The motivation for Optimizing the Supply Chain

Reality check: Logistics in the Manufacturing Firm

- Profit 4%
- Logistics Cost 21%
- Marketing Cost 27%
- Manufacturing Cost 48%

$ spent on Logistics in the Economy (1990, 1996)

- Freight Transportation Billion — $352, $455
- Inventory Expense Billion — $221, $311
- Administrative Expense Billion — $27, $31
- Logistics Related Activity — 11%, 10.5% of GNP

Source: Cass Logistics

Supply Chain Management: The Potential

- It is estimated that the US grocery industry could save $30 billion (10% of operating cost) by using effective logistics and supply chain strategies
  - A typical box of cereal spends 104 days from factory to sale
  - A typical car spends 15 days from factory to dealership
- Laura Ashley turns its inventory 10 times a year, five times faster than 3 years ago

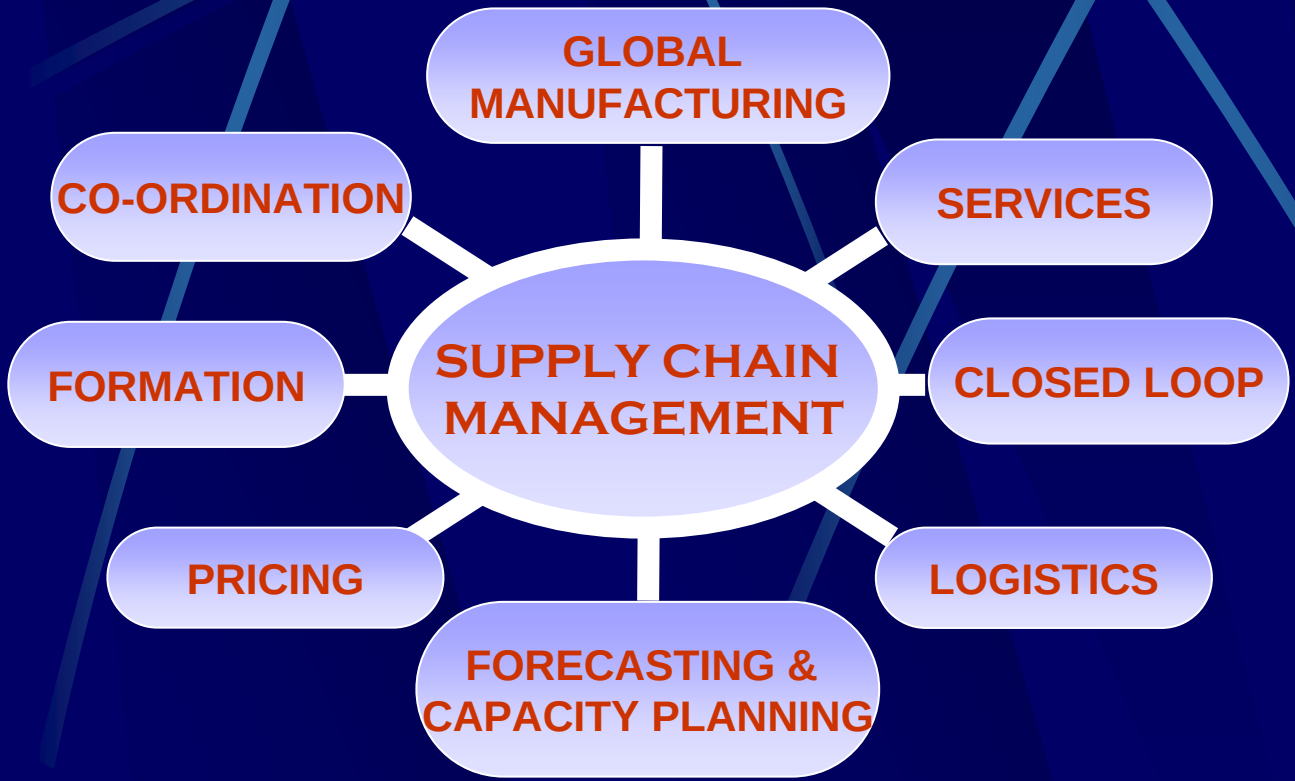
Key Challenge in SCM

Design a supply chain network that delivers high quality products to the right customers at the right time at minimum cost

Mismanaged Supply Chains: How they affect competitiveness

- Compaq estimated it lost $.5 billion to $1 billion in sales in 1995 because laptops were not available when and where needed
- P&G estimates it saved retail customers $65 million by collaboration, resulting in a better match of supply and demand

A Glimpse of what is to come today…



- Nonlinear optimization
- Simulation
- MIP models
- Mechanism Design
- Network flow models

Why bother about Supply Chains?

- Supply Chain Optimization leads to significant competitive advantages
- Collaboration occurs in planning, forecasting and replenishment
- SCM integrates supply and demand management within and across firms
  - → reduces cycle times and enhances responses throughout

Essentials of the Supply Chains

Benefits

reduce uncertainty and risks in the supply chain

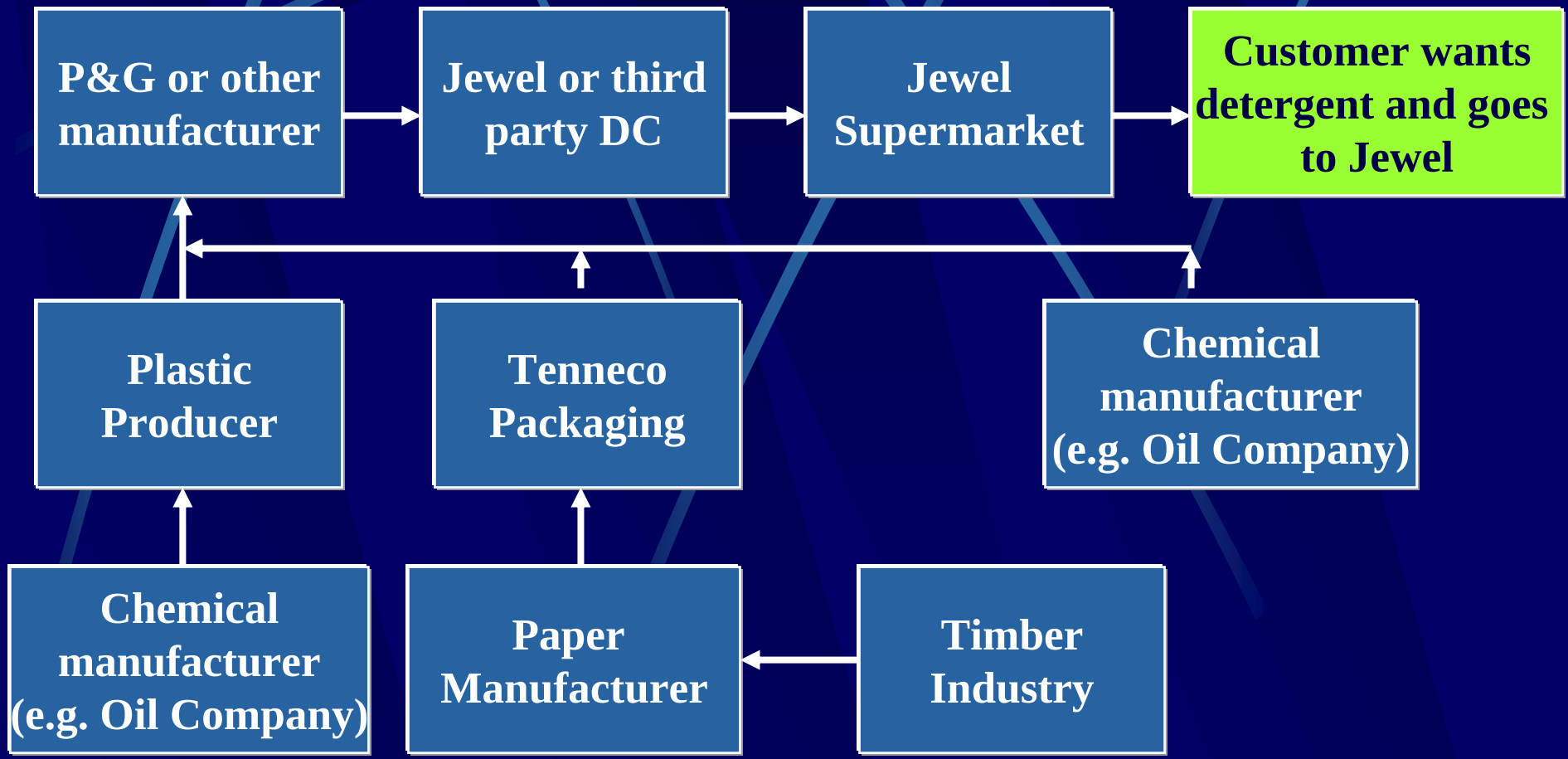
positively affecting inventory levels, cycle time, business processes, and customer service

