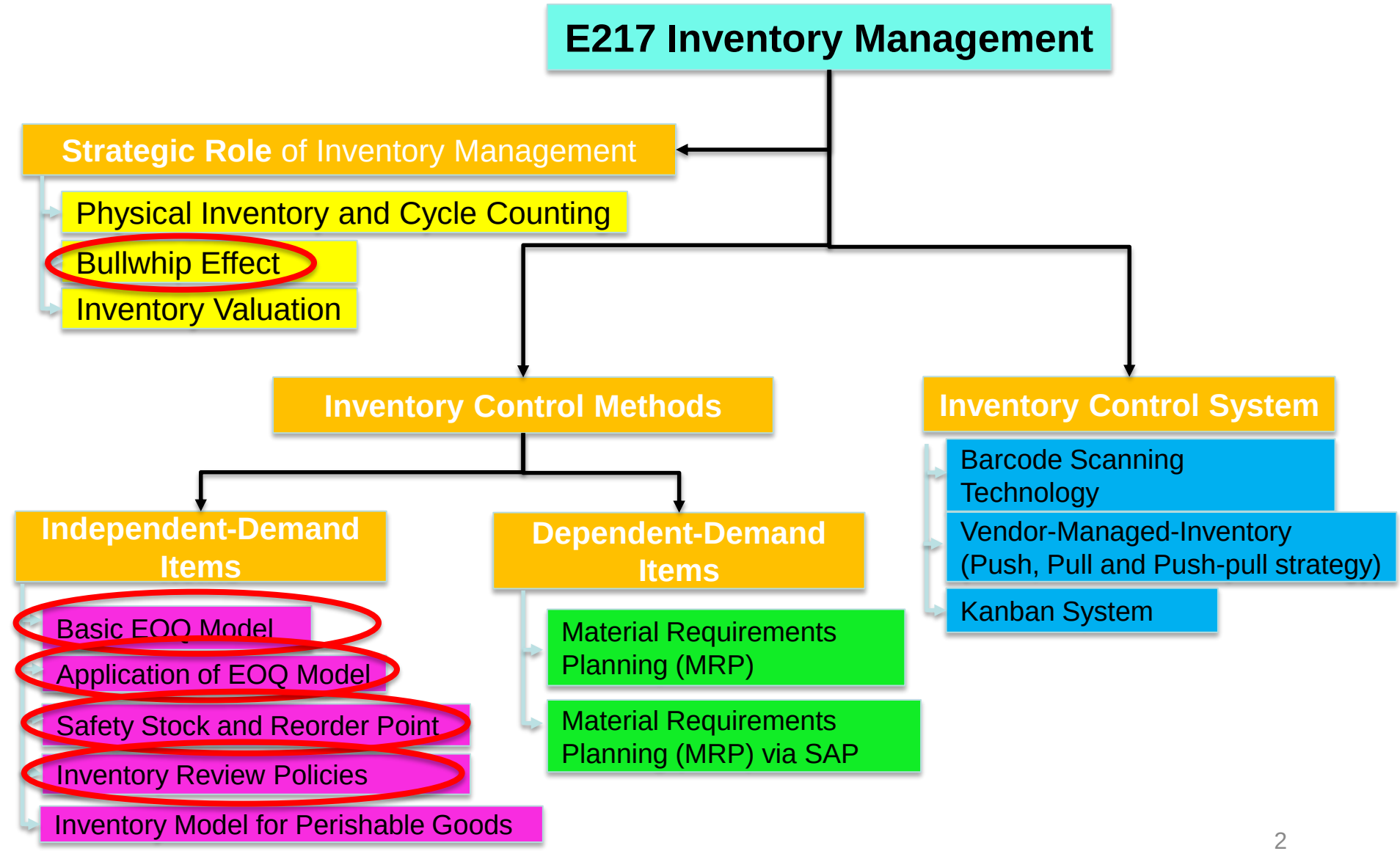
P05
Up and down

E217 – Inventory Management

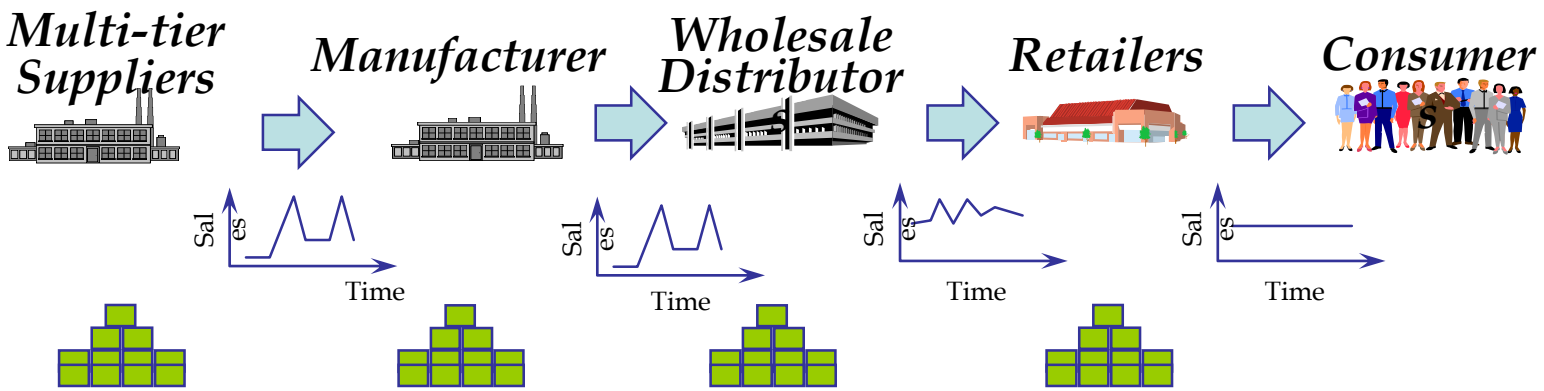
SCHOOL OF ENGINEERING

E217 Inventory Management Topic Tree



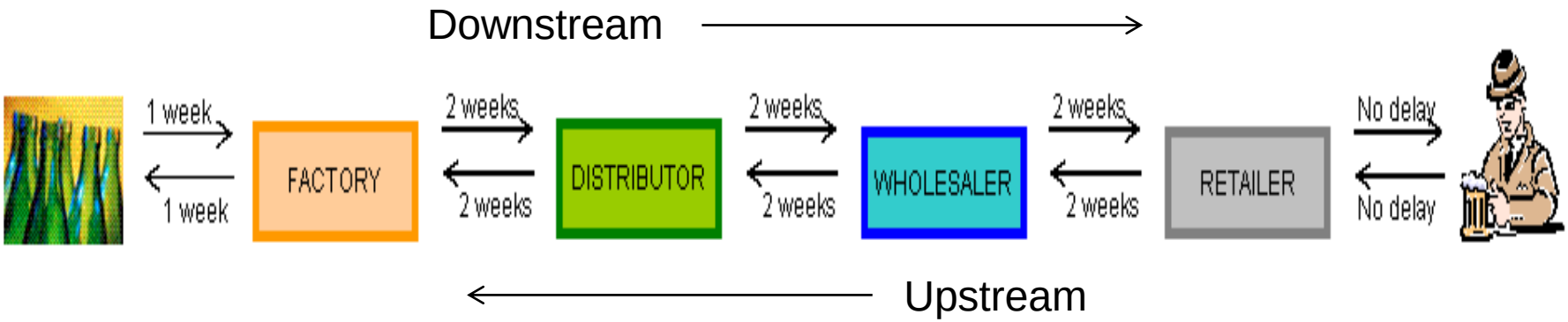
System Dynamics

- The Beer Game was developed to introduce the concept of system dynamics.
- The results of the beer game simulation teach a lot about how to coordinate the actions of different companies in a supply chain.
- Players experience the pressures of playing a role in a complex system and can see long range effects during the course of the game.
- Bullwhip Effect is one of the most common dynamics in supply chains



Bullwhip Effect

The Online Beer Game



① Beer Game shows the typical coordination problems of traditional supply chains without information sharing and collaboration

② Companies at different stages in the supply chain behave in ways that at first create product shortages and then lead to an excess supply of products

- Single product (beer)
- Fulfil demand from inventory
- 2-week lead time (order /delivery)
- One decision: how much to order?

The Online Beer Game (1)

Incoming order

On-hand Inventory+ incoming delivery

Incoming order + Backorder if any

