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The Bullwhip Effect

Supply Chain Behavior



A ripple at one end of the supply chain can trigger a tidal wave at the other!

Meet the Bullwhip Effect

Balancing demand and supply is not a trivial problem; it's one that over the years has caused many a manager to segregate the portions of the supply chain into the familiar manufacturing, distribution, sales, and marketing domains in order to make the parts more "manageable." This common attempt at simplifying the problem, though, created even more mysterious effects in a discipline already cloaked in the shroud of the dark arts. This paper seeks to illuminate one of the more intriguing of these behaviors—the bullwhip effect.

Virtually every company is facing increasing challenges in distribution and order fulfillment. As supply chain requirements continue to accelerate, the flow of information becomes more important up and down the supply chain—and the absence of "integrity" in the information is compounded throughout the chain. There are many reasons for a lack of integrity in information, and these causes, usually in combination, create the supply chain distortions that have become widely known as the bullwhip effect.

Broadly stated, it describes how a ripple at one end of a supply chain can trigger a tidal wave at the other.

While every company's situation is different, many are facing the same challenges in their demand, distribution, and fulfillment processes, including increasing distribution complexity and customer demands. However, the most common causes of supply chain distortions are:

Demand

- Promotions and features
- Sales

Distribution

- Transportation economies
- Stock outs and back orders

Manufacturing

- Lot size and changeover policies
- Processes and capacities
- Measurements and behaviors

Suppliers

- Variable supply
- Quality and reliability

Tracking the Order Through the Supply Chain

Typical disturbances that occur, such as unexpected demand being placed on the supply chain (see Figure 1), which may be a minor change at the retail or consumer level, propagate back through the supply chain with intensifying (and often uncontrollable) momentum.

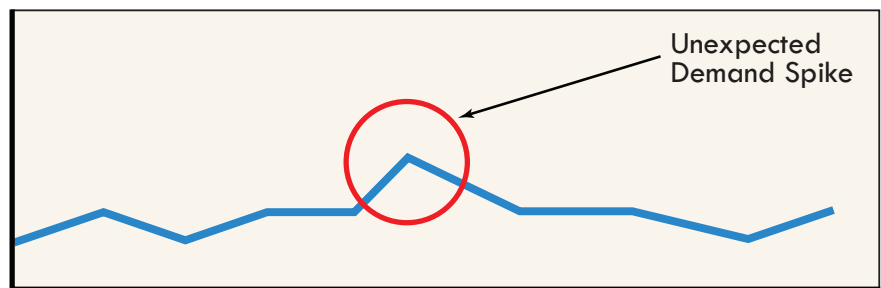
The demand (translated and passed back through the supply chain with the purchase order) is often “padded” with order policies and “safety factors” (see Figure 2).

These distortions serve as the base requirements to the next level in the supply chain, which predictably, are once again buffered with additional policies and conservative human behavior.

The result is a picture of demand at the manufacturer or supplier that bears very little resemblance to the “true” consumer demand, and which forces manufacturing to expedite more raw materials, alter firm schedules, and to feed the paranoia to suppliers (see Figure 3).

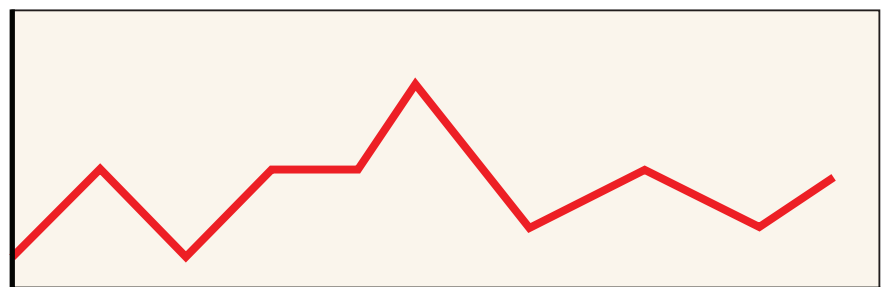
Sales to Consumers

Figure 1:
Demand pattern from the market as seen by the retailer over time



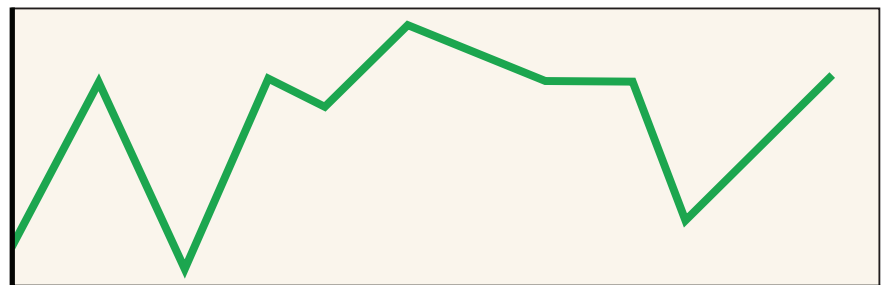
Orders to Distributor

Figure 2:
Order pattern as seen by the distributor over time



Orders to Manufacturer or Supplier

Figure 3:
Order pattern as seen by the manufacturer or supplier over time



This pattern manifests itself in supply chain performance as excess or obsolete inventories, long supply lead times, increased capacity (or capital) requirements, higher supply costs, overtime expenses, and higher transportation costs—to name a few.

