U.V.'s newsvendor problem
  - $C_u$ = $115-75 = $40, $C_o$ = $75-25 = $50, SL* = 40/90 = 44%
- What is optimal for entire supply chain?
  - $C_u$ = $115-35 = $80, $C_o$ = $35-25 = $10, SL* = 80/90 = 89%



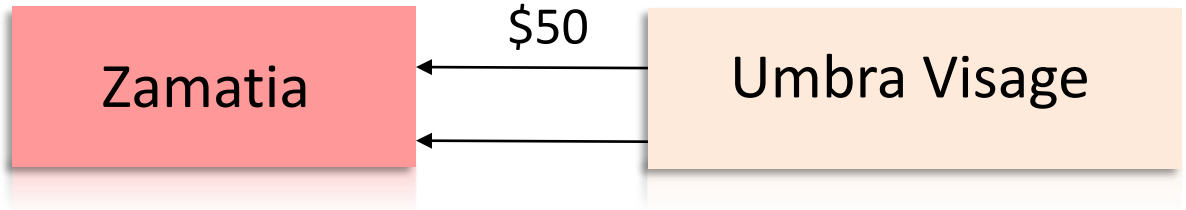

Manufacturing cost = $35

Retail price = $115

Salvage value = $25

- Zamatia offers to buy-back unsold glasses at *b* per unit. And UV incurs $1.5 cost to ship sunglasses back
  - $C_u$ = $40 (same as before); $C_o$ = $\underline{\$75 - (b\text{-}\$1.5)}$
- Is there a *buy-back price* wherein Zamatia can induce U.V. to act optimally for the entire supply chain? (U.V. achieves the service level that is optimal for the supply chain)

$$89\% = \frac{40}{40 + (75 - (b - 1.5))} \qquad \text{So, } b = \$71.50.$$




Revenue Sharing 20%

Retail price = $115

Salvage value = $25

- U.V.'s newsvendor problem
  - $C_u$ = $115*80%-50 = $42, $C_o$ = $50-25 = $25, SL* = 42/67= 63%