MIT Center for Transportation & Logistics

The Beer Game Debrief

August 22, 2017

Cambridge, MA

MIT Center for Transportation & Logistics

Debrief Plan

How did you feel while playing?

Were there any problems? If so, what?

What caused these problems?

What are some solutions to these problems?

Announce winners

Analysis

Heard While Playing

It just goes SO wrong SO quickly (factory)
Don't look at my backlog! (retailer)
We're in a BIG mess – I underforecasted and then I overforecasted (retailer)
(with sadness….) I didn't look where I was pulling from…. (retailer)
We got mixed signals (factory, about distributor)
I've seen this (bullwhip) too much in actual production (factory)
You guys CANNOT be talking to each other (table facilitator)
Two handed slide (sing song by one of the facilitators)
Game over – what?! Boooo….

How did you feel while playing?

Were there any problems? If so, what?

And how would you solve those problems?

How would you solve those problems?

So who won this game?

• The Smugglers**	$2,775
• IPAs*	$4,604
• Kool Beer*	$1,032
• Macro-Brew	$2,281
• MIT Brau	$1,840
• Fat Tire	$4,177
• Topp Hopps	$4,785
• On Tap	$4,166
Average for this game	$3,145

*Expert table

** Factory didn't count backlog for 10 weeks….

How do most teams do?

• Top scores	~$1,000+
• Worst scores	$24,000+
• Average	$2,000
• Best Possible	$200

A Mystery

Why do smart, well-intentioned people perform so poorly?

Unravelling the Mystery…

Most people deal with system at the level of ……

Events

Event Thinking

Saturday, May 14, 2005

Union divided over how to reverse membership drop

WASHINGTON – … Labor leaders cite many reasons for the decline: The global economy, trade agreements, … poor enforcement of labor laws, and Republican tax policies that squeeze the middle class.

Event Thinking

Union Membership Drops to Record Low

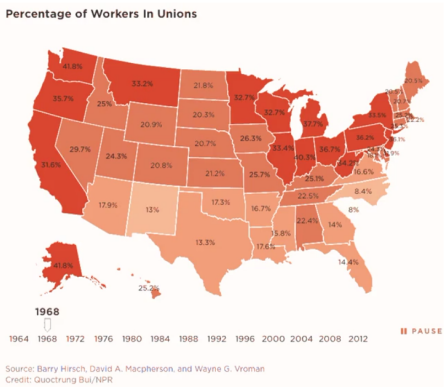
"Much of the decline is coming from shifts in the economy," said Greg Denier, a spokesman for Change to Win, a federation of labor unions. "Thousands of jobs are being outsourced or lost to technological changes."

"The unions are losing so many members each year because their jobs are being outsourced and they are organized in shrinking sectors of the economy, like autos, steel and textiles," said Gary Chaison, a labor specialist at Clark University in Worcester, Mass.

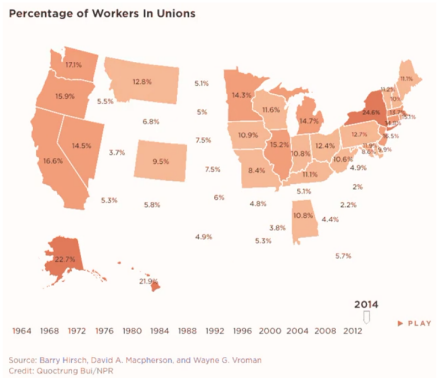
Ref: Will Lester, Associated Press, Thursday, January 25, 2007

