Behavioral Causes of the "Bullwhip" Effect in Supply Chains

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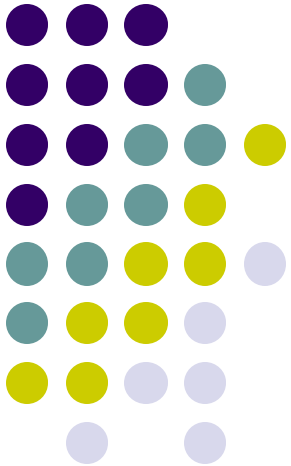
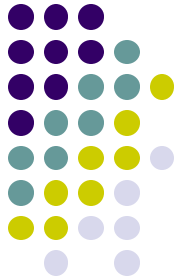


The “Bullwhip” Effect

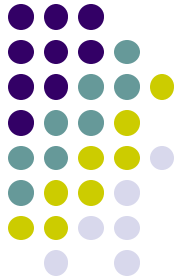


- Orders to increase in variation as one moves up a supply chain.
- The effect is costly because it causes excessive inventories, poor customer service, and unnecessary capital investment.

Operational Causes

- There is a great deal of research on operational causes of the bullwhip effect (see for example Lee et al. 1997):
  - demand signal processing,
  - inventory rationing,
  - order batching
  - price variations

Behavioral Causes of the Bullwhip Effect

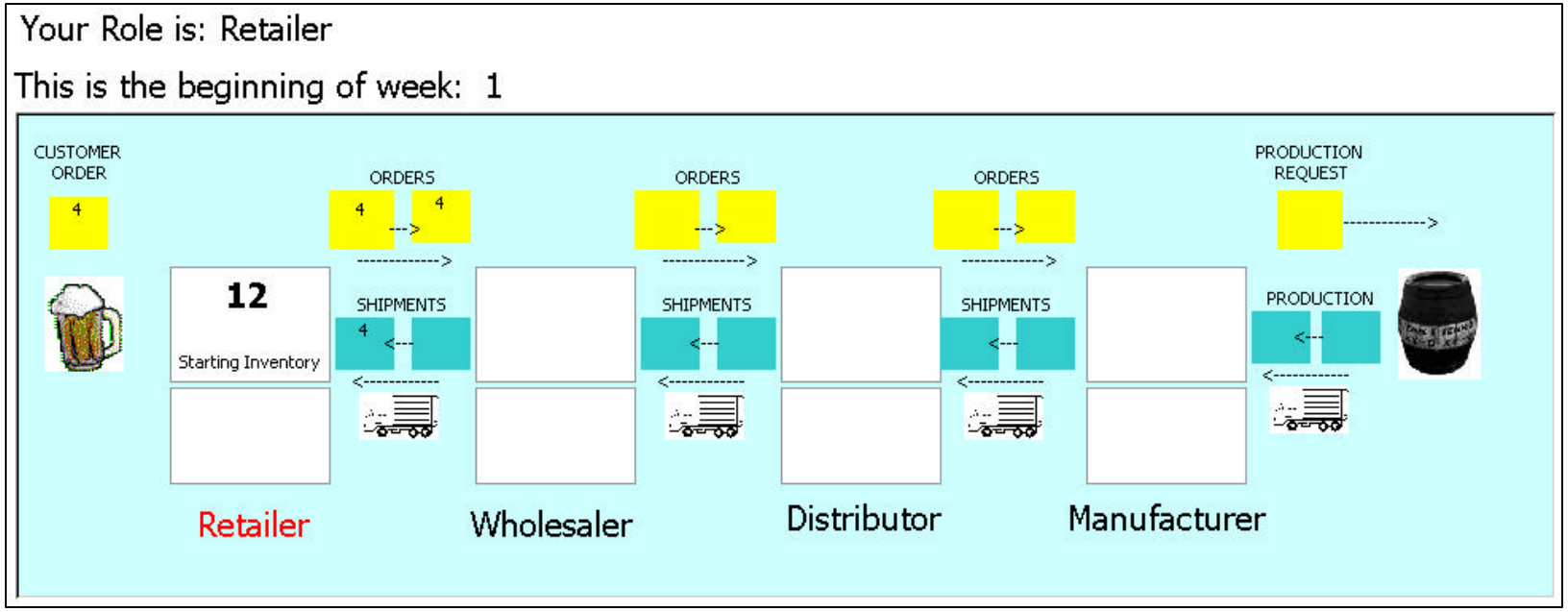


"…the key to improved performance lies within the policy individuals use to manage the system and not in the external environment. Even a perfect forecast will not prevent a manager who ignores the supply line from over ordering." (Sterman 1989, p. 336).