Input Screen for Retailer of Game 2

For Week **5**

Demand from Customer :	**8**	Beginning Inventory :	**12**
On Backorder :	**0**	Incoming Shipment :	**12**
Total requirements :	**8**	Total available :	**24**

Units Shipped to Customer this week: **8**
Ending inventory **16**

Enter the number of units to be purchased from Wholesaler :

submit

Retailer INFORMATION FOR THE LAST TEN WEEKS

NOTE : The two orders placed to Wholesaler before week 1 are 4 and 4 units

Week	Inv/Bk	Demand	Incom. ship	Outg. ship	Order placed	Current cost
1	12	4	4	4	12	6
2	12	4	4	4	12	12
3	12	4	4	4	8	18
4	12	4	4	4	8	24

Cumulative inventory cost, e.g. 12*0.5 = $6 per week

The Online Beer Game (2)

Status of other Supply Chain Channel Members of Game 2
This page will be refreshed every 15 seconds

When all the players have completed the order for the current week, the player will automatically receive a link to proceed to next week

The status will be updated in 6 seconds.

Week 5

Factory : **Has not ordered**

Distributor : **Has not ordered**

Wholesaler : **Has not ordered**

Retailer : **Has not ordered**

Inventory and Order Status plots For Retailer

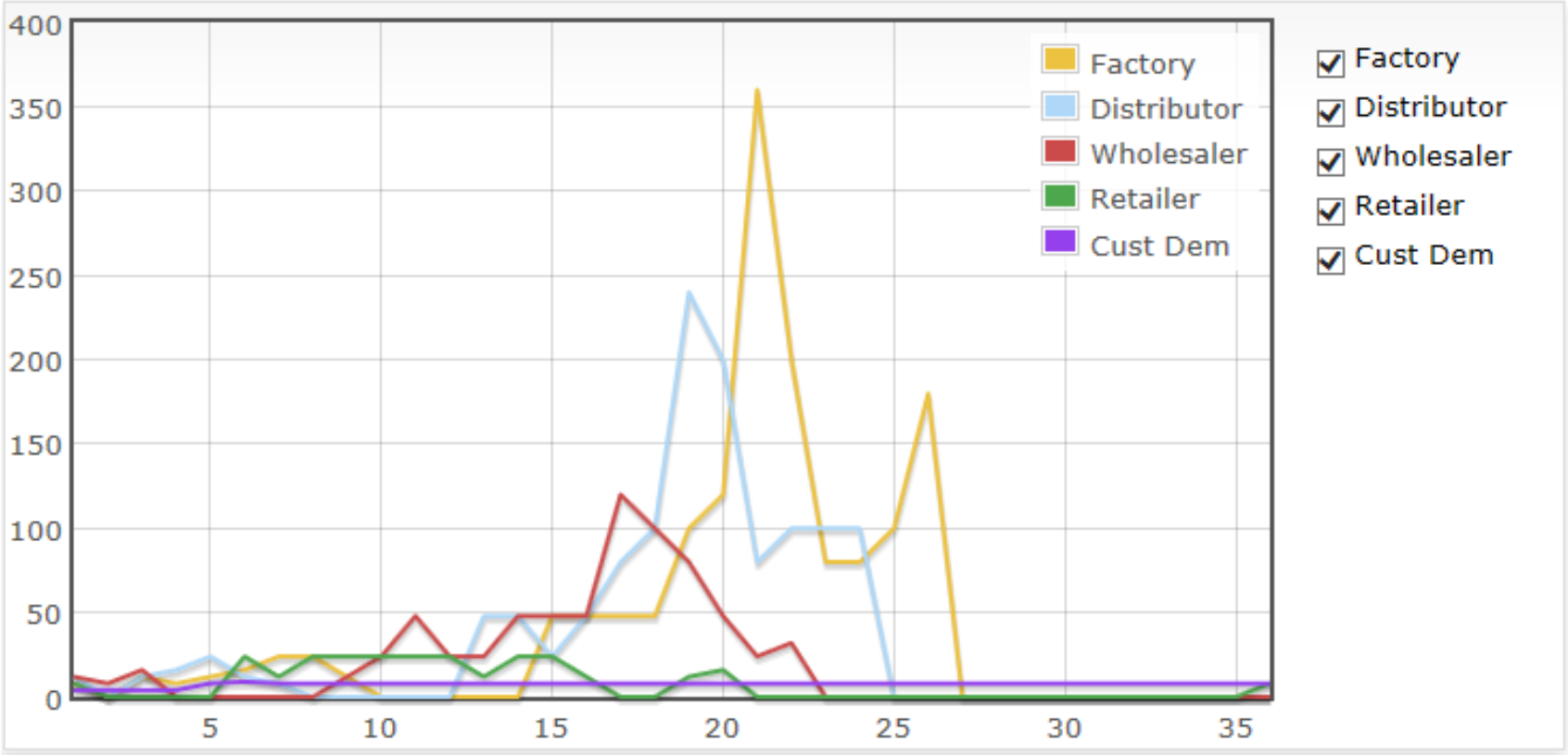
Customer Demand Plot | Inv/Backorder Plot