Understanding the Root Causes

There have been many independent studies on the behavior within business, supply chain, social, and political systems. There are surprising correlations between the results of these studies. These could be summarized as:

- **External Locus of Control**

Most difficulties are internally caused, even though there is an overwhelming tendency to blame troubles on forces beyond our control.

- **Solutions Often Become the Problem**

People take actions to correct problems—usually introduce new policies and procedures—which themselves become the cause of many more negative effects.

- **The Correct Action is Often Counterintuitive**

This phenomenon is often seen in alternative medicine where actions are taken on the body to heal the whole in ways that seem illogical and counterintuitive.

- **The Whole is Not Just the Sum of the Parts**

Since systems are a complex interconnected mixture of processes, attitudes, and behaviors, a single (local) action can create a chain reaction of events that may be completely misunderstood and often highly unproductive—even though all the local measurements and information suggest this action would be “optimal.”

The bullwhip effect arises due to the combination of these phenomena with the many daily as well as ad hoc interventions that people make throughout the supply chain.

These well-intentioned yet sometimes disastrous actions can be seen at all organizational levels in abundance—none more so than in mechanisms to stimulate market demand and the subsequent manipulation of the demand signal as it moves back through the supply chain.

Has your company ever suffered quarter-end pressure to “meet the numbers”?

Has your sales staff ever been offered attractive, additional incentives to achieve annual targets as the year draws to a close? These incentives typically stretch the elasticity of product prices to their limit—and customers respond by “pulling forward” their requirements to meet quantities that drive price breaks and heavy discounts. This in turn drives the more reactive demand forecasting

If it takes 10 days to pass a demand change upstream to the manufacturer then a 5% increase in demand will result in a 50% load increase in manufacturing.

models into predicting a different demand pattern. Distribution planning, which often receives this forecast in various forms, begins to manipulate this fictitious demand into a supply plan that includes “economic” delivery quantities and “standard” delivery schedules. Manufacturing takes this latest demand and forces it into a clean, fixed three-week planning horizon with defined sequences in the setups, long run sizes, and a product mix that maximizes the overhead recovery. The “dogs”—products that are notoriously difficult to manufacture—don’t even make it to the schedule, not in this month anyway. A quick Materials Requirements Planning (MRP) run will generate “dependent” demand that requires the supplier to expedite new materials on the one hand, yet still doesn’t fulfill the independent, consumer demand on the other. Seems an unlikely scenario though, doesn’t it?

So it appears that forecasting methods and order policies that respond only to local costs rather than supply chain-wide costs may just be the root of the evil. In addition, reducing cost, inventory, and lead times in one stage of the supply chain may not always improve performance but could result in chaos. Regardless of the causes of demand surges and unnecessary ebbs and flows of inventory, such disturbances explode outward through distribution and supply networks, often extending supply lead times.

Forrester observed that the impact of these decisions increases proportionally with the time that it takes to propagate the demand or general supply chain disturbance—if it takes 10 days to pass a demand change upstream to the manufacturer then a 5% increase in demand will result in a 50% load increase in manufacturing.

The first step in preventing this effect is to identify the combination of those policies, procedures, and behaviors within the specific supply chain—to understand what drives customer demand planning, ordering policies, and the triggers for supply replenishment quantities at various points in the supply chain. Some of the more common causes are:

Demand Forecast

- **No visibility**

- **of consumer demand**

- Forces parts of the supply chain to predict demand—a constantly incorrect number

- **Multiple forecasts**

- Send multiple (and often conflicting) signals in the supply chain

- **Long lead times**

- Cause a longer-term forecast with even higher forecast errors.

Order Batching

- **High order costs**

- Drives procurement to consolidate orders and order less frequently

The less that customers understand the variability of supply, the more likely they are to “buffer” themselves.

■ **Change over, production batch size economics**

Marginal costing and local overhead recoveries send a false signal to manufacturing managers who drive to longer production runs which are less representative of the customer’s true needs.

■ **Full truckload economics**

Local transportation costs drive consolidation of loads and holding back of orders until the truck or container is full, thus driving manufacturing to fill to this altered schedule.

■ **Random or correlated ordering**

Random ordering on one side of the supply chain becomes the input for prediction in another, driving organized chaos upstream. Correlated ordering—“We usually buy product X when we buy product Y”—places a false requirement in the supply chain for product X.

Price Fluctuation

■ **High/low pricing**

As pricing fluctuates it either stimulates large orders from customers for price breaks or delays customer orders with price increases. This sporadic ordering pattern is often confused with the true market needs—and usually drives higher safety stock requirements throughout the supply chain.