Event Thinking

1968

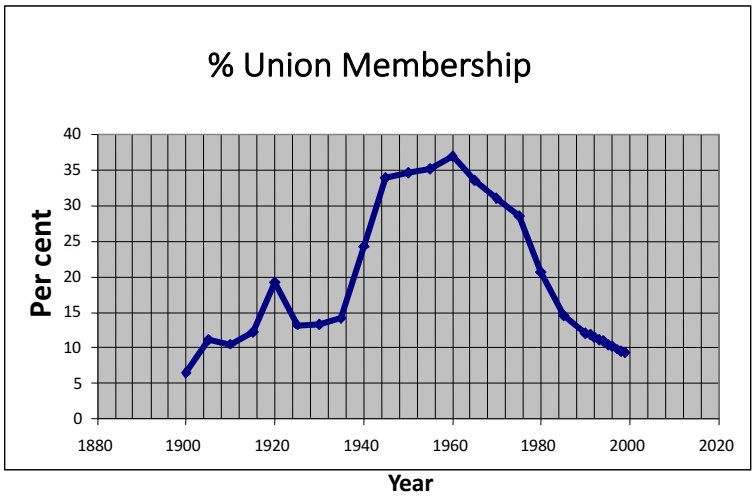


2014



https://gfycat.com/gifs/detail/DaringEmbellishedHake
https://www.washingtonpost.com/news/wonk/wp/2015/02/24/the-incredible-decline-of-american-unions-in-one-animated-map/?utm_term=.534a3cc2404f

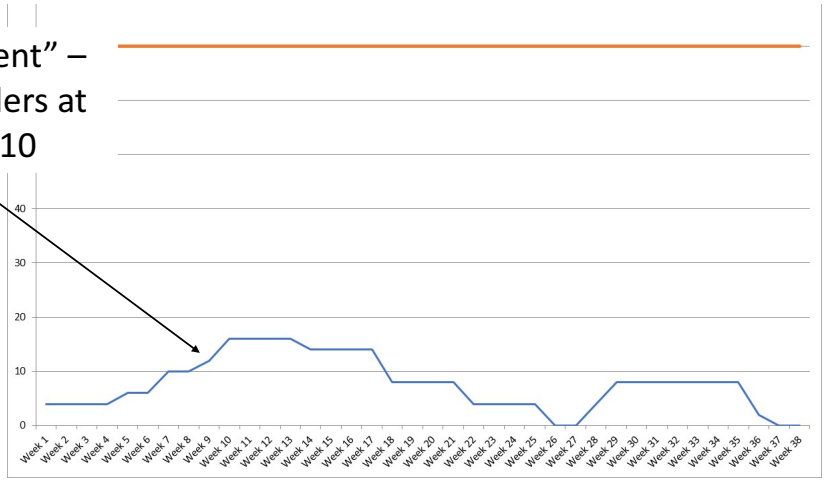
Event Thinking



Example

Ex. Jan '16 Sam Adams – Orders by Retailer

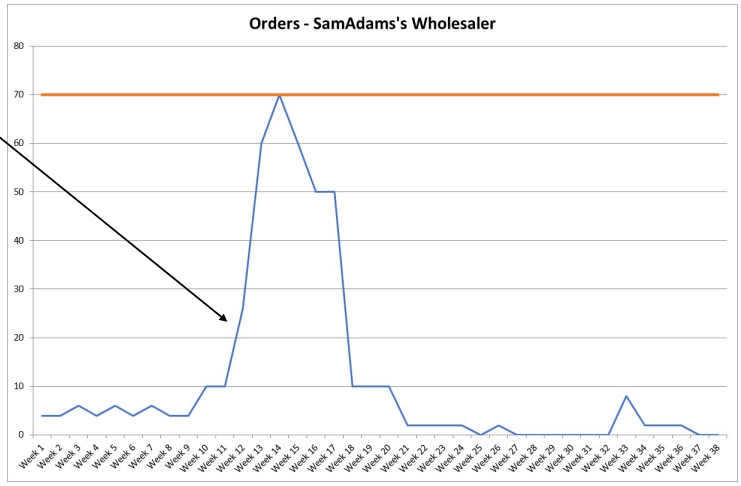
Trigger "Event" – spike in orders at week 9-10