Order Plot | Plot all

Supply Chain Settings for Retailer:
Holding cost : **0.5**
Backorder cost : **1**
Downstream Player : Customer
Upstream Player: Wholesaler
Shipping Delay : **2 weeks** (Wholesaler -> Retailer)
Information Delay : **2 weeks** (Retailer -> Wholesaler)

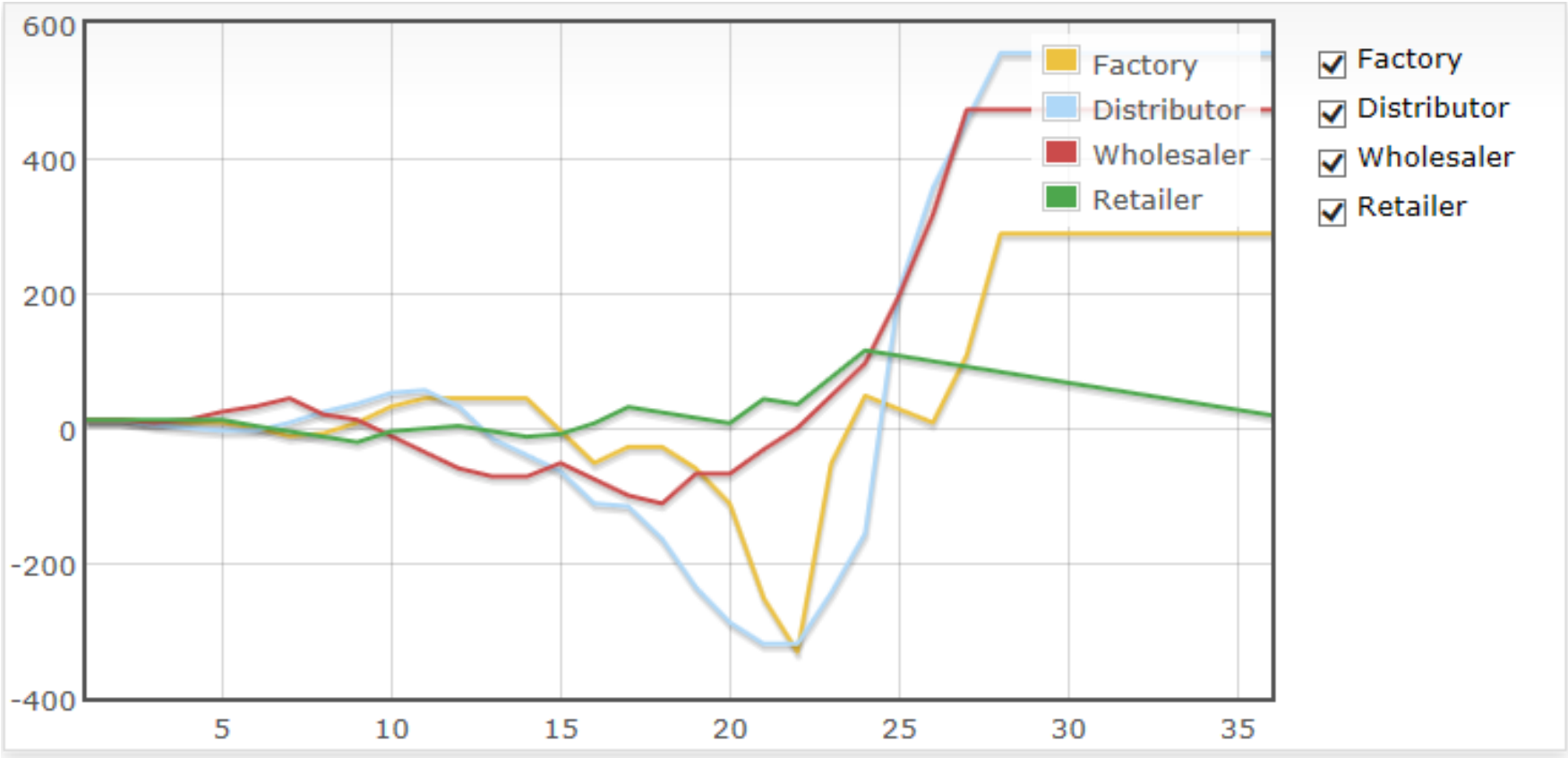
Game settings