Rationing and Shortage Game

■ **Proportional rationing scheme**

As supply becomes limited and customers realize that suppliers are consistently delivering only a portion of their orders they begin to increase their future orders in such a manner so that their proportional “allocation” meets their total needs. This inflates the true demand significantly and has even driven significant capital investments, such as additional plants, to meet a demand that clearly does not exist.

■ **Ignorance of supply conditions**

The less that customers understand the variability of supply, the more likely they are to “buffer” themselves.

■ **Unrestricted orders and free return policy**

Such policies give customers the best of both worlds, but when abused they create enormous amounts of inventory within the supply chain. Customers place large orders to gain “volume discount” pricing and then return the inventory when overstocked or when the financial period is closed, creating an extremely “lumpy” demand picture.

The most effective process for smoothing out disturbances caused by the bullwhip effect is to propagate the true (unrestricted) demand data quickly up the supply chain.



To reduce the bullwhip effect your supply chain should function without boundaries.

Secondly, make sure customers and suppliers understand what drives demand and supply patterns, then collaborate on improving the integrity of this information, the speed at which it's transmitted, and the overall focus on global supply constraints.

The Do's and Don'ts of the Bullwhip...

To reduce the bullwhip effect your supply chain should function without boundaries; the result is called "Supply Chain Synthesis" which is defined as a holistic, continuous improvement process of ensuring customer satisfaction—from the raw material provider to the final consumer of the finished product.

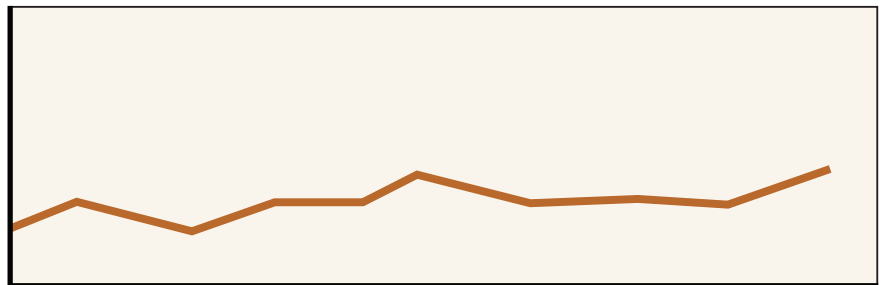
To achieve this goal, companies must first look at their own internal operations. They must reevaluate

Most importantly they must establish internal communication channels so everyone is part of the solution.

With an internal operation under control the focus shifts externally—and managing externally means across the entire supply chain, from a company's supplier's supplier to the company's customer's customer. Communication is key to delivering a smooth and efficient total supply chain. Don't second-guess what's happening in the supply chain; base your business on facts, not the altered or "false" demand flowing through the pipeline. Companies that truly integrate and move beyond simply "interfacing" applications have a competitive edge that allows smoothing the bullwhip. The power lies in the process and how people's behavior is driven within the process.

A Smoothed Total Supply Chain

Figure 4:
A total supply chain with the bullwhip effect smoothed to a minimum



and ensure that policies and procedures designed to improve or realize specific local optimization costs are not detrimental to the total supply chain. They must consider how demand and supply signals are contaminated and distorted as they pass from group to group and operation to operation.

To reduce the bullwhip effect, companies should strive toward:

- **Accessing real customer data**
Nothing is more effective than seeing and communicating true demand throughout the supply chain.

Discovering the bullwhip effect does not automatically solve the problem.

■ **Sharing capacity and supply information**

Collaboration and communication throughout the supply chain helps prevent poor decision making.

■ **Selecting the most appropriate forecasting method**

Inaccurate forecasts begin the downward spiral and encourage mistrust and judgment.

■ **Adopting smoother forecasting policies**

Adopt policies that impose less volatility on the supply base. Develop exception alerts and limits. Instigate better business practices. Communicate!

■ **Avoiding forecasting methods and order policies that respond only to local costs rather than supply chain-wide costs**

■ **Viewing the supply chain as a complete entity—from your supplier’s supplier to your customer’s customer.**

In general, the major cause of the bullwhip effect seems to be a lack of “systems thinking” and a global approach to optimization by management. This is most evident in the measurements on local managers and employees that contradict each other through the parts of the supply chain. The main gains afforded by reducing the time in transferring

actual consumer sales data are better order control and reduced stock levels. Reduced distortion and delay of propagation of market data through the supply chain limits the effects of uncertainty resulting from the magnification of orders upstream.

Discovering the bullwhip effect does not automatically solve the problem. The effect can only be avoided if well-established business behavior is altered. People often don’t understand what overall behavior will result from the complex interconnections of known local actions, but they’ve been “driven” to enforce these decisions, in many cases for years. Improving data integration and “real-time” flow does not necessarily mean better coordination and collaboration—this occurs when decisions are made using information to improve the total supply chain performance.

Removing the true barriers to integration means removing those policies and procedures that alter, massage, and manipulate the demand signal—that ultimately result in the sting of the bullwhip effect.



To learn more, contact the supply chain specialists at Spinnaker. Call **877-476-0576** or visit **www.spinnakermgmt.com**.

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