- Implication: the Bullwhip effect will persist even if ALL operational causes are removed (even with constant and known demand).

The “Beer Distribution Game”

- A vehicle we use to study the bullwhip effect in the laboratory.



Research Questions

- Will the bullwhip effect persist in an environment with constant and known demand?
- If so, then we can separate possible causes into two broad categories
  - Cognitive limitations
  - Inability to coordinate

Experimental Design

- Compares performance of subjects in the same roles in teams with all human participants, to teams with one human participant.
- If we see improved performance in the automated teams, we can conclude that, at least partially, the problem is due to the inability to coordinate.

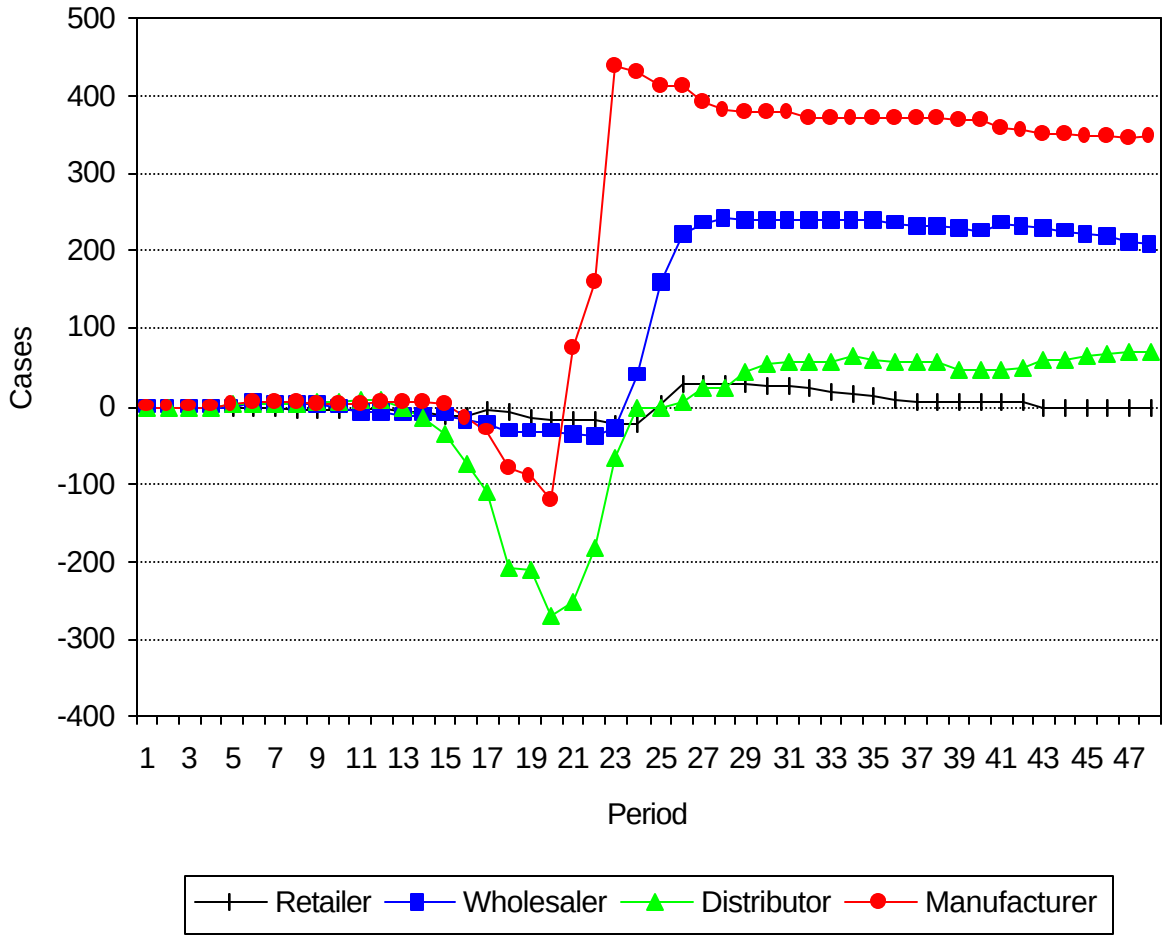
Experimental Design

	Team Composition	
Know Optimal Policy	All Human Teams	One Human per Team
YES	I = 12, 5 teams I = 0, 5 teams	I = 12, 20 teams I = 0, 20 teams
NO	I = 12, 5 teams I = 0, 5 teams	

Customer demand is constant at 4; this is public information
There are 4 cases in each delay position

I = Initial Inventory is either 0 or 12, depending on the treatment.

One Example

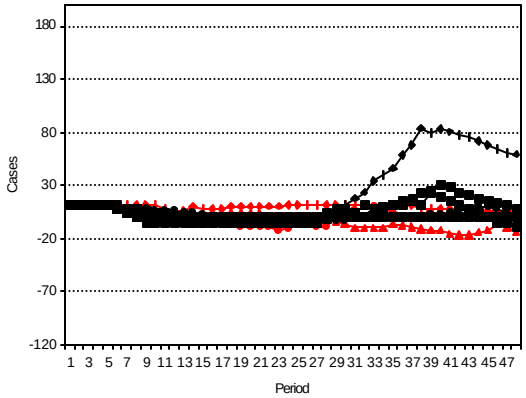


<u>All human team</u>

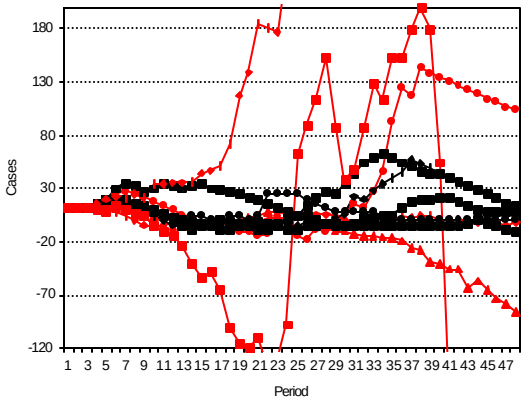
- On-hand inventory
- Initial inventory = 0
- No information about optimal policy provided