Order Pattern Observed in Beer Game



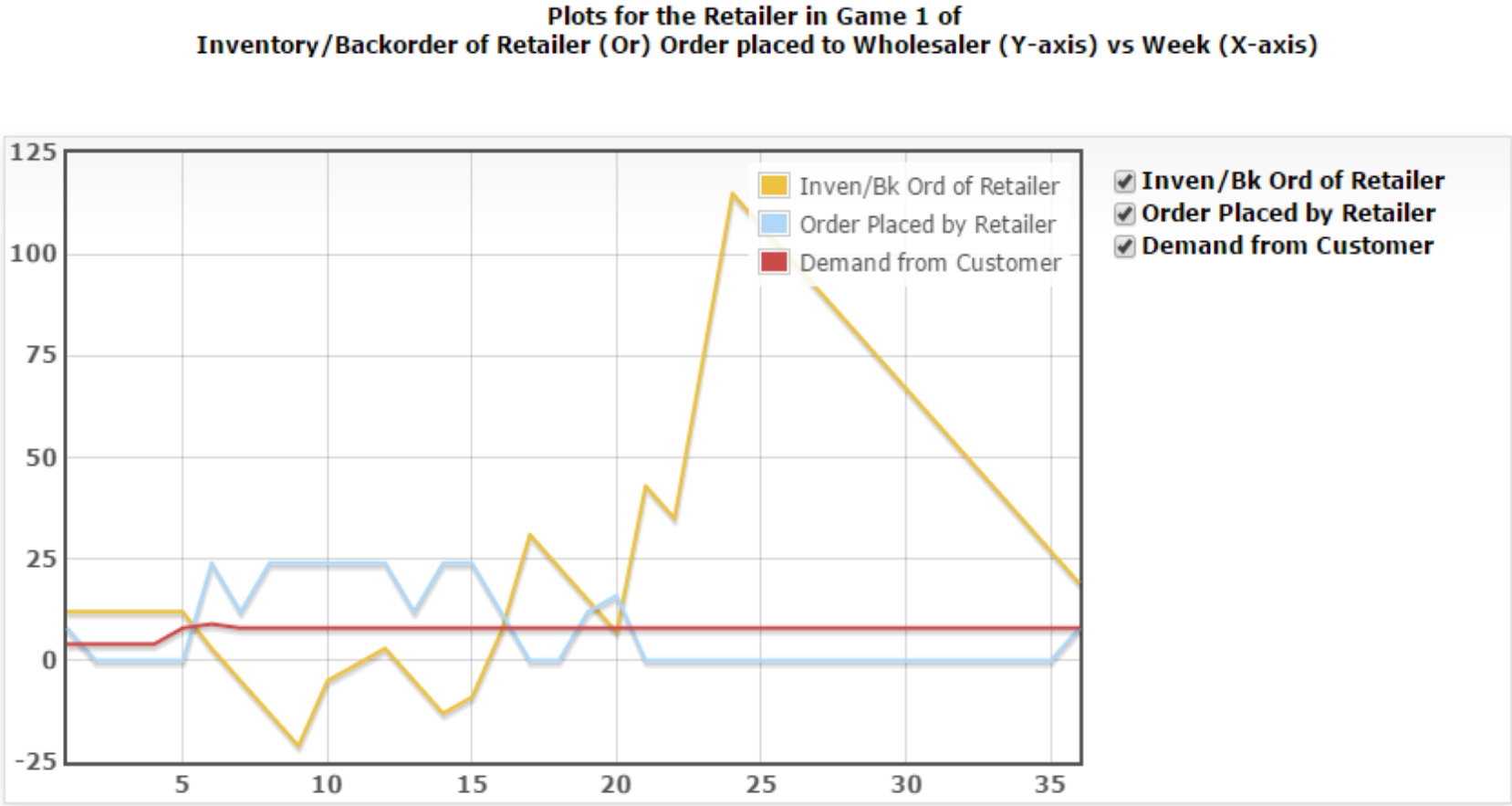
- Companies at different stages in the supply chain come to have very different pictures of market demand
- Factory performed the worst with the biggest demand variability
- Demand variability increases as one moves upstream from the retailers to the manufacturers (factory).

