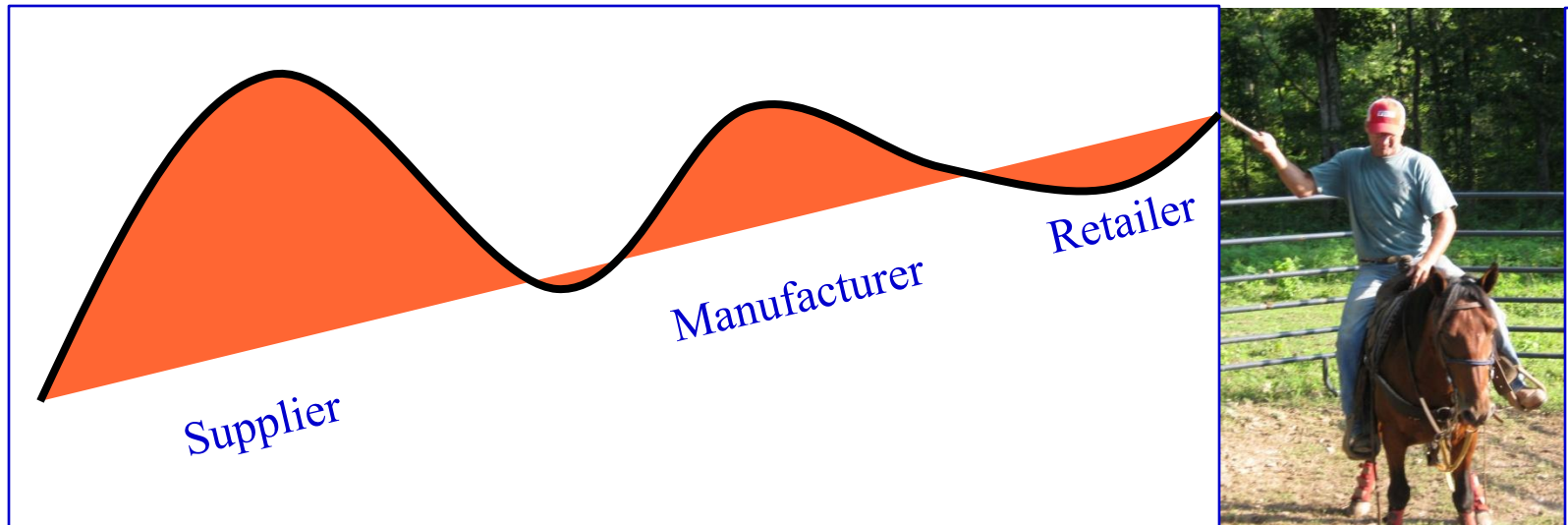# Bullwhip Effect

Bullwhip Effect

Distortion of demand information of a product while it passes from one firm to the next across SC.

» Misinterpretation

» Unreliable EDI protocols

» Loss during encryption / decryption

» Buyback contracts

◆ Rediform buysback planners from retailers. Its shipment data is quite different from the sales data. The retailers return a lot of planners at the end of the season.

Bullwhip Effect: Initial Empirical Evidence

◆ P&G found out that the diaper orders issued by the distributors have a degree of variability that cannot be explained by consumer demand fluctuations.
  – Diaper consumption should be stable with a low standard deviation, about 5-6 per day per baby.
  – P&G observed orders with a high standard deviation at the distributors.

◆ At HP, orders placed by retailers to printer division have much bigger variations than consumer demands

◆ Then on, Bullwhip effect started its own life without reference to cost/profit.

◆ The information transferred in the form of "orders" tend to be distorted and can misguide the upstream in SC in their inventory and production decisions.

◆ In particular, "variance of my orders" > "variance of my sales"
  – Or, variance of my production > variance of my demand

◆ Information sharing in SCs is important
 – Sales Information deduced form the orders received from the downstream should be used with great caution.

Three Causes of Bullwhip Effect

◆ Suppose that we have three conditions
1. Finite supply shared by many retailers
   » Rationing game: retailer orders more than demand
2. Fixed ordering cost
3. Wholesale price varies over time
   » Inflationary / deflationary environment
   » Prices with no trend but variability

Each condition by itself leads to the bullwhip effect.

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1. The Rationing Game

◆ A product whose demand sometimes exceeds supply due to limitation in production capacity or uncertainty of production yield.

 – Innovative products with short lead time and high profit margin fall in this category
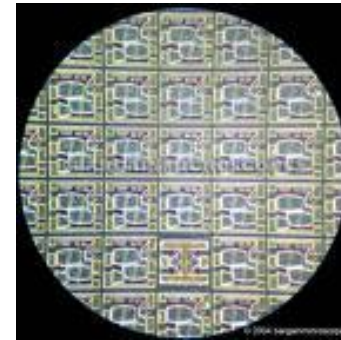
◆ Manufacturer allocates capacity to retailers proportionally to their orders.