increase profitability and competitiveness

What is a Supply Chain?

- *All* stages involved, directly or indirectly, in fulfilling a customer request
- Includes manufacturers, suppliers, transporters, warehouses, retailers, and customers
- *Within* each company—
  - all functions involved in fulfilling a customer request (product development, marketing, operations, distribution, finance, customer service)
- Examples:
  - Detergent supply chain (Wal-Mart—next slide),
  - Dell

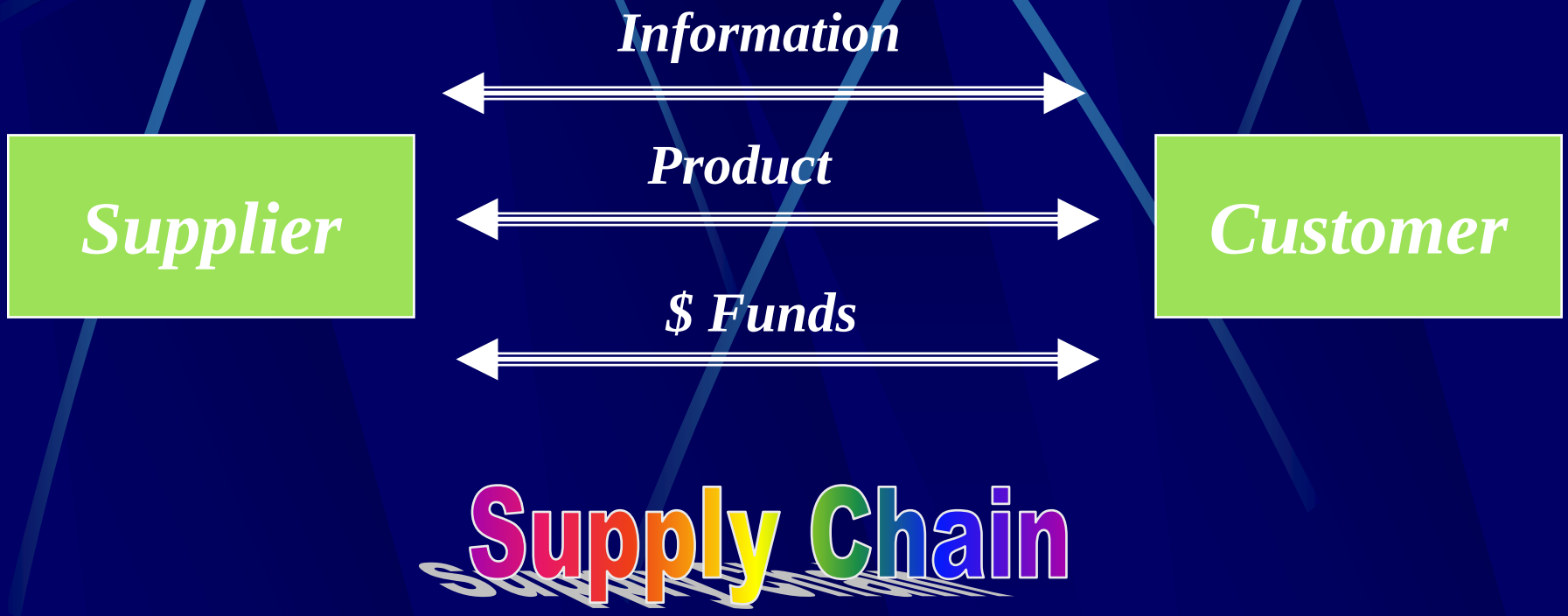
Supply Chain?
…from Oil to Detergent



What is a Supply Chain?

- Customer an integral part of the supply chain
- Includes movement of products suppliers → manufacturers → distributors, also movement of information, funds, and products in both directions
- More accurate to call it “supply network” or “supply web”
- Typical supply chain stages: customers, retailers, distributors, manufacturers, suppliers
- All stages may not be present in all supply chains (eg, no retailer or distributor for Dell)

Flows in a Supply Chain



The Objective of Optimizing the Supply Chain

- Maximize overall value created
  - Supply chain value: difference between what the **final product is worth** to the customer and the **effort** the supply chain expends in filling the customer's request
  - Value is correlated to supply chain profitability (difference between revenue generated from the customer and the overall cost across the supply chain)

Example of a Supply Chain's Objective

- Example: Dell receives $2000 from a customer for a computer (revenue)
- Supply chain incurs costs (information, storage, transportation, components, assembly, etc.)
- Difference between $2000 and the sum of all of these costs is the supply chain profit
- Supply chain profitability is **total profit to be shared** across all stages of the supply chain → **Dell's Laptops cost less for identical features**

→ Supply chain success should be measured by total supply chain profitability, not profits at an individual stage

Total Supply Chain Profitability is the Goal

- Sources of supply chain revenue: the customer
- Sources of supply chain cost: flows of information, products, or funds between stages of the supply chain
- ***SCM is the management of flows between and among supply chain stages to maximize total supply chain profitability***