Inventory/Backorder Observed in Beer Game



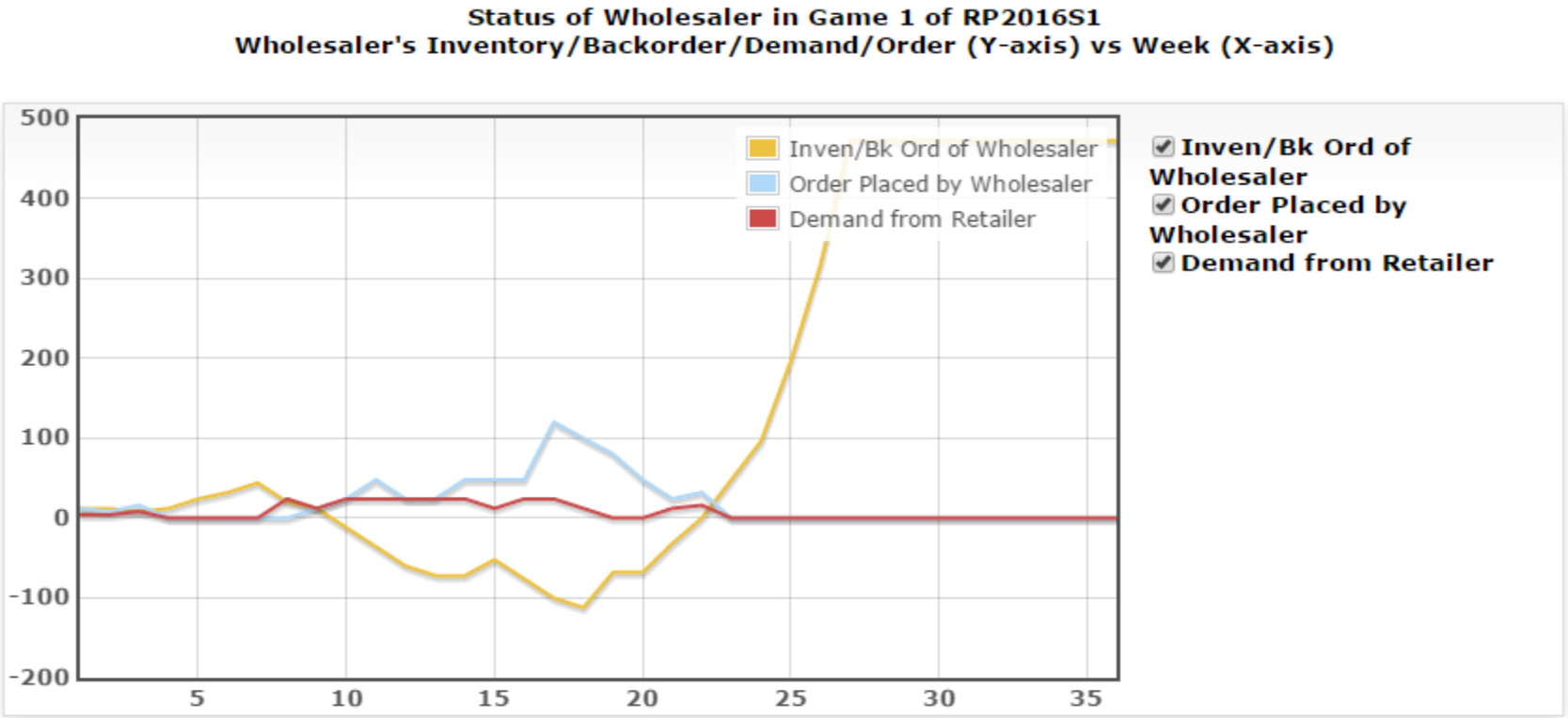
Note: **X -axis** represents Number of weeks and **Y-axis** represents Number of Beer cases (in units).

Fluctuations Along the Supply Chain (Retailer)



Note: X -axis represents Number of weeks and Y-axis represents Number of Beer cases (in units).

Fluctuations Along the Supply Chain (Wholesaler)



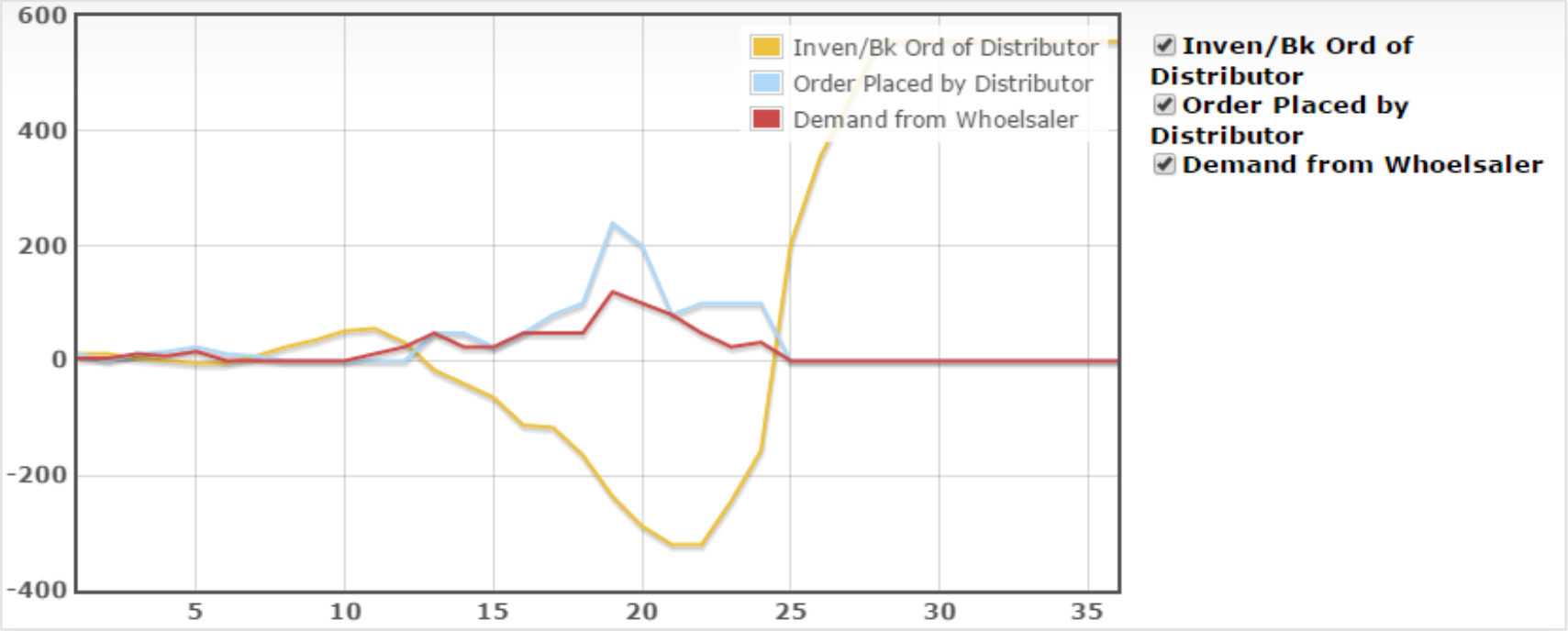
Note: X -axis represents Number of weeks and Y-axis represents Number of Beer cases (in units).

