
What is the Bullwhip Effect caused by?

Study based on the Beer Distribution Game online

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Agenda

Part I  What is the Bullwhip Effect? What are reasons for the Effect?

Part II  The Beer Distribution Game: Simulating a Supply Chain

Part III  What is the Role of Human Behavior in the Bullwhip Effect? (Study based on the Beer Distribution Game online)

Part IV  How can Supply Chains cope with the Effect?
The Bullwhip Effect

Orders and Stocks in a Supply Chain

OEM  1\textsuperscript{st} Tier  2\textsuperscript{nd} Tier  3\textsuperscript{rd} Tier

Information (Orders)  

Material
The Bullwhip Effect

Orders and Stocks in a Supply Chain

OEM  1\textsuperscript{st} Tier  2\textsuperscript{nd} Tier  3\textsuperscript{rd} Tier

Observations:

- Variation of stocks and orders increases up the supply chain from customer to supplier.
- The longer lead times of information and material are, the stronger the effect is.

Famous example:
Demand for Pampers disposal diapers, analyzed and published by Procter&Gamble

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The Bullwhip Effect

Main Reason for the Effect: It is inherent in the System!

Current Demand

1'000

Stock to meet Demand

1'200

Current Production Level

1'000 1'000 1'000 1'000

Effect is caused by lead time:
- If customer demand sinks, the supplier needs to empty its pipeline to avoid high capital costs.
- If it raises, pipeline needs to be filled to avoid backlog.
The Bullwhip Effect

Secondary Reasons for the Effect

Planning:
• Changing forecasts lead to changing safety stocks. Suppliers not only react on changed demand, they adapt the level of safety stock. Thus variability increases.
• Procurement in batches adds variability

Behavior:
• Variability of prices (especially: promotions) has an effect on variability of demand.
• Facing shortage of supply customers tend to order more than their actual demand. After shortage is over, cancellations occur.

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The Beer Distribution Game

Idea: A simple Simulation of a Make-to-Stock Supply Chain

Retailer  |  Wholesaler  |  Distributor  |  Factory

Information (Orders)

Material

Goal: To minimize cost of capital employed in stock while avoiding out-of-stock situations.

Costs: 0,50 € per product on stock per round  
1,00 € per product, that could not be delivered
The Beer Distribution Game

How much to order from your supplier?

Order received from customer

Taking into account
• outstanding orders
• products in transfer
• and on stock

How many products does my company need to meet future demand?

Products ... on stock   ... in transport

... being received
The Beer Distribution Game

Results are surprising...

Orders

Stocks

- Customer
- Wholesaler
- Factory

Retailer

Distributor
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The Role of Human Behavior

Is there a Best Solution to the Simulation?

If you could centrally plan supply chain operations (those of all four partners) how would you react on this customer behavior?
The Role of Human Behavior

The Best Strategy does not even require central planning!

Orders

Stock

lead time of information (1 period)

lead time of information and material (3 periods)

If each partner would target at a constant level of stock by *simply passing on his customers’ order* to his supplier ...

... initial stock levels would cover the higher usage during the lead time of information and material.

\[
\text{unexpected usage} \times \text{lead time} = \text{stock necessary}
\]

\[
4 \times 3 = 12
\]
The Role of Human Behavior

Human vs. Computer Performance

This *best solution*, which was achieved by a „group“ of computer players, only has costs of 228 €. Those are costs of capital employed in stock.

*Groups with humans* in average have costs of about 500-600 €. Generally speaking, the more human players are in a group, the higher costs are.

Maximum costs „achieved“ by a group of four humans: 1526 €
The Role of Human Behavior

Humans tend to an extreme behavior.

Penalty for out-of-stock situations

Cost of capital employed in stock

- Green dots: Costs of Human Players
- Orange dots: Costs of Computer Players

Strategy: “Panic”

Strategy: “Safe Harbour” of the Supply Chain

Best solution (Computers only)
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How to cope with the Bullwhip Effect

Measures

Planning
• Reduce lead time of information
  (orders, demand and capacity forecast, point-of-sale data for the whole supply chain)
• Reduce lead time of material
  (Just-in-Time, Postponement)

Behavior
• Decrease variability of prices
• Cooperation with suppliers on issues of demand and capacity (supply chain management).
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You are invited to get known to the Bullwhip Effect:

http://www.beergame.lim.ethz.ch

Thanks for your attention!