Comparisons by Role

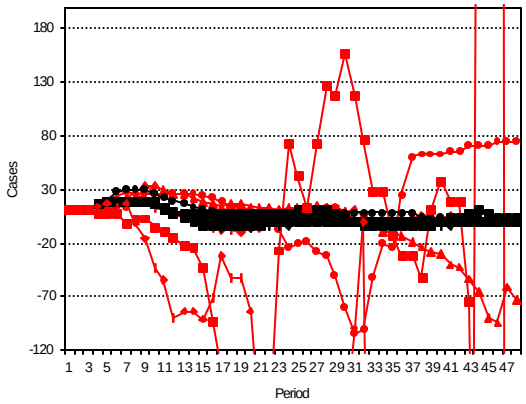
Retailers



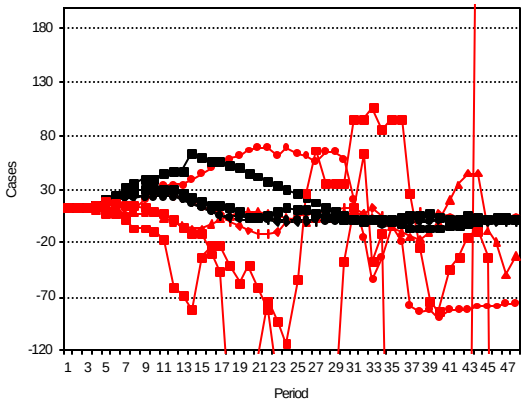
Wholesalers



Distributors



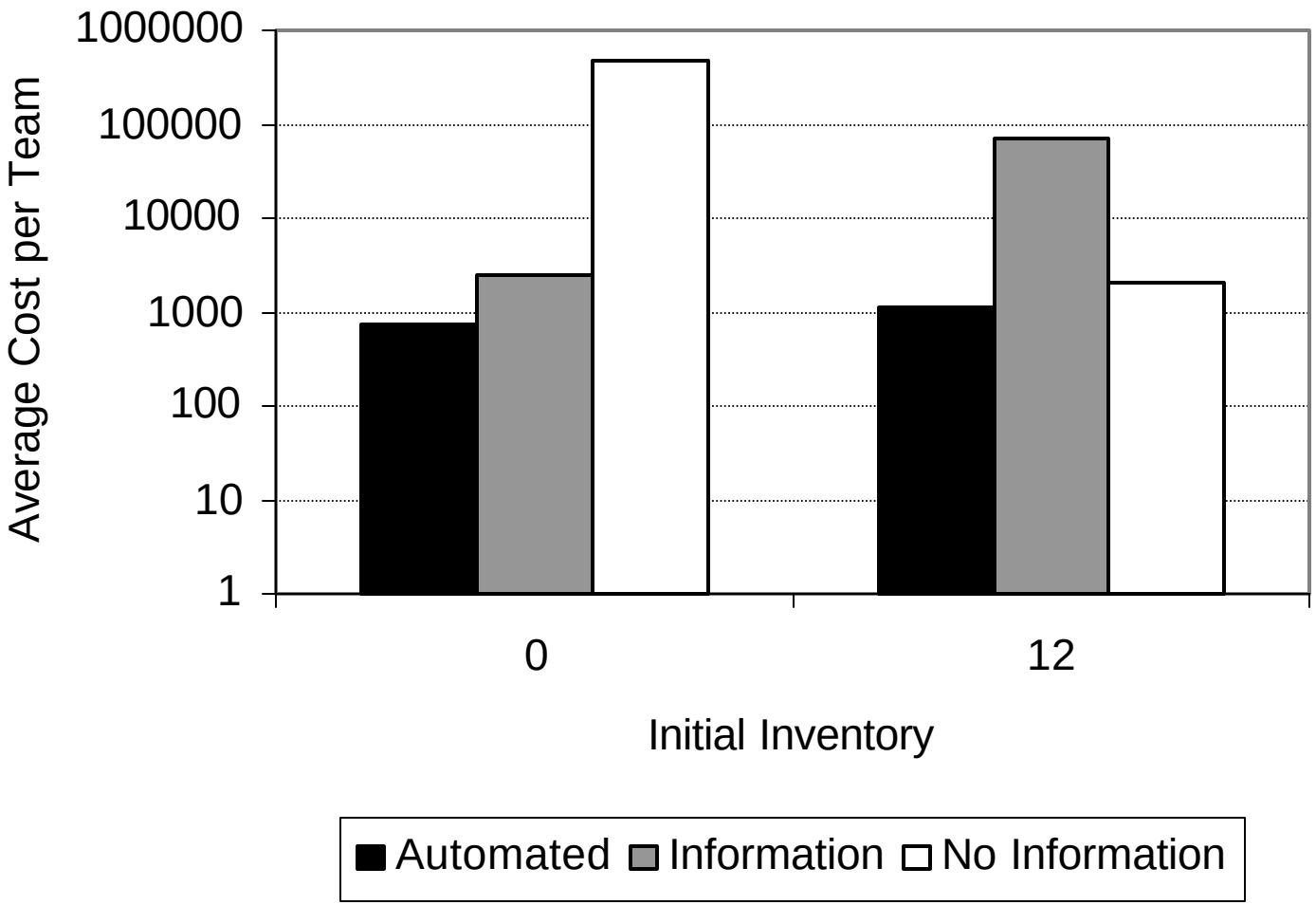
Manufacturers



Automated

Human

Overall Performance...