Decision Phases of a Supply Chain

- Supply chain strategy or design
- Supply chain planning
- Supply chain operation

Optimization opportunities exist in each phase

Supply Chain Strategy for Design

- Decisions about the structure of the supply chain and what processes each stage will perform
- Strategic supply chain decisions
  - **Locations** and **capacities** of facilities
  - **Products** to be made or **stored** at various locations
  - **Modes** of transportation
  - **Information** systems
- Supply chain design must support strategic objectives
- Supply chain design decisions are long-term and expensive to reverse – must take into account market uncertainty

Supply Chain Planning

- Spells out a set of policies that govern short-term operations
- Fixed by the supply configuration from previous phase
- Starts with a forecast of demand in the coming year

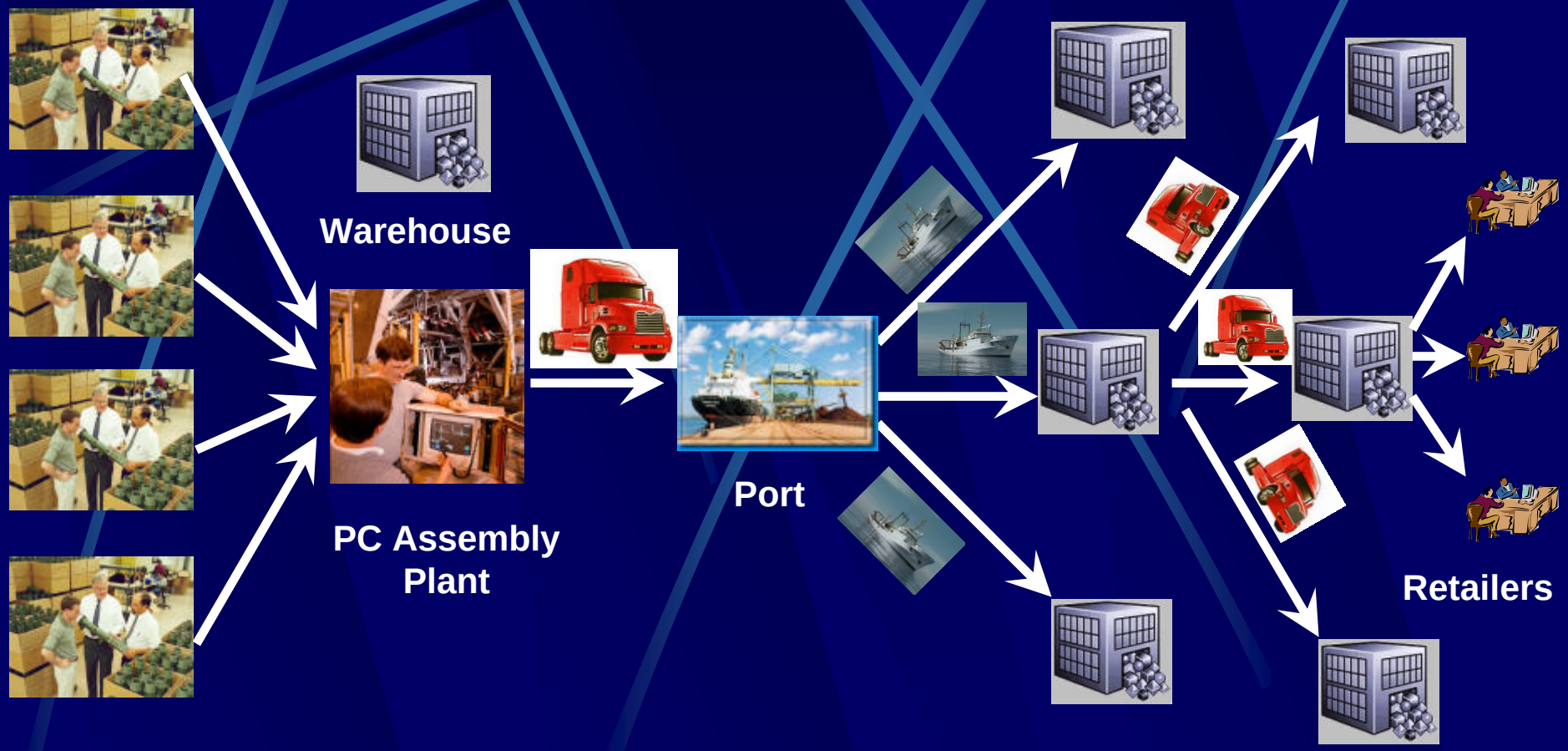
Supply Chain Planning

- Planning decisions:
  - Which markets will be supplied from which locations ← **Optimization**
  - Planned buildup of inventories ← **Optimization**
  - Subcontracting, backup locations
  - Inventory policies ← **Optimization**
  - Timing and size of market promotions
- Must consider in planning decisions demand uncertainty, exchange rates, competition over the time horizon