Total Current Cost : $ 3536
Average cost per week : $ 98.2222222222222

See values in table format

Fluctuations Along the Supply Chain (Distributor)

Status of Distributor in Game 1 of RP2016S1
Distributor's Inventory/Backorder/Demand/Order (Y-axis) vs Week (X-axis)

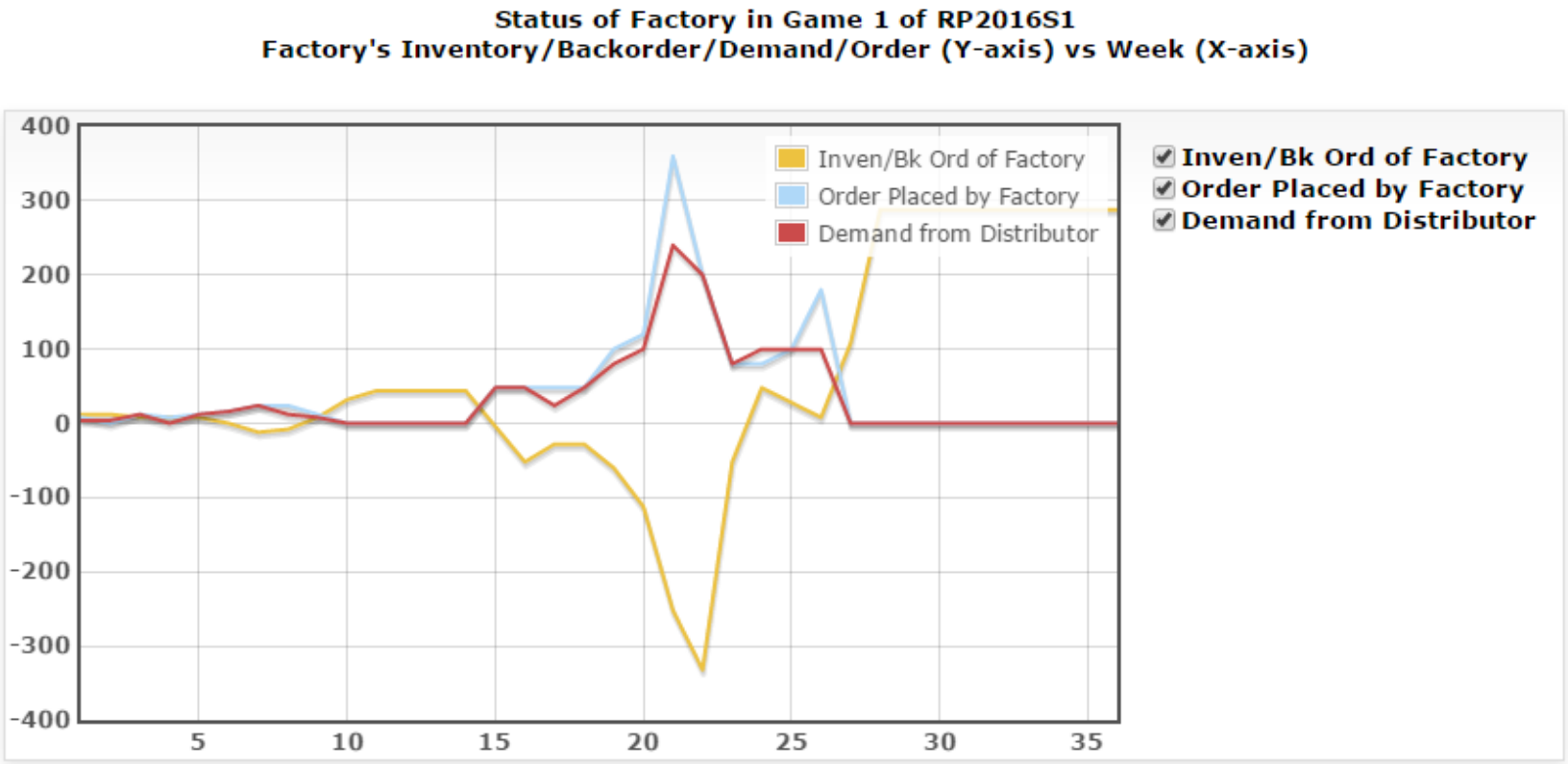


Note: X -axis represents Number of weeks and Y-axis represents Number of Beer cases (in units).

Total Current Cost : $ 5212
Average cost per week : $ 144.777777777778

See values in table format

Fluctuations Along the Supply Chain (Factory)



Note: X -axis represents Number of weeks and Y-axis represents Number of Beer cases (in units).