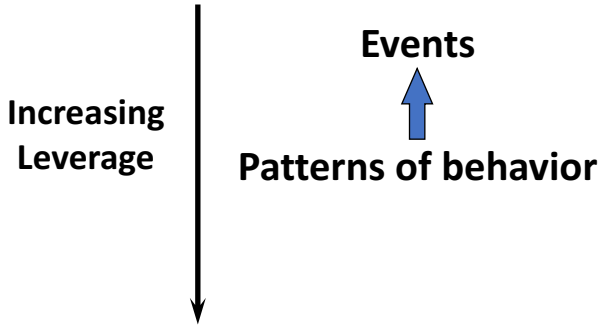
Example

Ex. Jan '16 Sam Adams – Orders by Wholesaler

Response to Event – giant orders at weeks 11-12



Events are "just" the visible manifestation of patterns



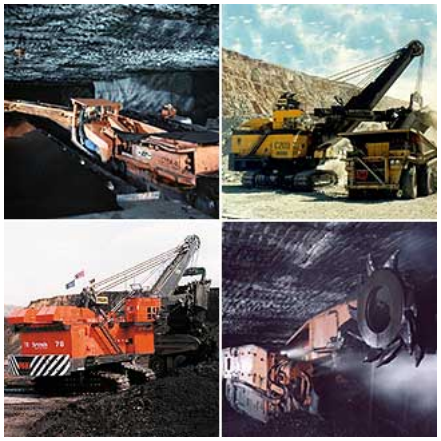
Industry Example: Andre Horn

JOY MINING MACHINERY

Founded in 1920

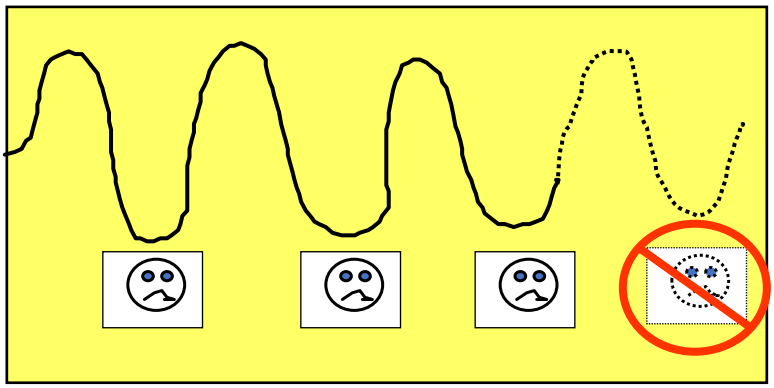
Pioneer in underground mining equipment

Andre Horn offered CEO post after unprofitable year….



Andre Horn

Before he took the job, Horn presented to the Joy Mfg Board….



change in profits

What patterns did you observe?

Common Patterns

- Oscillation
  - Large amplitude fluctuations, average 20 weeks.
- Amplification
  - Amplitude and variance of orders increases steadily from customer to retailer to factory.
- Phase Lag
  - The order rate tends to peak later as one moves from the retailer to the factory.

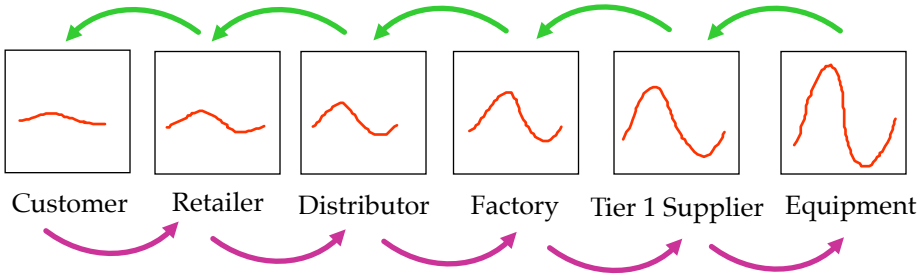
We call these collective patterns "The Bullwhip Effect"

- "Bullwhip" coined by Prof. Hau Lee (1997)
  - is where "information transferred in the form of orders tends to be distorted and can misguide upstream members in their inventory and production decisions… the variance of orders may be larger than that of sales, and the distortion tends to increase as one moves upstream"*
  - describes the general tendency for small changes in consumer demand to be amplified within a production-distribution system**