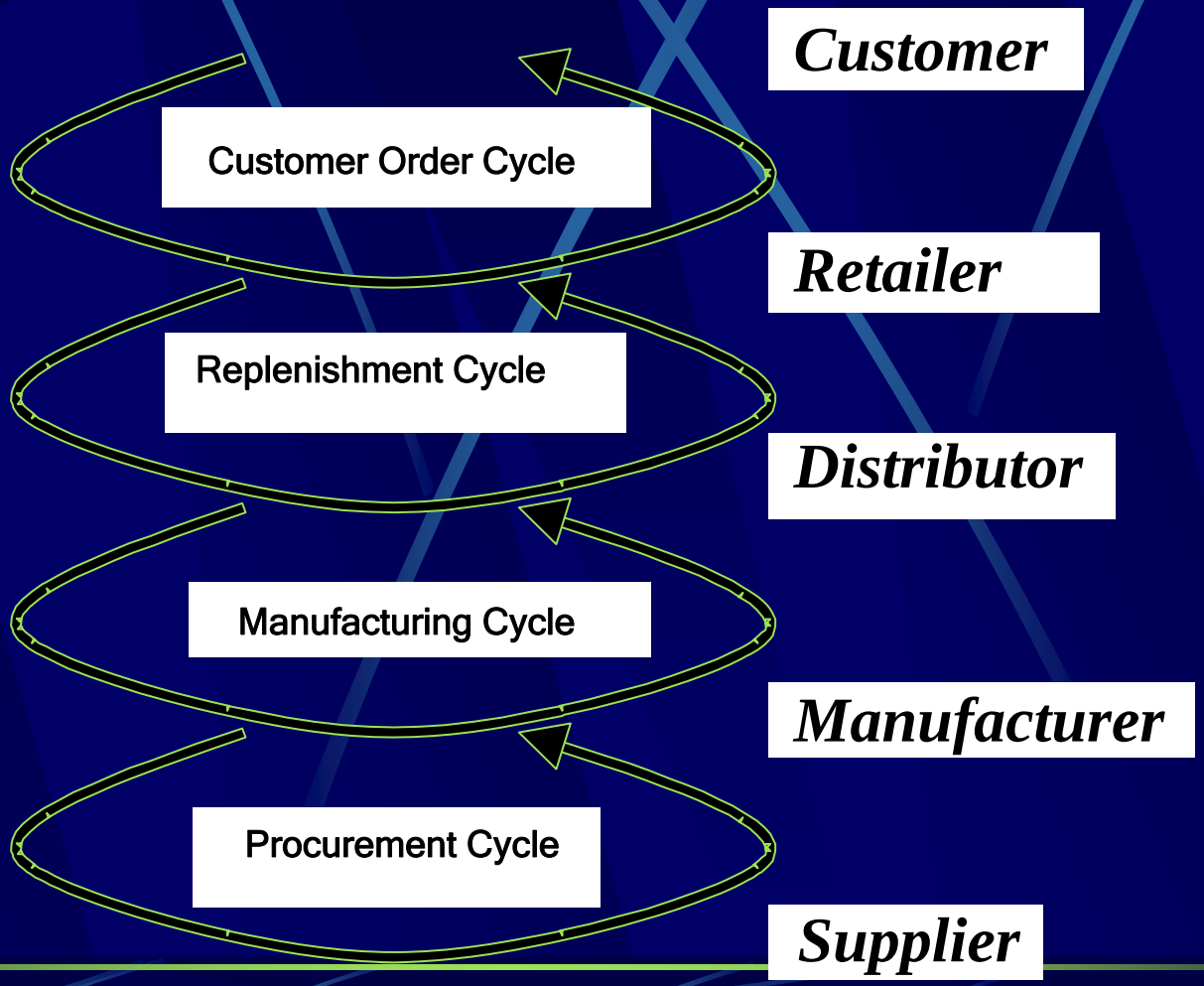
Process View of a Supply Chain

- **Cycle view**: processes in a supply chain are divided into a series of cycles, each performed at the interfaces between two successive supply chain stages
- **Push/pull view**: processes in a supply chain are divided into two categories depending on whether they are executed in response to a customer order (**pull**) or in *anticipation* of a customer order (**push**)

Example of a Typical Supply Chain: IBM Europe PC Supply Chain



Cycle View of Supply Chains



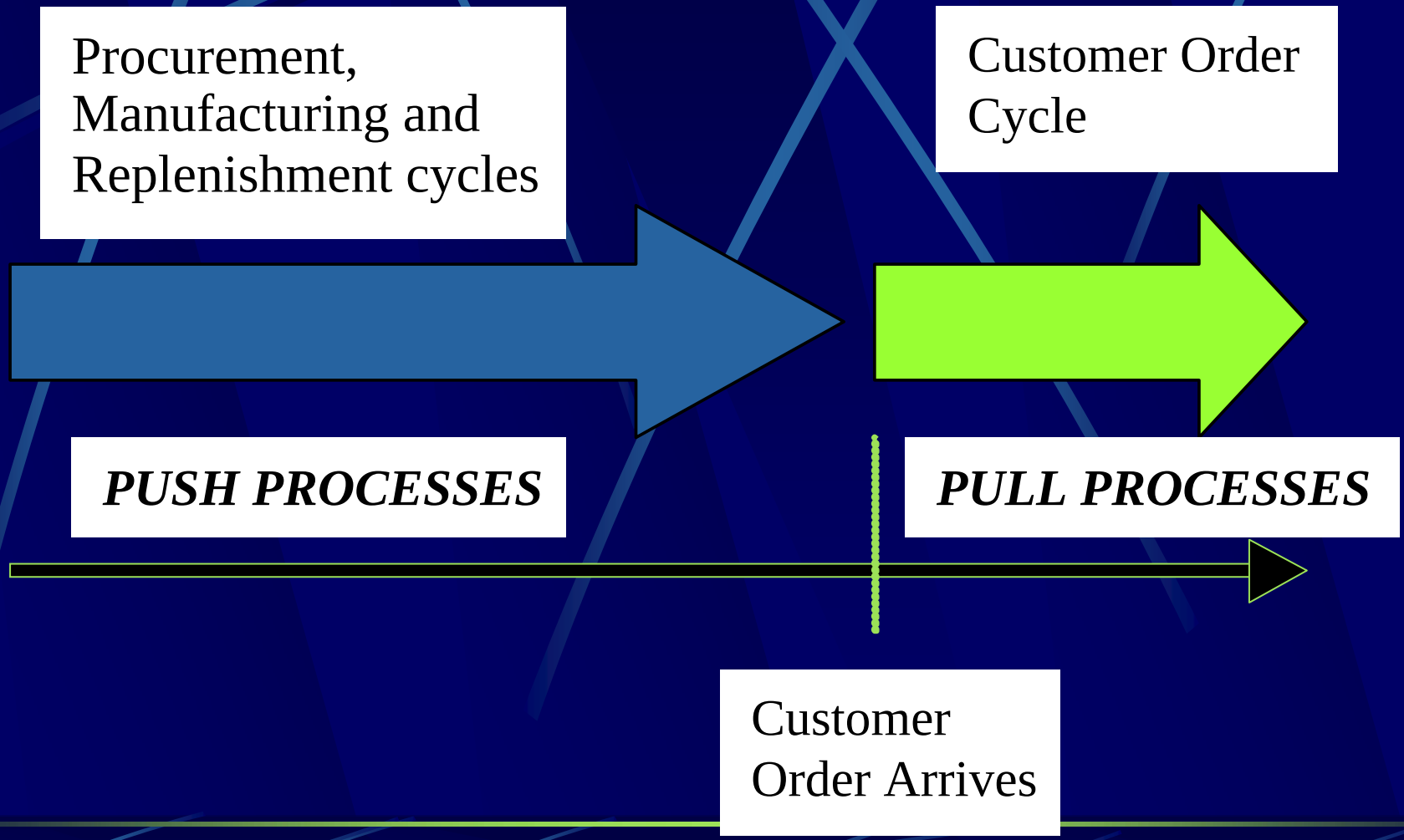
Cycle View of a Supply Chain

- Each cycle occurs at the interface between two successive stages
- Customer order cycle (customer-retailer)
- Replenishment cycle (retailer-distributor)
- Manufacturing cycle (distributor-manufacturer)
- Procurement cycle (manufacturer-supplier)
- Cycle view clearly defines processes involved and the owners of each process. Specifies the roles and responsibilities of each member and the desired outcome of each process.