 – In order to secure more, each retailer will issue an order which exceeds in quantity what the retailer would order if the production is unlimited.

 » IBM's semiconductor manufacturing plants allocate capacity to products

 ◆ Memory, CPU, Telecommunication chips

 » Units (called product towers) managing these products overestimate their orders.

◆ Optimal order quantity for retailer in the rationing game exceeds the order quantity in the traditional newsvendor problem.

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2. Order Batching

◆ Fixed ordering costs lump the demand together
  – Order in some periods in big quantities
  – Ex. Given the demand rate of 1 per day.
    » Suppose that ordering becomes infrequent with fixed ordering costs.
    » What happens to the standard deviation of order sizes over a month of 30 days while the standard deviation of demand is constant at zero?

	Order Once in				
	1 day	2 days	3 days	4 days	5 days
St deviation	0	1.017	1.438	1.799	2.034

◆ Sales commissioned salespeople tend to close deals generally at the end of a period (such as a month or a year). Few orders early in the month; many orders later in the month.

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3. Price Variations

◆ Frequent markdowns or promotions by the supplier will distress SC.
◆ Smart (strategic) retailers will wait for the lower price.
  – Supplier's demand is not uniform because orders shift to low price periods.
  – Overstocking buying inventory in low-cost periods and consuming it at other times
    » First-time home buyer tax credit of $8000, cash for clunkers and mall traffic during holidays

Biggest Day
Retailers hope to avoid the Black Friday spike by luring shoppers over the course of the season. Below, daily traffic to a typical mall.

One week Sunday to Saturday
BLACK FRIDAY
Daily shopper traffic in thousands 40
30
20
10
16   22
23   29
30   6
7   13
14   20
21   27
Nov. 2008
Dec.
Source: ShopperTrak

◆ Even when there is no price trends but variability, a risk sensitive company will order in larger quantities to reduce the exposure to price variability.
    » Southwest airlines buys jet gas in advance to reduce its risk exposure to oil prices
◆ The reverse can be argued for a risk-seeking retailer. But many SC partners are not risk-seeking.

Beergame results 2002 Spring

Average demand=50, stdev=20, daily averages and stdev of orders:

Factory	DC	W/H	Retailer	
112	93	71	46	Year 2002
46	45	48	47	Year 2002
50	51	51	51	Year 2002

Factory	DC	W/H	Retailer	
227	141	96	50	Year 2002
38	32	30	26	Year 2002
35	31	31	17	Year 2002
49	39	41	46	Year 2002

Beergame results in 2005 Spring

Average demand=50, stdev=20, daily averages and stdev of orders:

Factory	DC	W/H	Retailer	
45	45	45	50	Year 2005
-	39	40	45	Year 2005
117	126	117	51	Year 2005

Factory	DC	W/H	Retailer	
32	38	16	18	Year 2005
-	41	19	18	Year 2005
127	143	122	15	Year 2005

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Is there really a bullwhip effect everywhere?

In search of the bullwhip effect. Unpublished paper by Cachon, Randall and Schmidt

Claim is that there is not much empirical evidence for bullwhip effect.
Based on aggregate data from Department of Commerce.

$V[Y]$ = variance of production
$V[D]$ = variance of demand
$V[Y']$ = variance of seasonally adjusted production
$V[D']$ = variance of seasonally adjusted demand

RETAIL INDUSTRIES	$V[Y]/V[D]$
Aggregate Retail Series	0.50
Building Mat. and Garden Equip. and Supplies Dealers	0.92
Clothing and Clothing Access. Stores.	0.36
Food and Beverage Stores	0.98
Furniture, Home Furnishings, Electronics, & Appliance Stores	0.63
General Merchandise Stores	0.28
Motor Vehicle and Parts Dealers.	**1.90**

Bullwhip effect found!!

Is there really a bullwhip effect everywhere?

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WHOLESALE INDUSTRIES

Aggregate Wholesale Series	1.14
Apparel, Piece Goods, & Notions	1.10
Beer, Wine, & Distilled Alcoholic Beverages	0.54
Chemicals & Allied Products	1.48
Drugs & Druggists' Sundries.	3.80
Electrical and Electronic Goods.	0.95
Farm Product Raw Materials.	3.87
Furniture & Home Furnishings.	1.48
Grocery & Related Products	1.36
Hardware, & Plumbing & Heating Equip & Supplies	1.17
Lumber & Other Construction Materials	1.04
Machinery, Equipment, & Supplies	1.20
Metals & Minerals, ex. petroleum	1.36
Miscellaneous Durable Goods.	1.12
Miscellaneous Nondurable Goods	1.28
Motor Vehicle & Motor Vehicle Parts & Supplies	1.18
Paper & Paper Products	1.57
Petroleum & Petroleum Products	0.95
Professional & Commercial Equip.& Supplies	1.14

See the article for manufacturing industries.