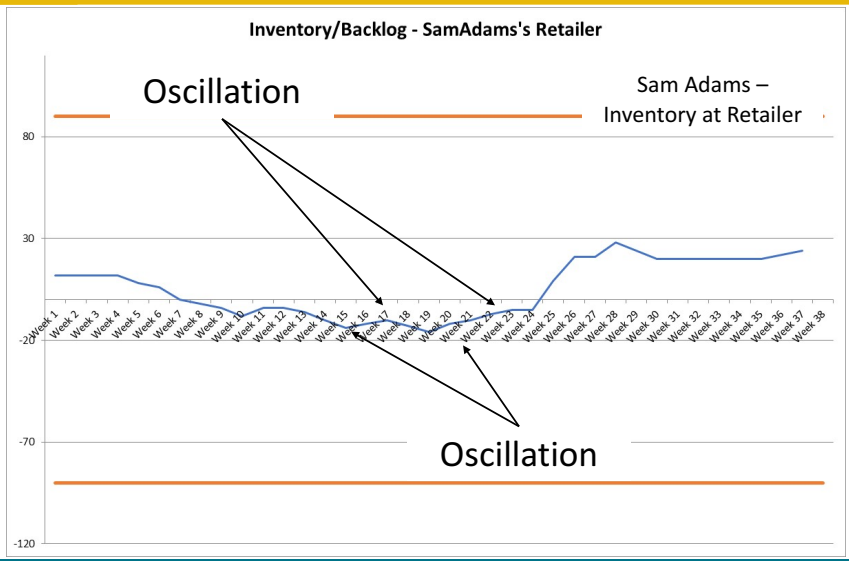
* Lee, Padmanabhan and Whang, The Bullwhip Effect in Supply Chains, Sloan Management Review, Spring 1997

** McCullen and Towill, Diagnosis and reduction of bullwhip in supply chains, Supply Chain Management: An International Journal, Vol 7, No 3 2002

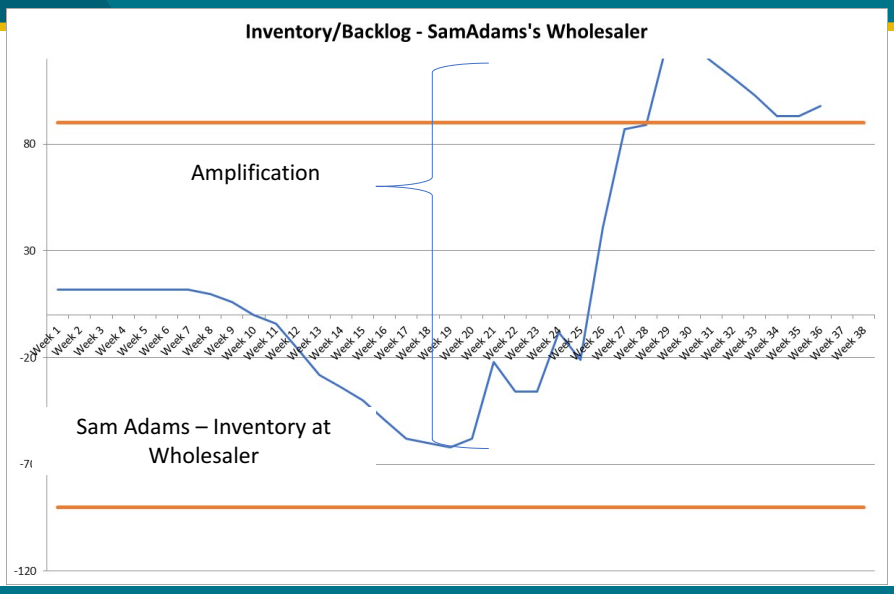
"The Bullwhip Effect"