Push/Pull View of Supply Chain Processes

- Supply chain processes fall into one of two categories depending on the timing of their execution relative to customer demand
- Pull: execution is initiated in response to a customer order (reactive)
- Push: execution is initiated in anticipation of customer orders (speculative)
- Push/pull boundary separates push processes from pull processes

Push/Pull View of Supply Chains



Push/Pull View of Supply Chain Processes

- Useful in considering strategic decisions relating to supply chain design – more global view of how supply chain processes relate to customer orders
- → Can combine the push/pull and cycle views
  - L.L. Bean
  - Dell
- The relative proportion of push and pull processes can have an impact on supply chain performance ← **Optimization opportunity**

Supply Chain Macro Processes in a Firm

- Supply chain processes discussed in the two views can be classified into (Figure 1.8):
  - Customer Relationship Management (CRM)
  - Internal Supply Chain Management (ISCM)
  - Supplier Relationship Management (SRM)
- Integration and Optimization among the above three macro processes is critical for effective and successful supply chain management

Examples of Optimization Issues in SCM

- 7 Eleven
- Toyota
- Amazon / Borders / Barnes and Noble

What are some key issues in these supply chains?

7-Eleven's Issues

- What factors influence decisions of opening and closing stores? Location of stores?
- Why has 7-Eleven chosen off-site preparation of fresh food?
- Why does 7-Eleven discourage direct store delivery from vendors?
- Where are distribution centers located and how many stores does each center serve? How are stores assigned to distribution centers?
- Why does 7-Eleven combine fresh food shipments by temperature?
- What point of sale data does 7-Eleven gather and what information is made available to store managers? How should information systems be structured?

Toyota's Issues

- Where should plants be located, what degree of flexibility should each have, and what capacity should each have?
- Should plants be able to produce for all markets?
- How should markets be allocated to plants?
- What kind of flexibility should be built into the distribution system?
- How should this flexible investment be valued?
- What actions may be taken during product design to facilitate this flexibility?

Amazon.com's Issues

- Why is Amazon building more warehouses as it grows? How many warehouses and where to be located?
- What advantages does selling books via the Internet provide? Are there disadvantages?
- Why does Amazon stock bestsellers while buying other titles from distributors?
- Does an Internet channel provide greater value to a bookseller like Borders or to an Internet-only company like Amazon?
- Should traditional booksellers like Borders integrate e-commerce into their current supply?
- For what products does the e-commerce channel offer the greatest benefits? What characterizes these products?

Drivers of Supply Chain Performance

- Facilities
  - places where inventory is stored, assembled, or fabricated
  - production sites and storage sites
- Inventory
  - raw materials, WIP, finished goods within a supply chain
  - inventory policies
- Transportation
  - moving inventory from point to point in a supply chain
  - combinations of transportation modes and routes
- Information
  - data and analysis regarding inventory, transportation, facilities throughout the supply chain
  - potentially the biggest driver of supply chain performance
- Sourcing
  - functions a firm performs and functions that are outsourced
- Pricing
  - Price associated with goods and services provided by a firm to the supply chain

Information

- Role in the supply chain
- Role in the competitive strategy
- Components of information decisions

Information: Role in the Supply Chain

- The connection between the various stages in the supply chain – allows coordination between stages
- Crucial to daily operation of each stage in a supply chain – e.g., production scheduling, inventory levels

Information: Role in the Competitive Strategy

- Allows supply chain to become more efficient and more responsive at the same time (reduces the need for a trade-off)
- Information technology
- What information is most valuable?
- Example 3.4: Andersen Windows
- Example 3.5: Dell

Components of Information Decisions

- Push (MRP) versus pull (demand information transmitted quickly throughout the supply chain)
- Coordination and information sharing
- Forecasting and aggregate planning
- Enabling technologies
  - EDI
  - Internet
  - ERP systems
  - Supply Chain Management software
- Overall trade-off: Responsiveness versus efficiency

What Value is Research in SCM?

The Bullwhip Effect in Supply Chains

Hau L. Lee • V. Padmanabhan • Seungjin Whang

Distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies: excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation, and missed production schedules. How do exaggerated order swings occur? What can companies do to mitigate them?

Not long ago, logistics executives at Procter & Gamble (P&G) examined the 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. At first glance, the variabilities did not make sense. While the consumers, in this case, the babies, consumed diapers at a steady rate, the demand order variabilities in the supply chain were amplified as they moved up the supply chain. P&G called this phenomenon the "bullwhip" effect. (In some industries, it is known as the "whiplash" or the "whipsaw" effect.)

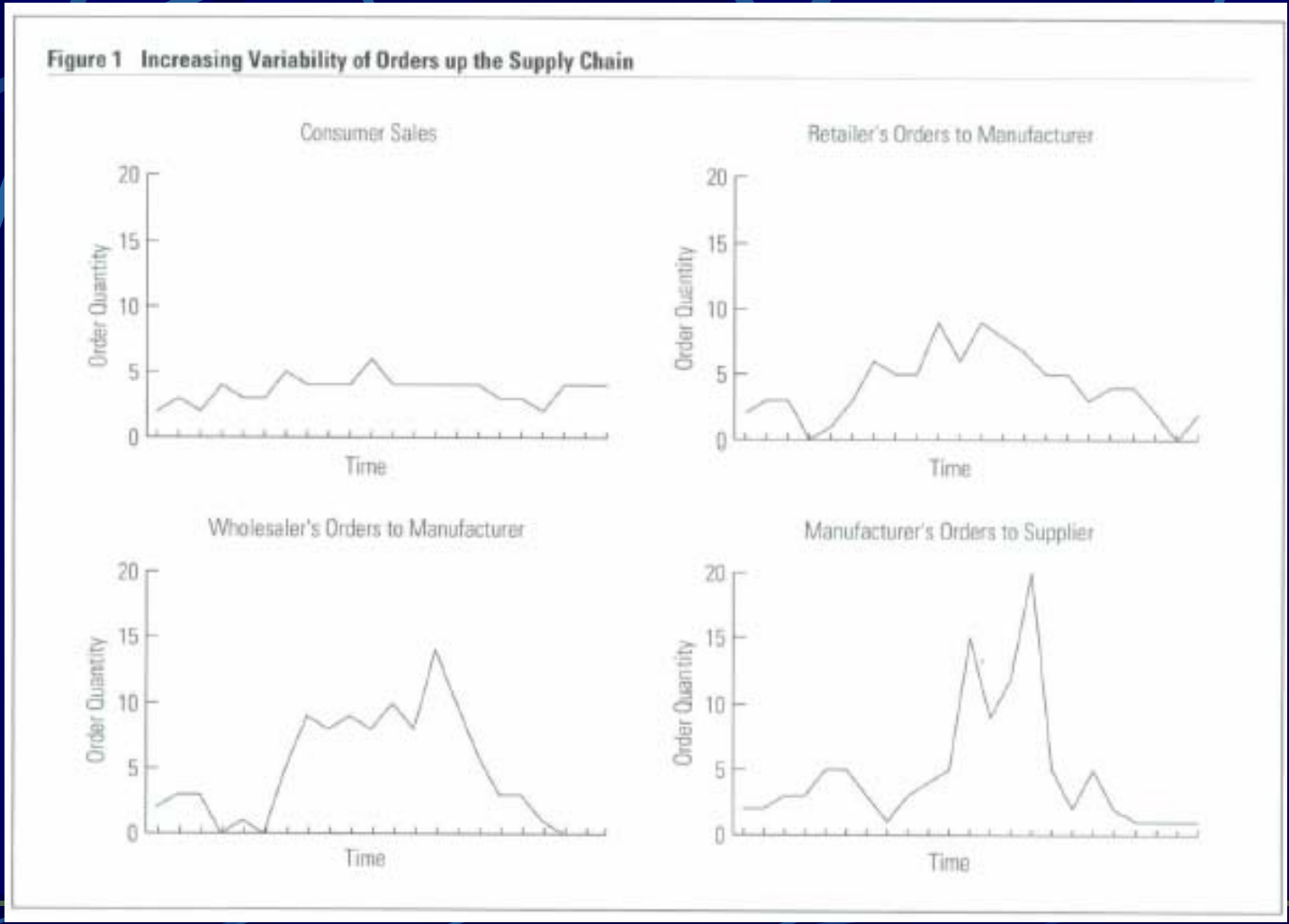
When Hewlett-Packard (HP) executives examined the sales of one of its printers at a major reseller, they found that there were, as expected, some fluctuations over time. However, when they examined the orders from the reseller, they observed much bigger swings. Also, to their surprise, they discovered that the orders from the printer division to the company's integrated circuit division had even greater fluctuations.

