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# **The Bullwhip Effect in Supply Chains**

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## The Bullwhip Effect in Supply Chains

One of the most important phenomena in Supply Chain Management is the Bullwhip Effect. It was discovered by Stanford Business School Professor and P&G. P&G noticed that orders it received from its customers (Wal-Mart, grocery chains, Target, etc.) for diapers varied much more than the variation in demand from consumers. It then looked upstream in the supply chain and found that the orders it placed to its suppliers varied more than the orders it received from its customers.

Dr. Hau Lee from Stanford coined the term The Bullwhip Effect because demand variation amplifies the further one goes upstream in the supply chain; similarly to how a small movement of a bull whip at the handle creates a large movement at the end. The bullwhip effect looks like a wave with very high peaks and very low valleys. But these peaks and valleys are “artificial” in that they don’t represent the real variation of end-customer demand.



Figure 1: Dr. Hau Lee, discoverer of the Bullwhip Effect

In Figure 2 and 3 below you can see the Bullwhip Effect in action. Sales vary less than shipments in the top of figure 2. The furthest back echelon in the supply chain varies the greatest as shown in the bottom of figure 2. Manufacturing output decreased almost 15% in the Great Recession of 2007-2009, but total economic output decreased only 4.1%.

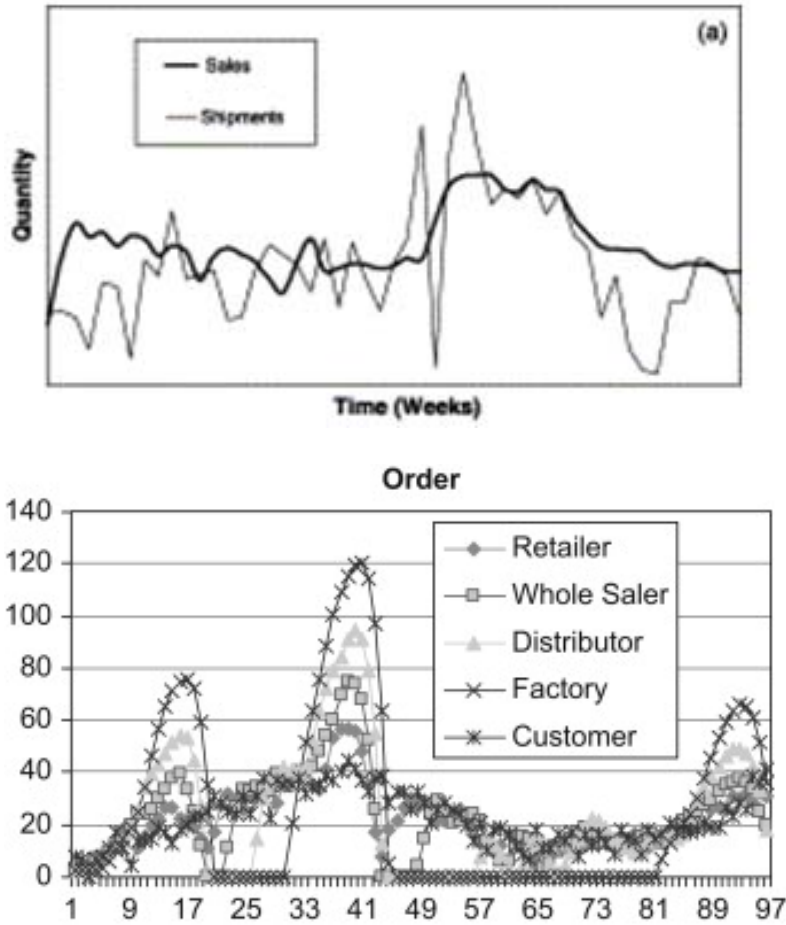


Figure 2: Examples of the Bullwhip Effect

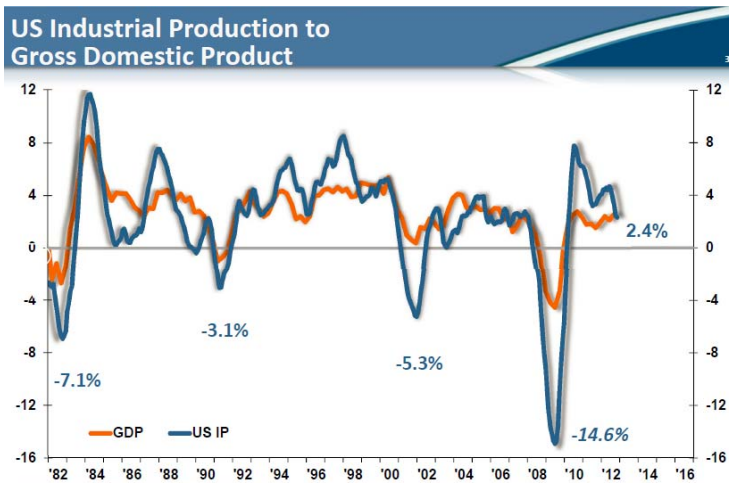


Figure 3: The Bullwhip Effect in the Manufacturing Economy



### Why the Bullwhip Effect is so Bad for Supply Chains and Companies

By creating these peaks and valleys, companies have to handle alternating periods of very high demand followed by very low demand. Because companies are loath to forgo sales they will size their factories, warehouse, staff and inventory to handle these peaks. The size of these is greater than what is needed to handle true customer demand variation, but because of the bullwhip effect companies have to over-size to fulfill customer orders. In addition, they will have to schedule overtime, followed by periods where their employees may be idle because of lower demand during a bullwhip “valley”.

### What Causes the Bullwhip Effect

Dr. Lee discovered three very common causes of the bullwhip effect. (Note, he also discovered a less common cause, which I will not cover in this article.) The three common causes are:

- Over and Under Forecasting
- Economies of Scale in Ordering and Transportation
- Price Discounts

“Over and Under Forecasting” occurs when a company forecasts demand to place orders with its suppliers. People (being people) will react to current demand trends, even if history doesn’t support these trends being sustained. Who wants to under-order when demand is “going through the roof” or over-order when demand is “cratering”? Therefore, people use the latest customer demand levels to adjust forecasts, and orders to suppliers, up or down. In addition, people (again being people) forget to consider inventory they may already have on order, and will adjust orders above what a computer reorder point will recommend.

