
In search of the bullwhip effect

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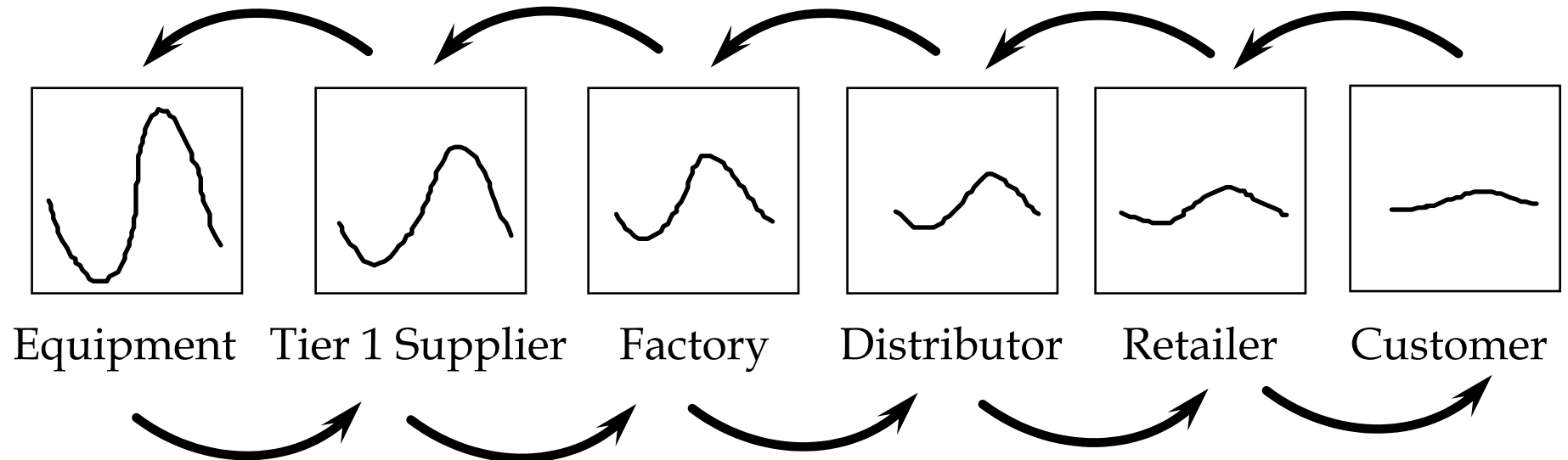
Presented

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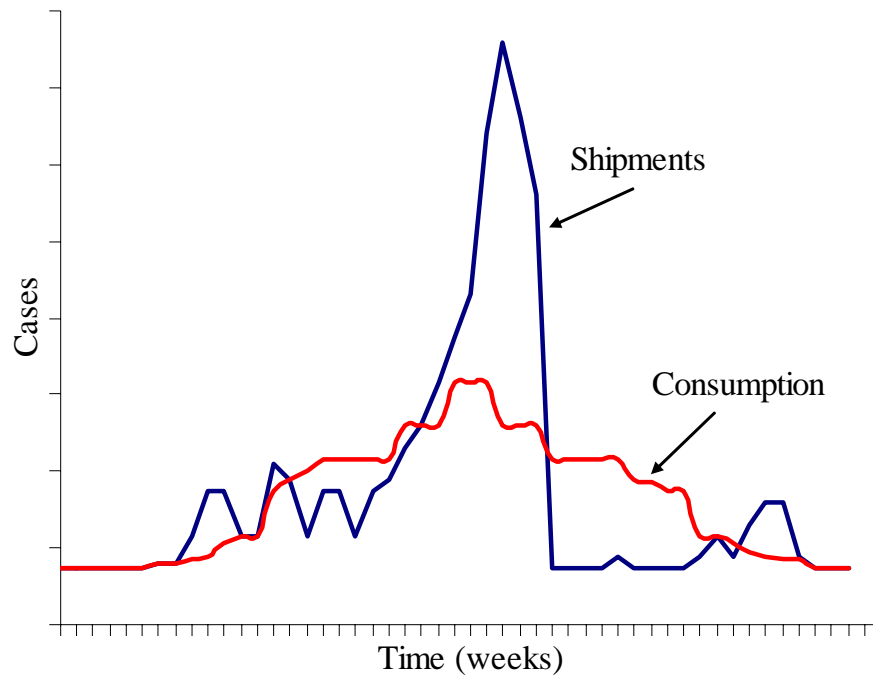
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The bullwhip effect