Amplification of Bullwhip Effect

◆ Bullwhip effect propagates in an amplified form upwards the supply chain if each member processes order signals coming immediately from below.

Tier 1 Supplier — Manufacturer — Distributor — Retailer — Customer
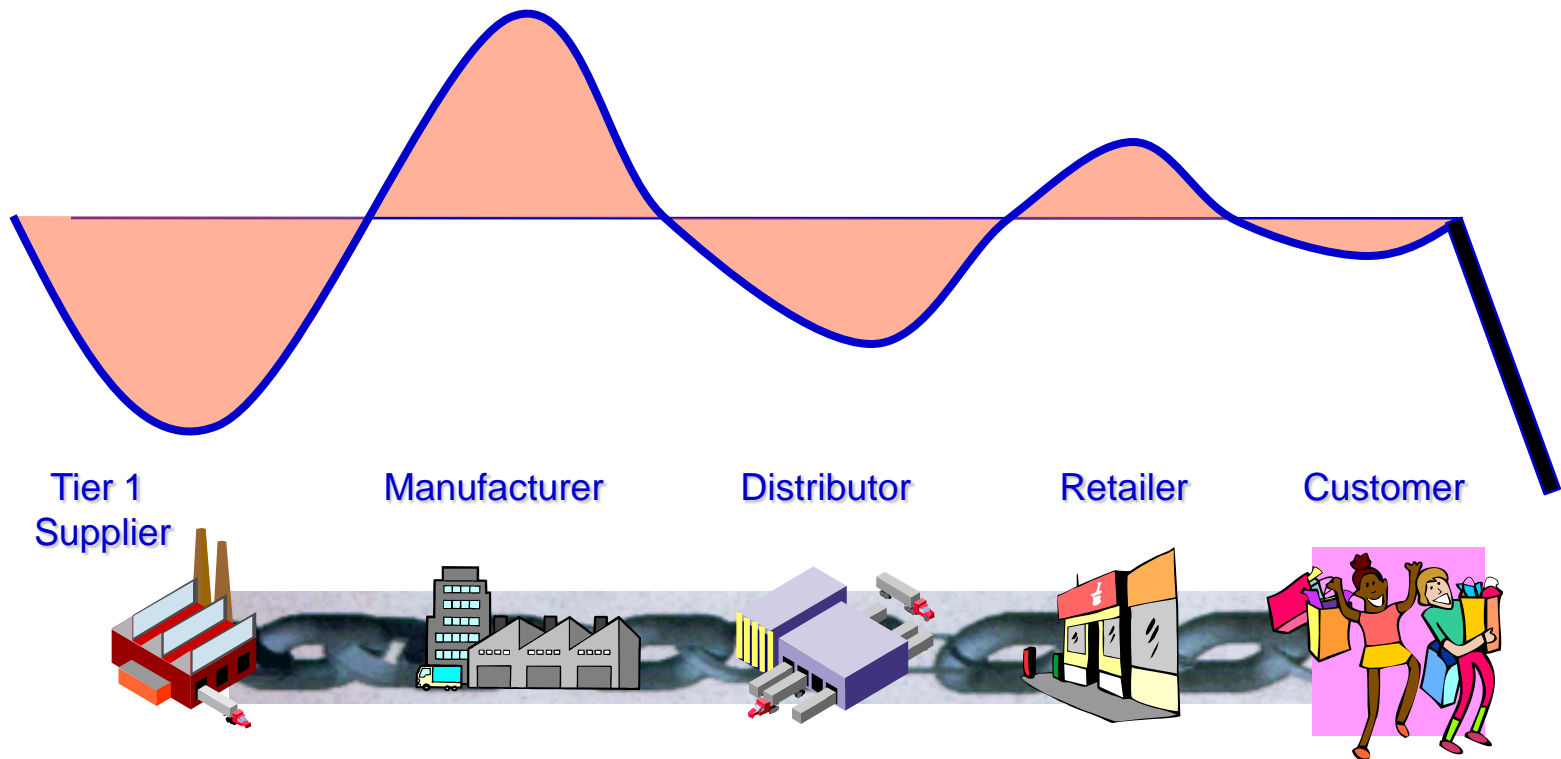
Summary

◆ Bullwhip effect

   – Does it exist?

   – If it does, so what?