Oscillation Example – Jan 2017



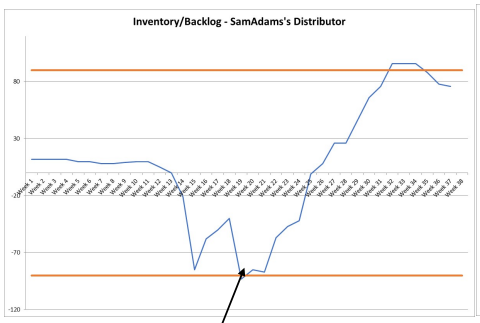
Amplification Example – Jan 2017

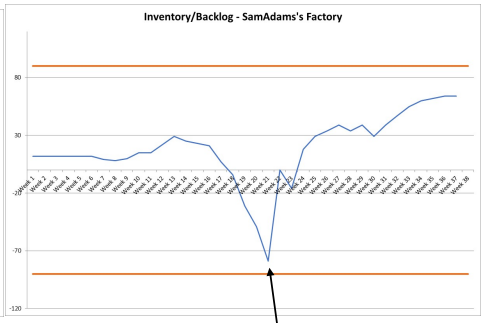


Inventory Phase Lag Example – Jan 2017

Sam Adams – Inventory at Distributor

Sam Adams – Inventory at Factory





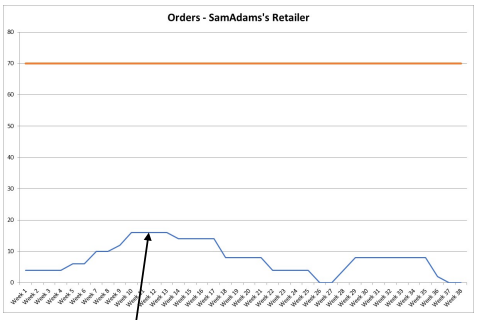
Phase lag – low point at week 19

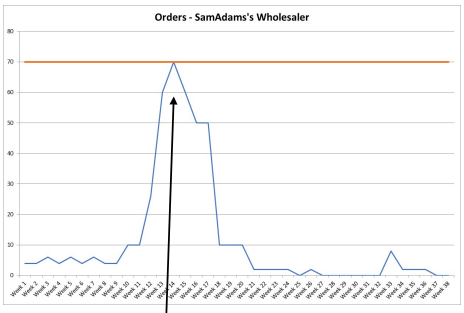
Phase lag – low point at week 22

Orders Phase Lag Example – Jan 2017

Sam Adams – Orders by Retailer

Sam Adams – Orders by Wholesaler

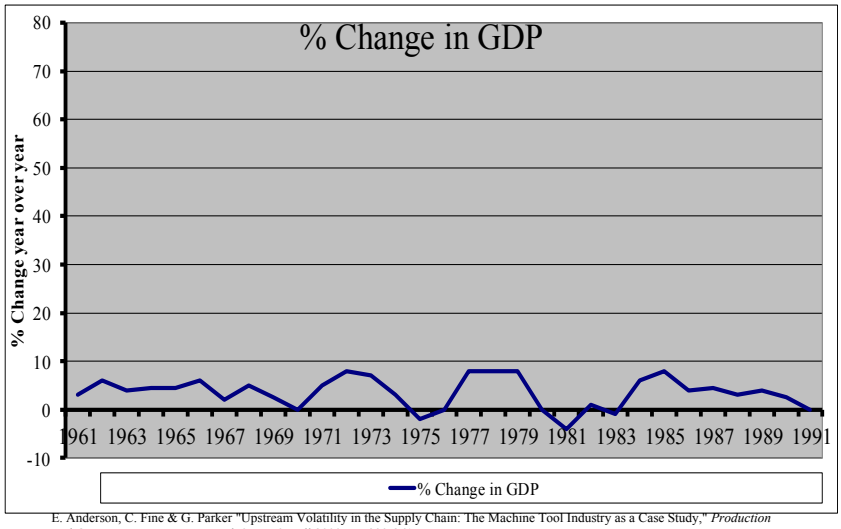




Peak at Weeks 10-13

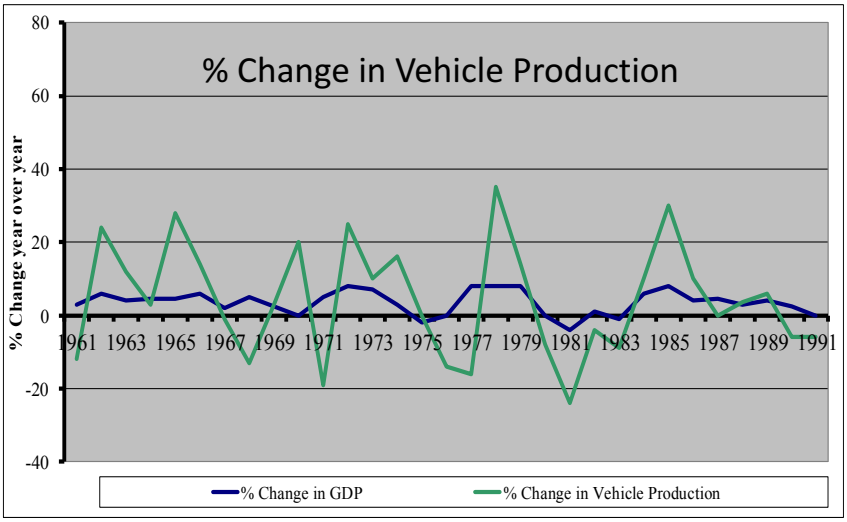
Peak at Weeks 13-15

Supply Chain Volatility Amplification: Machine Tools at the tip of the Bullwhip



E. Anderson, C. Fine & G. Parker "Upstream Volatility in the Supply Chain: The Machine Tool Industry as a Case Study," *Production and Operations Management*, Vol. 9, No. 3, Fall 2000, pp. 239-261.

Supply Chain Volatility Amplification: Machine Tools at the tip of the Bullwhip