What happens when a supply chain is plagued with a bullwhip effect that distorts its demand information as it is transmitted up the chain? In the past, without being able to see the sales of its products at the distribution channel stage, HP had to rely on the sales orders from the resellers to make product forecasts, plan capacity, control inventory, and schedule production. Big variations in demand were a major problem for HP's management. The common symptoms of such variations could be excessive inventory, poor product forecasts, insufficient or excessive capacities, poor customer service due to unavailable products or long backlogs, uncertain production planning (i.e., excessive revisions), and high costs for corrections, such as for expedited shipments and overtime. HP's product division was a victim of order swings that were exaggerated by the resellers relative to their sales; it, in turn, created additional exaggerations of order swings to suppliers.

In the past few years, the Efficient Consumer Response (ECR) initiative has tried to redefine how the grocery supply chain should work.[1] One motivation for the initiative was the excessive amount of inventory in the supply chain. Various industry studies found that the total supply chain, from when products leave the manufacturers' production lines to when they arrive on the retailers' shelves, has more than 100 days of

Hau L. Lee is the Kleiner Perkins, Mayfield, Sequoia Capital Professor in Industrial Engineering and Engineering Management, and professor of operations management at the Graduate School of Business, Stanford University. V. Padmanabhan is an associate professor of marketing, and Seungjin Whang is an associate professor of operations information and technology, also at Stanford.

The Bull Whip Effect



What we observe

The ordering patterns share a common, recurring theme: the variabilities of an upstream site are always greater than those of the downstream site.

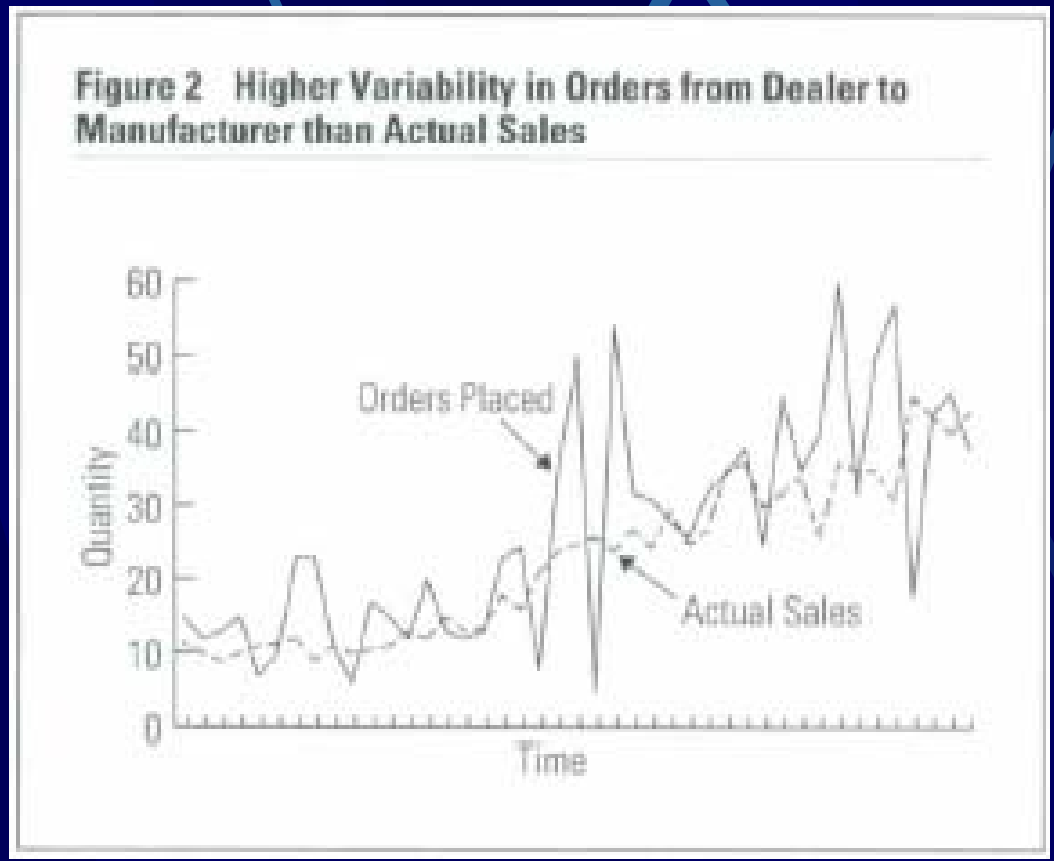
What Hau Lee's research revealed about Bull Whip Effect

We have identified four major causes of the bull-whip effect:

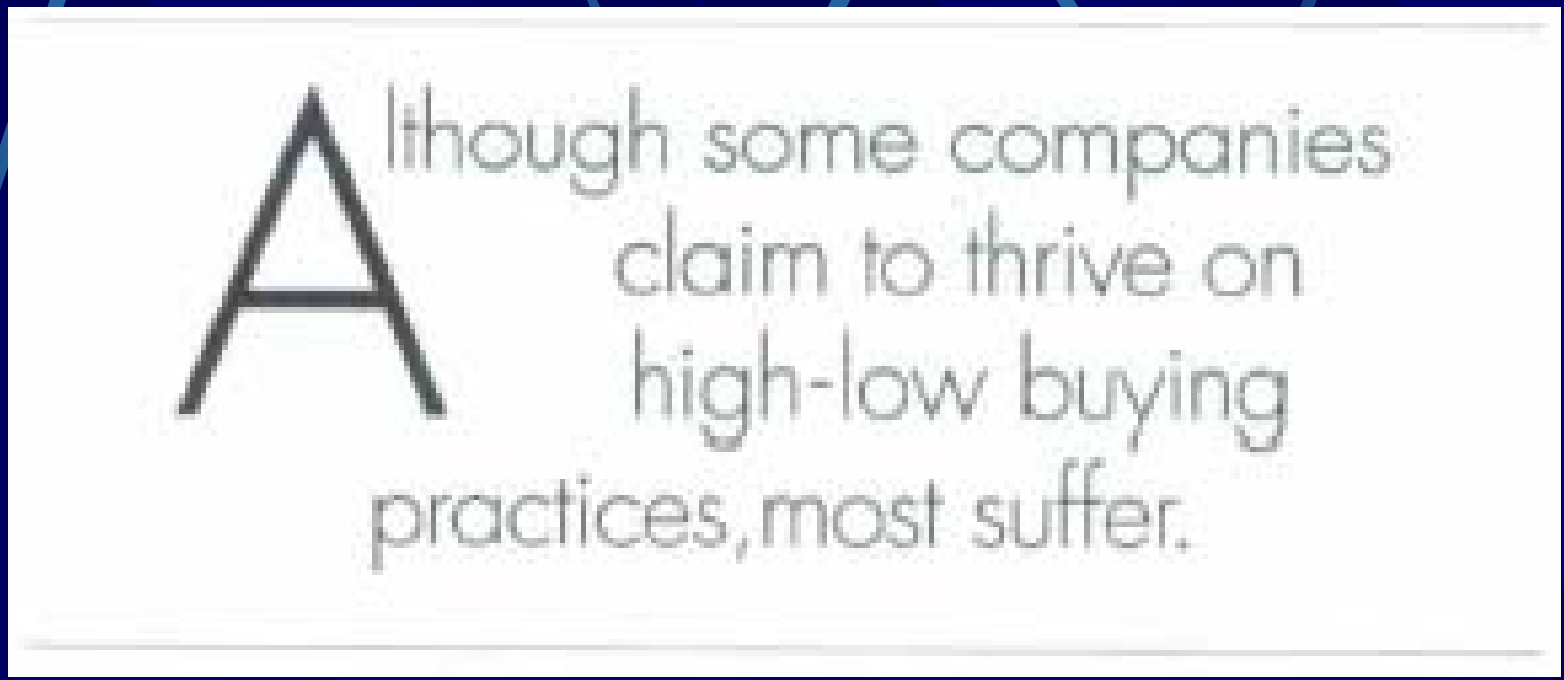
1. Demand forecast updating
2. Order batching
3. Price fluctuation
4. Rationing and shortage gaming

Sloan Management Review, Spring 1997

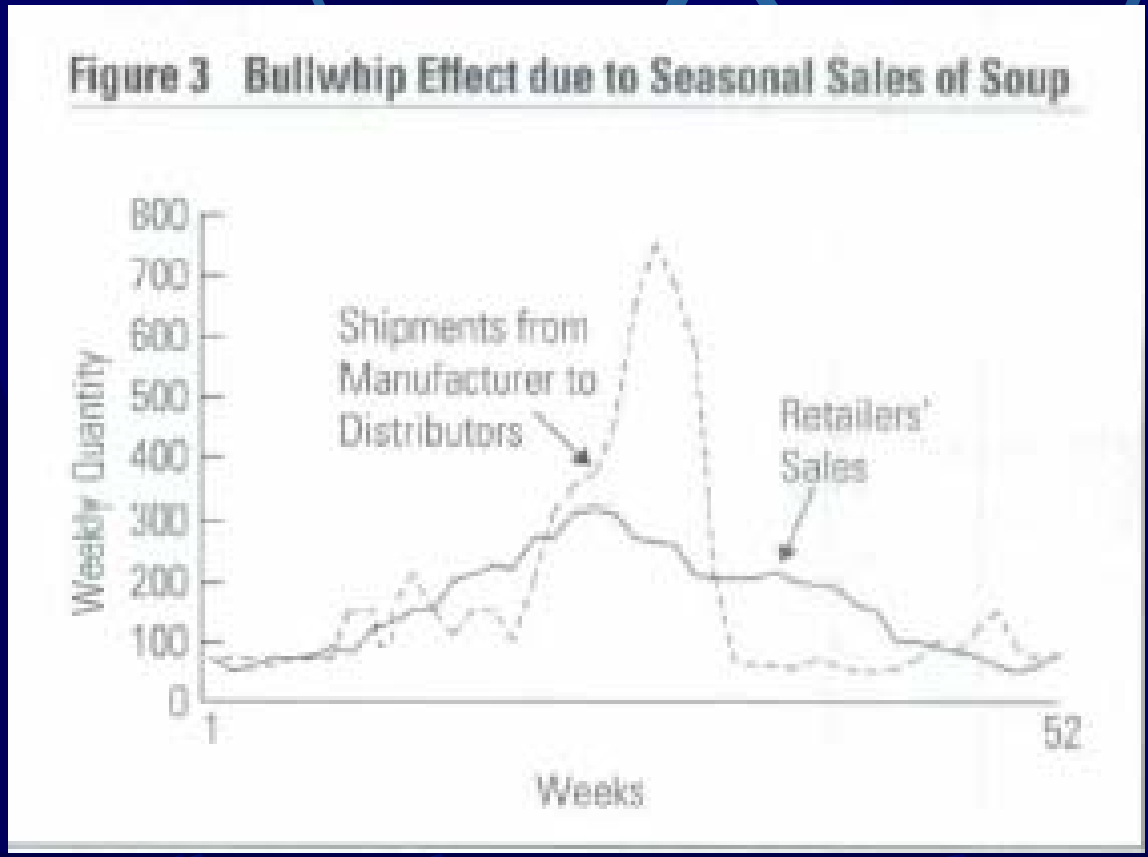
Verification of the Hypothesis



Gaming in Wholesale discounts



Seasonal Sales of Soup



The Conclusions of expert research in SCM

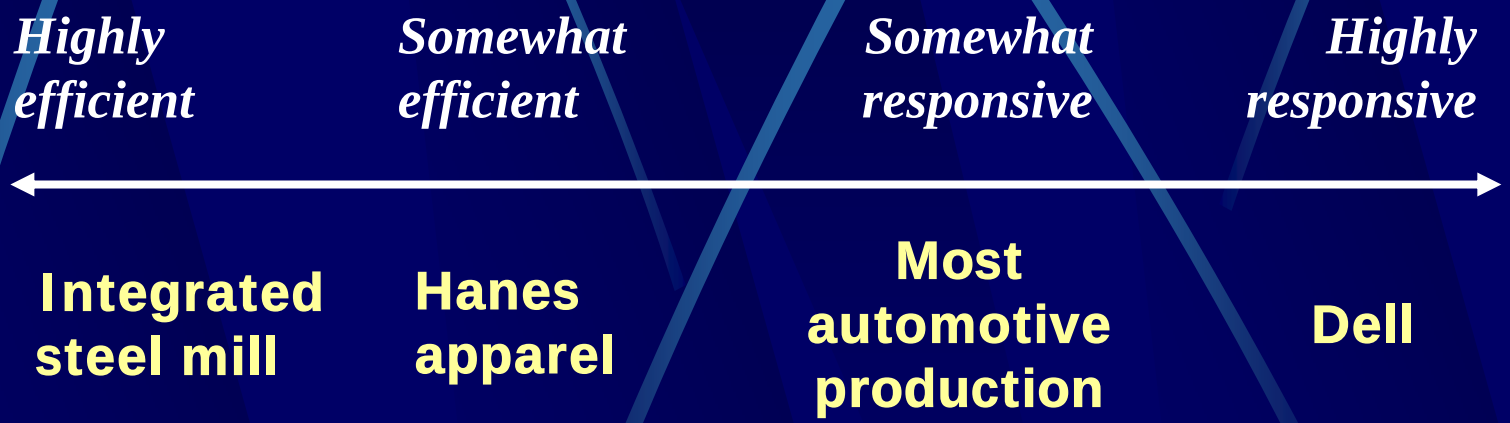
Table 1 A Framework for Supply Chain Coordination Initiatives