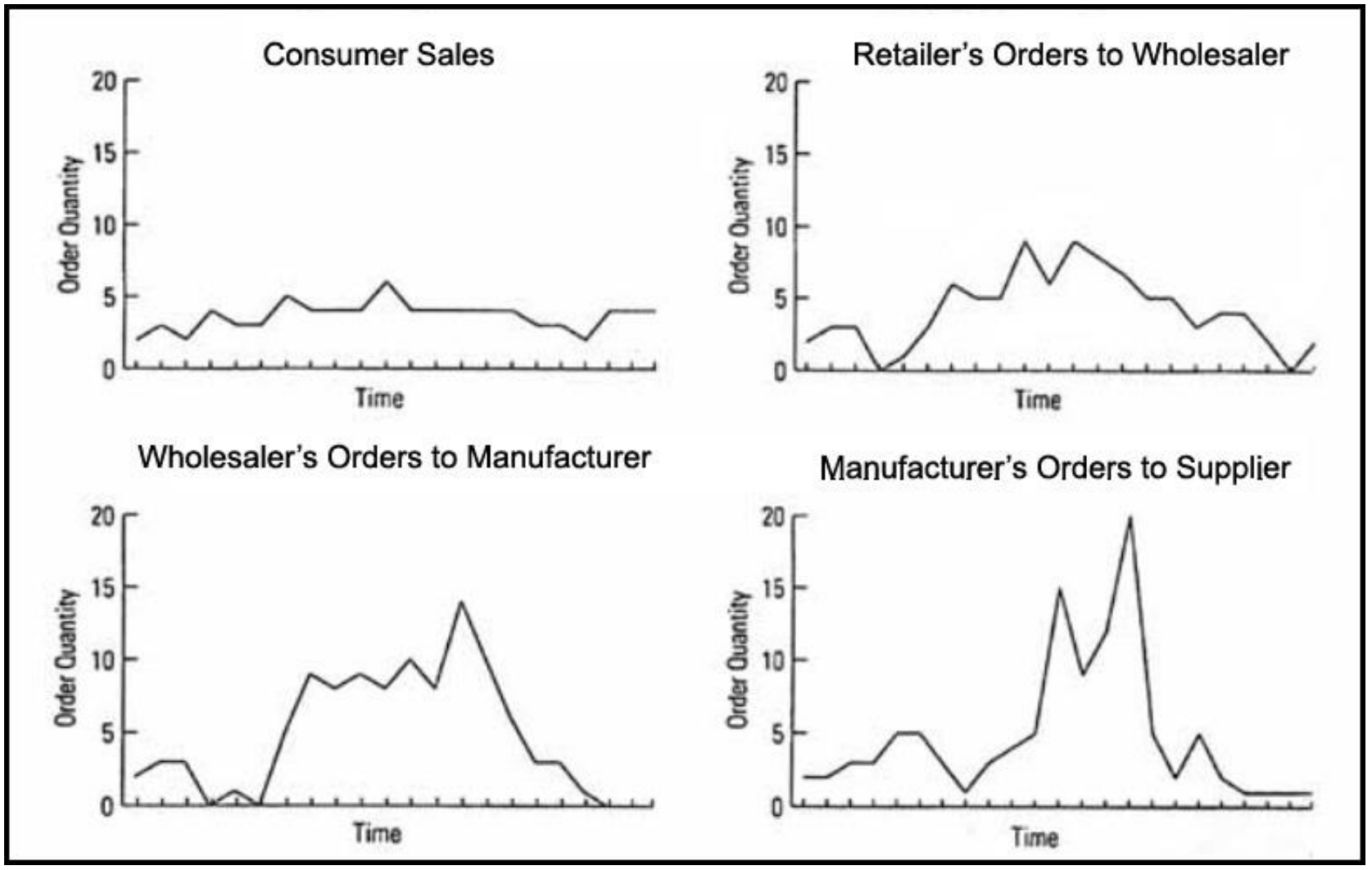
Total Current Cost : $ 2464
Average cost per week : $ 68.4444444444444

See values in table format

Origins of Bullwhip Effect

- Proctor & Gamble (P&G) coined the term “Bullwhip Effect” by studying the demand fluctuations for disposable diaper, “Pampers”.
- Retail sales of “Pampers” were fairly uniform, there is no particular day or month whereby demand is significantly higher or lower than the other
- However, the distributor’s orders placed to the factory fluctuated more than the retail sales
- In addition, P&G’s orders to its suppliers fluctuated even more
- This increase in demand variability as we travel up the supply chain is known as the Bullwhip Effect

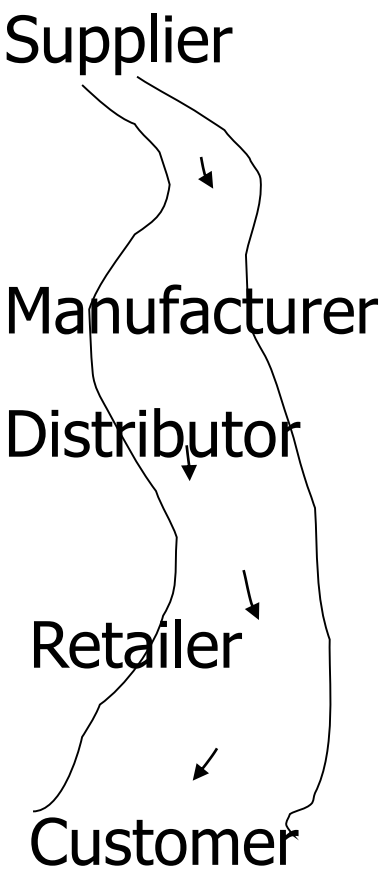
Bullwhip Effect in the Real World (P&G Diapers)



Bullwhip Effect

- ✓ Distortion in demand information, what you see is not what they face
- ✓ A small change in customer demand can result in large variations in order placed upstream because of the distortion in information that occurs with each step in the supply chain, from consumer, to retailer, to wholesaler, to manufacturer.
- ✓ Through the Beer Game, we experience typical coordination problems of traditional supply chains without information sharing and collaboration.
- *Note that the Beer Game only simulates a simplified 4-stage beer supply chain; you can imagine how complex the real-life supply chains are!*

Causes of Bullwhip Effect in Beer Game



- No communications with other supply chain player when you make order decisions, based solely on orders from the next downstream player which become available only after the delivery delay (lead time).
- The ordering patterns share a common, recurring theme: the variability of an upstream site is always greater than those of the downstream site. This is a simple and yet powerful illustration of the bullwhip effect.
- The bullwhip effect is a consequence of the **players' rational behavior** within the supply chains infrastructure.