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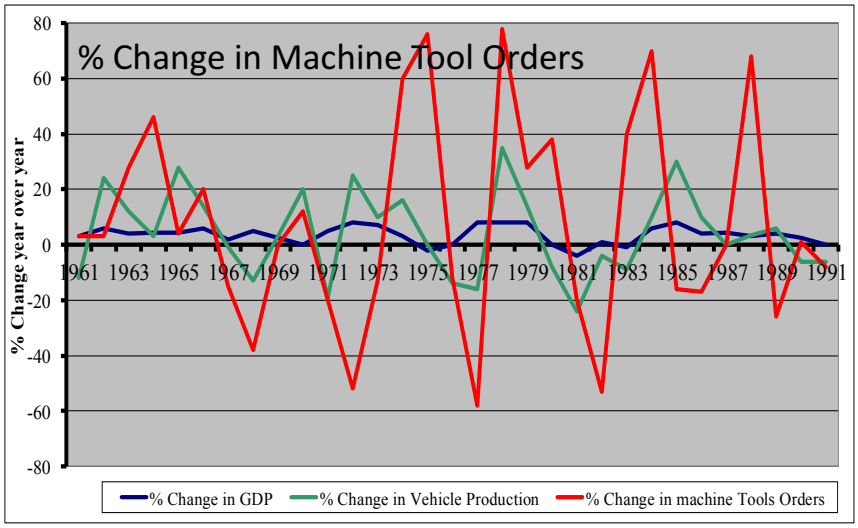
Supply Chain Volatility Amplification: Machine Tools at the tip of the Bullwhip



E. Anderson, C. Fine & G. Parker "Upstream Volatility in the Supply Chain: The Machine Tool Industry as a Case Study," *Production and Operations Management,* Vol. 9, No. 3, Fall 2000, pp. 239-261.

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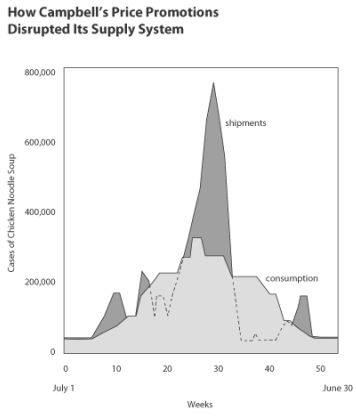
Examples of patterns in your supply chain?

- Oscillation
- Amplification
- Phase Lag

Bullwhip & Soup: Event, Pattern

- **Event:**
  - **Spike in winter season soup sales**
- **Patterns:**
  - **Consumption shows an increase in winter season**
  - **Shipments increase 2X maximum consumption in the winter season**



Graphic Ref.: Harvard Business Review, March-April 1997, pg 112

Questions about patterns

- Who did the worst on each team?
- Was the experience the same or different for each team?
- What did the demand patterns by customer look like?