Estimating Behavior

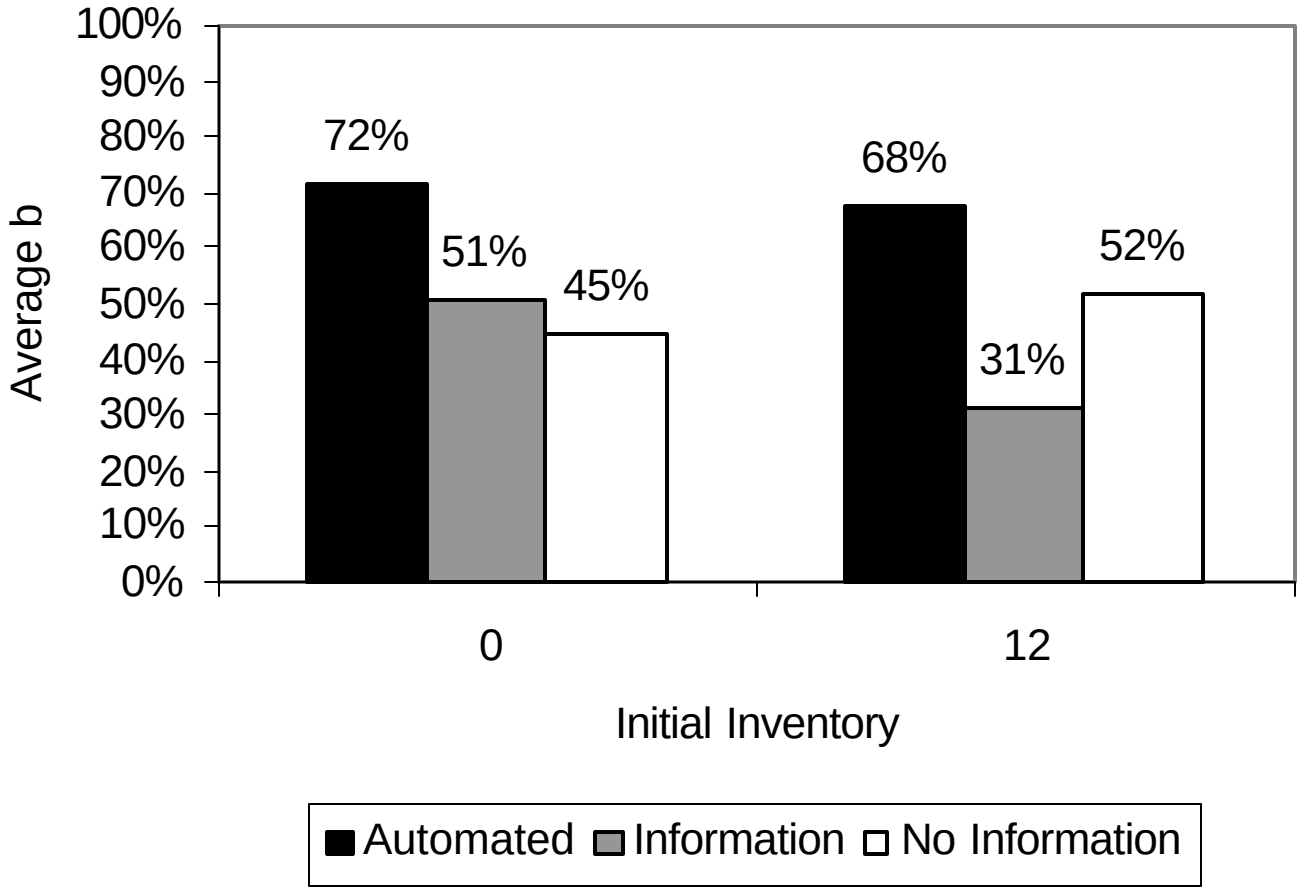
From Sterman ’89:

$$Order = \max\left\{0, EO + a\left[\left(I^* - I\right) - b\left(SL^* - SL\right)\right]\right\}$$

Where:

EO = expected order
I* = target inventory
SL * = target supply line
I = actual inventory
SL = actual supply line
a and *b* are adjustment parameters to be estimated

Ignoring supply line…



Conclusions

- The bullwhip effect persists with known and constant demand.
  - Behavioral explanation
- Telling subjects what the optimal ordering policy is does not help them.
- Human subjects do better when other team members are computerized than when the other team members are human.
  - Coordination is part of the story

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