Operational Causes of Bullwhip Effect (I)

- Demand Forecast Updating
  - Forecasting is often based on the order history from immediate customers.
  - Demand forecasting based on orders received instead of end user demand data will inherently become more and more inaccurate as it moves up the supply chain.
  - Lead times cause companies to hold safety stock, which in turn worsens the fluctuation in orders placed.
  - Retailers often order more when they notice a slight increase in demand
- Price Fluctuations
  - Promotions, discounts and rebates may cause customers to buy in bulk and stock up.
  - When price returns to normal, customer demand often drops
- Overreactions to backlogs
- No communication and coordination

Operational Causes of Bullwhip Effect (II)

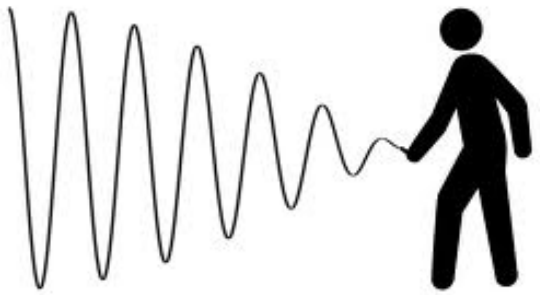
- Order Batching
  - Companies often place orders in batches to reduce order processing costs, save transportation cost or in anticipation of seasonal demands
  - Because of order batching, these orders vary from the actual demand and this variance is magnified as it moves up the supply chain.

- Rationing and Shortage Gaming
  - In times of anticipated shortage of products (such as the introduction of popular hand-phones or computers during the holidays), manufacturers will impose limits on customer orders, for example shipping each customer only 40% of an actual order.
  - Customers therefore try to “game” and “beat” the rationing system, by ordering extra quantities in advance.
  - In the end, manufactures do not get a realistic sense of the size of actual demand, and after the rationing is over, many customers cancel duplicate orders that they had placed to several manufacturers, causing excess inventory costs in the supply system.

Consequences of Having the Bullwhip Effect

When a supply chain is plagued with the Bullwhip Effect and demand information is distorted, it results in:

- Excessive inventory
- Insufficient or excessive capacity (transportation, production, etc)
- Longer cycle times
- Poor customer service due to unavailable products or long backlogs
- Poor forecast accuracy
- Lost sales and profit
- Overall costs increase



Strategies to Manage the Bullwhip Effect

Reducing uncertainty

- Centralize actual customer demand information and each player in the supply chain can still use different forecasting techniques and buying practices
- All companies in a supply chain to share a common set of demand data from which to do their forecasting
- Information sharing along the supply chain
- Sharing of Point-of-sale (POS) data captured by bar-coding system

Reducing variability

- Reduce factors that increase variability in customer demand (e.g. Promotions and discounts)
- Year round or everyday low price strategy, etc.
- If the end customers for a product believe that they will get a good price whenever they purchase the product, they will make purchases based on real need and not other considerations. This in-turn makes demand easier to forecast and companies in the supply chain can respond more efficiently.

Strategies to Manage the Bullwhip Effect

Reducing Lead Time

- Supply chain redesign, networks, processes, tasks and roles
- Information lead time: accurate information passed on electronically, such as the Internet, Electronic Data Interchange (EDI), etc.
- Order lead time: Cross-docking, etc.

Alliances: Collaboration in the supply chain

- Build strategic partnerships among the supply chain players
- Develop effective collaborative demand forecasting methods
- Vendor-Managed Inventory (VMI)
- Coordinated planning
- Integrated distribution strategy, etc.

We can only reduce, but can never eliminate the Bullwhip Effect !

Case-study of Wal-Mart

- Theoretically the Bullwhip Effect does not occur if all orders exactly meet the demand of each period. This is consistent with findings of supply chain experts who have recognized that the Bullwhip Effect is a problem in forecast-driven supply chains, and careful management of the effect is an important goal for Supply Chain Managers

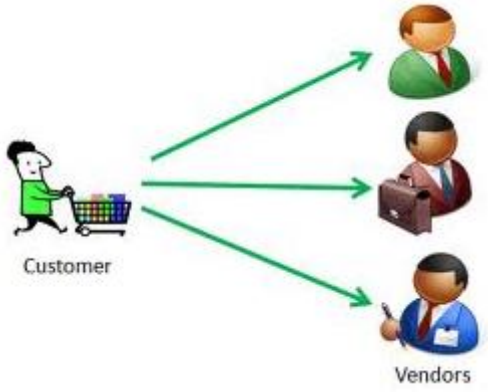
- Therefore it is necessary to extend the visibility of customer demand as far as possible. One way to achieve this is to establish a demand-driven supply chain which reacts to actual customer orders. In manufacturing, this concept is called Kanban. This model has been most successfully implemented in Wal-Mart's distribution system.

- Individual Wal-Mart stores transmit point-of-sale (POS) data from the cash register back to corporate headquarters several times a day.

Case-study of Wal-Mart

- This demand information is used to queue shipments from the Wal-Mart distribution center to the store and from the supplier to the Wal-Mart distribution center.

- The result is near-perfect visibility of customer demand and inventory movement throughout the supply chain. Better information leads to better inventory positioning and lower costs throughout the supply chain. Barriers to the implementation of a demand-driven supply chain include the necessary investment in information technology and the creation of a corporate culture of flexibility and focus on customer demand.



Today's Problem Statement

- The phenomenon that the manufacturer (Infinite Grain) is experiencing is called the Bullwhip Effect.
- The simulation study using Beer Game suggested that Bullwhip Effect is caused by lack of communications between each player in the supply chain. While the game is being played, each supply chain partner has no information about the upstream or downstream inventory cost or order quantity.
- Operational cause of Bullwhip Effect can be a result of demand forecasting based on historical demand rather than real time data. It can also be caused by price fluctuations, large orders with quantity discount, ration and shortage gaming, etc. Hence, demand variability increases as one moves upstream from the retailers to the manufacturers (factory) and the overall inventory cost increases also.
- Hence, some suggested strategies: centralized inventory information, reduce lead time in information passing, supply chain partnership.

Learning Objectives

- Analysis via the Beer Simulation Game

- Describe the roles of the 4 supply chain partners in the Beer Game
  - Retailer, Wholesaler, Distributor and Factory
  - Concept of downstream and upstream stage
  - Incoming orders and deliveries
  - Outgoing orders and deliveries
  - Backorders
  - Total inventory cost

- Describe the Bullwhip Effect
  - Background
  - Major Causes
  - Consequences
  - Strategies to cope with

E217 Inventory Management Topic Flow