Unfortunately “Economies of Scale” in transportation and ordering is a real factor. While we would all like to have supplies shipped “just-in-time”, it is usually not practical or cost-effective. Filling up a large truck or rail car is the best way to lower unit costs of transportation. Freight rates for less-than-truckload shipments are much higher than truck-load because of economies of scale for the shipping company. It is much easier (and costs less) to fill up an entire truck at one site, drive it to the destination and unload the entire truck. There are many other reasons for economies of scale in transportation, and all procurement and logistics people know they exist. For example, if a company needs 100 units to fulfill their production requirements for the next week, they may order 500 because it fills up a large truck. This 500 unit order becomes a peak of demand to the supplier.

“Price Discounting” is one of the most confounding causes of the Bullwhip Effect to us Supply Chain people, because it seems so easily avoidable. However, companies know that they need to create retail excitement or compete during important holiday



seasons. Therefore, they lower their prices, moving demand to the price discounting period. Customers purchase more than they need, or wait until the time of the year when discounting is rampant to make their purchases. This artificially creates peaks and valleys of demand shown in Figure 2.

### How to Reduce the Bullwhip Effect

#### “Over and Under Forecasting”

There are two ways to easily reduce “over and under forecasting.” The first is to use computer advice to order materials. Computers don’t react, worry about running out or react to current demand signals from customers. They are more logical and don’t over or under forecast. Second, and more importantly, you should work with suppliers to reduce lead times. Dr. Lee proved mathematically that longer lead times increase the bullwhip effect because you have to forecast over a longer period of time.

#### “Economies of Scale in Transportation”

As stated before, there is no getting around the fact that full trucks are lower unit cost than small or partially full trucks. So the key is that you have to fill up a large truck, but not fill one up. How can you do this... by using a third-party logistics (often called a 3PL) company. These firms work with many customers and fill up trucks from multiple stops that then travel a freight lane full. It is not as inexpensive as filling up a truck all by yourself, but it is a good compromise and helps to reduce the bullwhip effect.

#### “Price Discounting”

Wal-Mart got it right when it introduced Every Day Low Pricing (EDLP). If people know that you won’t have a sale, they won’t wait to purchase what they need or want. If you don’t deep discount then they won’t over-purchase causing first the sharp peak and then the deep valley of demand in the following time period.