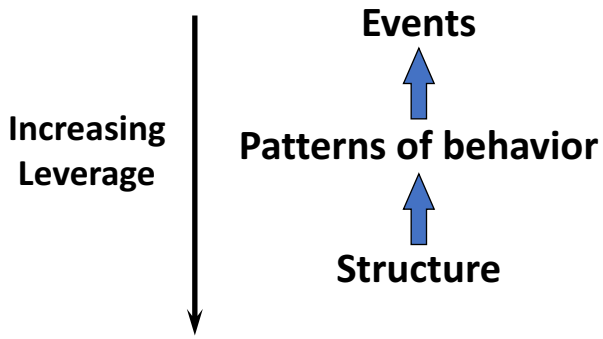
What demand patterns did you observe?

The actual pattern was……

But the "Estimates" of Customer Demand Indicate

- People are transferring "event orientation" to patterns
- The cause is still a single thing
- The cause is 'out there'

The Ultimate Cause is Structure

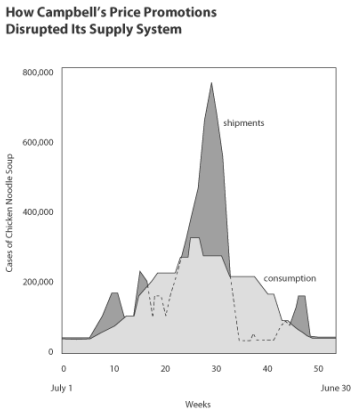


The behavior of the players is controlled by the structure of the system

Slide adopted from Dr. Jim Hines, MIT System Dynamics Group

Bullwhip & Soup: Event, Pattern, Structure

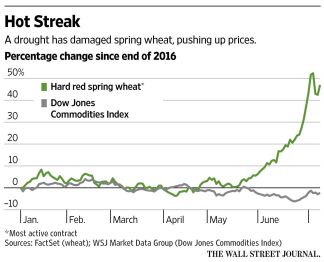
- **Event:**
  - **Spike in winter season soup sales**
- **Patterns:**
  - **Consumption shows an increase in winter season**
  - **Shipments increase 2X maximum consumption in the winter season**
- **Structure:**
  - **Sales promotions and incentives encourage inventory buildup beyond demand**



Graphic Ref.: Harvard Business Review, March-April 1997, pg 112

Bullwhip & Wheat: The Facts

- **WSJ 5-3-17 reports grain surplus, food processors have no incentive to buy in advance**
- **WSJ 7-10-17 reports wheat shortage, 40% price increase, speculators buying**



THE WALL STREET JOURNAL.

MARKETS

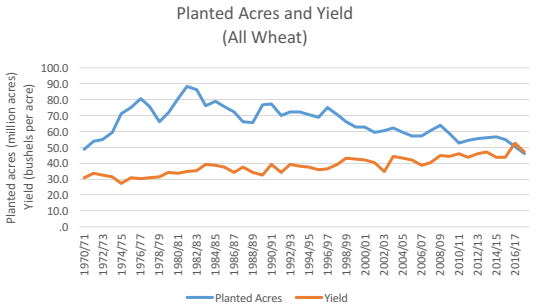
Traders Gobble Up Wheat Amid Great Plains Drought

Spring wheat futures surge, drawing speculative investors to a typically lonely corner of financial markets

By Benjamin Parkin
Updated July 10, 2017 11:38 a.m. ET

Bullwhip and Wheat: Event, Pattern, Structure

- **Event: Global grain glut Spring 2017**
  - **Response: Farmers fallow fields (i.e. they do not plant)**
  - **"Farmers sowed the fewest acres of wheat in a century this year."**
- **Patterns:**
  - **# planted acres of wheat has been declining for decades**
  - **Yield has been increasing for decades (enabled by technology and process)**