Causes of Bullwhip	Information Sharing	Channel Alignment	Operational Efficiency
Demand Forecast Update	• Understanding system dynamics • Use point-of-sale (POS) data • Electronic data interchange (EDI) • Internet • Computer-assisted ordering (CAO)	• Vendor-managed inventory (VMI) • Discount for information sharing • Consumer direct	• Lead-time reduction • Echelon-based inventory control
Order Batching	• EDI • Internet ordering	• Discount for truckload assortment • Delivery appointments • Consolidation • Logistics outsourcing	• Reduction in fixed cost of ordering by EDI or electronic commerce • CAO
Price Fluctuations		• Continuous replenishment program (CRP) • Everyday low cost (EDLC)	• Everyday low price (EDLP) • Activity-based costing (ABC)
Shortage Gaming	• Sharing sales, capacity, and inventory data	• Allocation based on past sales	

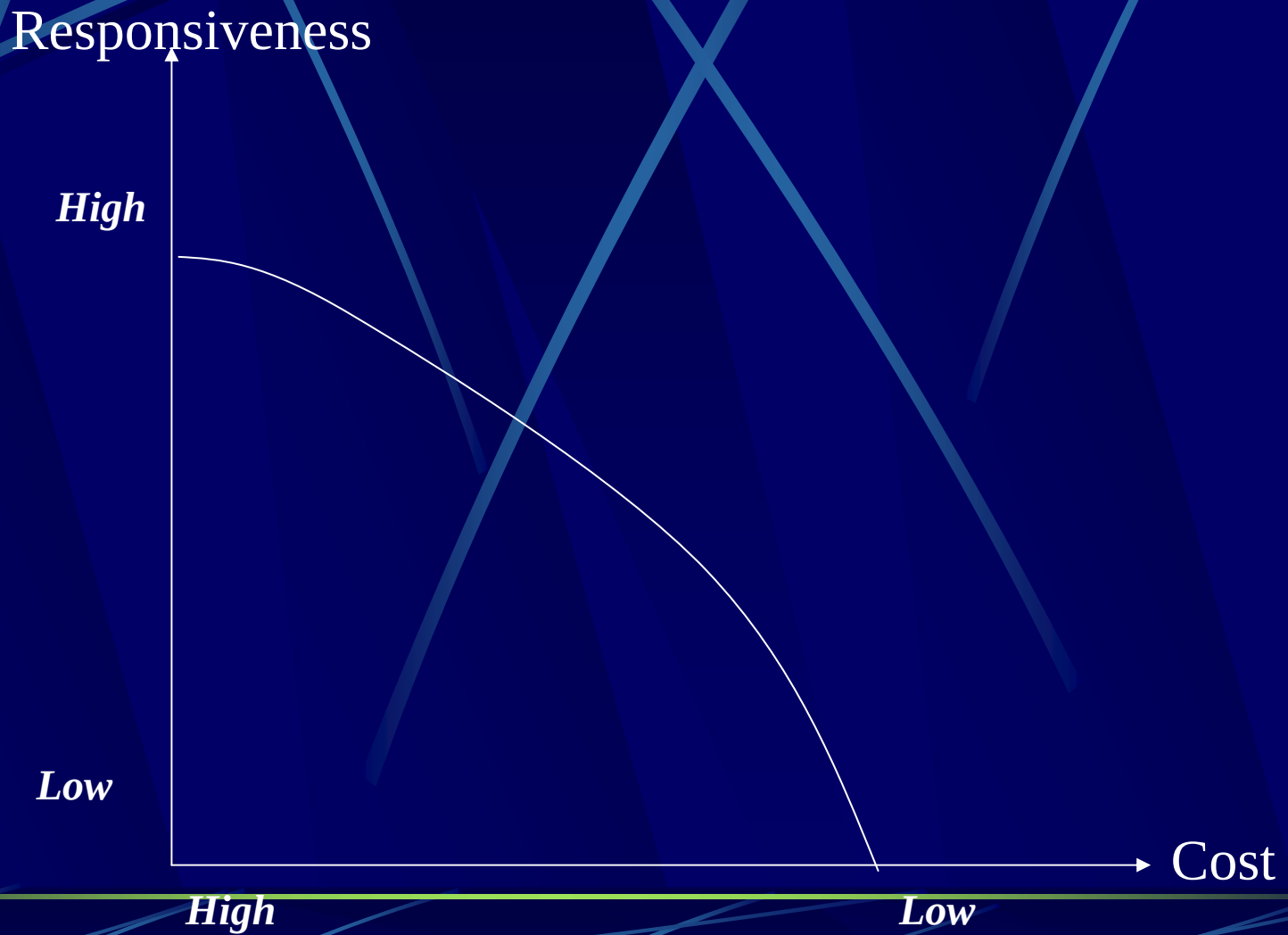
What the practitioner should do

The simplest way to control the bullwhip effect caused by forward buying and diversions is to reduce both the frequency and the level of wholesale price discounting.

Responsiveness Spectrum



Understanding the Supply Chain: Cost-Responsiveness Efficient Frontier



Correlation Between Implied Demand Uncertainty and Other Attributes

Attribute	Low Implied Uncertainty	High Implied Uncertainty
Product margin	Low	High
Avg. forecast error	10%	40%-100%
Avg. stockout rate	1%-2%	10%-40%
Avg. forced season-end markdown	0%	10%-25%

Comparison of Efficient and Responsive Supply Chains

	Efficient	**Responsive**
Primary goal	Lowest cost	Quick response
Product design strategy	Min product cost	Modularity to allow postponement
Pricing strategy	Lower margins	Higher margins
Mfg strategy	High utilization	Capacity flexibility
Inventory strategy	Minimize inventory	Buffer inventory
Lead time strategy	Reduce but not at expense of greater cost	Aggressively reduce even if costs are significant
Supplier selection strategy	Cost and low quality	Speed, flexibility, quality
Transportation strategy	Greater reliance on low cost modes	Greater reliance on responsive (fast) modes