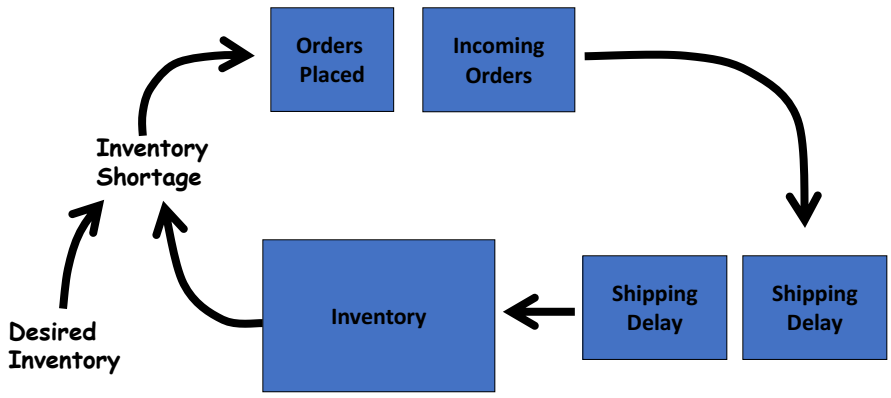


- **Structure:**
  - **Fewer planted acres are required for the same output**
  - **Fewer acres planted makes for system more prone to drought risk**

Bullwhip and Wheat: Options

- We see that structure is driving the patterns:
  - The agriculture system requires fewer acres for the same output
  - But less acreage planted makes for system more prone to drought risk
- Knowing there's more risk in the agricultural wheat production system, consider some actions to take:
  - Buy contracts early to lock up supply
  - Contract for supply direct
  - Contract for supply from different locations to spread regional drought risk

Beer Game Structure



Causal Loop Diagrams

Now that we understand the patterns and structure…

- What are the structural problems?
- What are some solutions?

What are the structural problems?

What are the structural problems?

- Information lags – 2 weeks between each stage
- Delivery lags – 2 weeks between each stage
- Limited information - each weekly order is the only info provided
- Each stage forecasting independently
  - No coordination permitted
- Actual demand unknown except at retailer
- Cost structure – twice expensive to stockout than to carry inventory

Other common structural problems

- Pricing policy – encouraging bulk purchases, forward buying→ artificially creates spikes
- Cancellation policy – can enable over-ordering if there are no downsides for cancellations
- Promotions & discounting – can shift demand into cyclical purchase patterns rather than steady resupply based on actual demand
- Allocation policy in constrained supply environment – can enable over-ordering
- Inconsistent incentives
  - Quarterly sales goals, unit cost factory measure, lowest cost distribution

What are the some solutions?

What are the some solutions?

- Collaboration
- Increase visibility
- Use historical data
- Shorter delays
- Eliminate middle-man
- Strategic partnership & information sharing
- Align policies, incentives, perf. measures

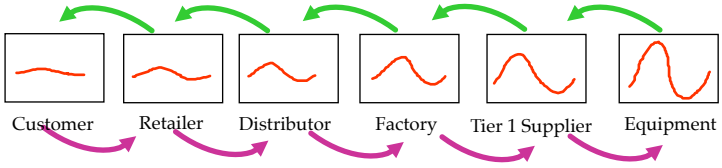
Some suggestions & challenge to implement

- Collaboration
- Increase visibility
- Use historical data
- Shorter delays
- Eliminate middle-man
- Strategic info sharing
- Align incentives, KPIs

Difficult	Less Difficult
√	
√	
	√
√	
√	
	√
	√

These all effect the structure of the system…..

Applying these to "The Bullwhip Effect"



STRUCTURAL PROBLEMS:
Information lags
Delivery lags
Independent forecasting
Order batching
Price fluctuations
Inconsistent incentives
- Gaming allocations
Promotions/discounting

SOLUTION STRATEGIES:
- Reduce Uncertainty
- Reduce Variability
- Reduce Lead time
- Improve Channel Mgt
- Align policies, incentives, KPIs

Thoughts to Leave With

- What caused the problems?
  - Rush to solutions before seeing the problem (oscillations)!
  - Even after seeing the problem we rushed to solutions without understanding the real dynamics (flat demand) and the root cause (structure)
- What will you do when you return to the workforce?
  - Rush to solution?
  - Or will you first determine the root causes?
  - How will you do that?
  - How will you find the big problem in your system?

Thank you

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Reference

- "The Fifth Discipline" by Peter Senge
- Available at the MIT COOP (next to Marriott)