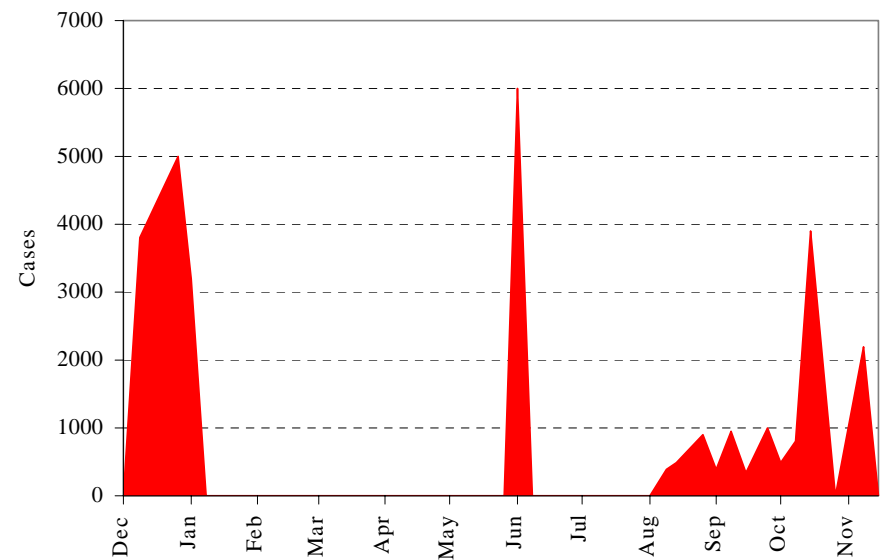
- Demand variability increases as you move up the supply chain from the customer towards supply



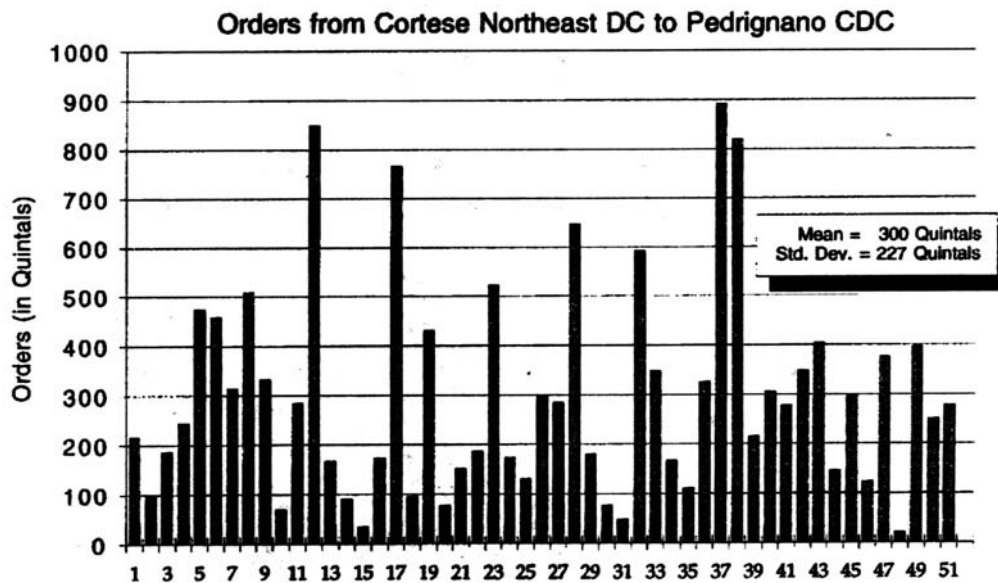
Campbell's Chicken Noodle Soup



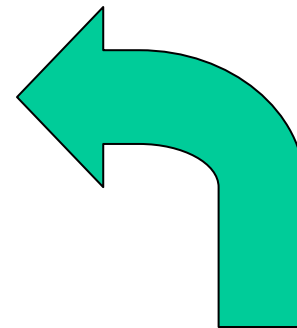
One retailer's buy



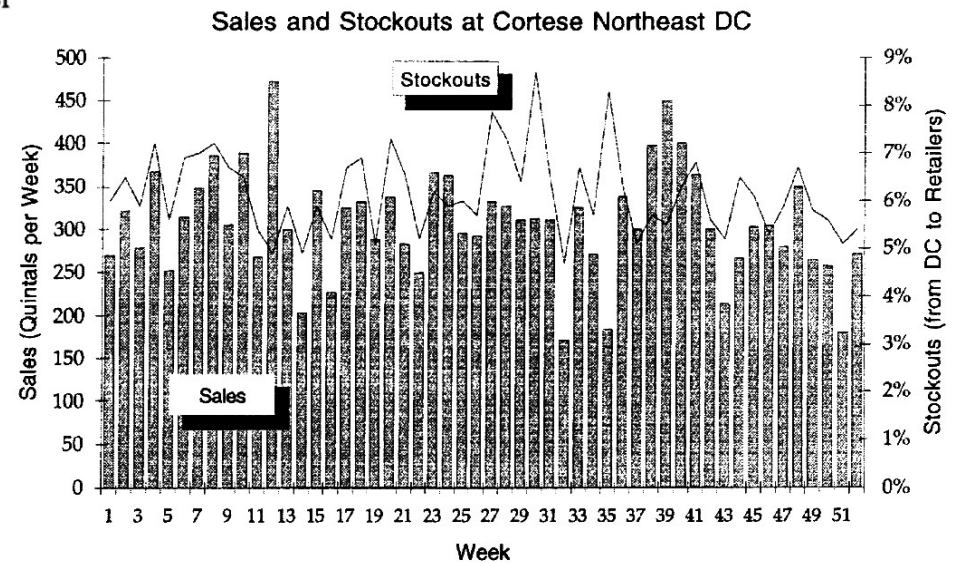
The bullwhip at Barilla pasta



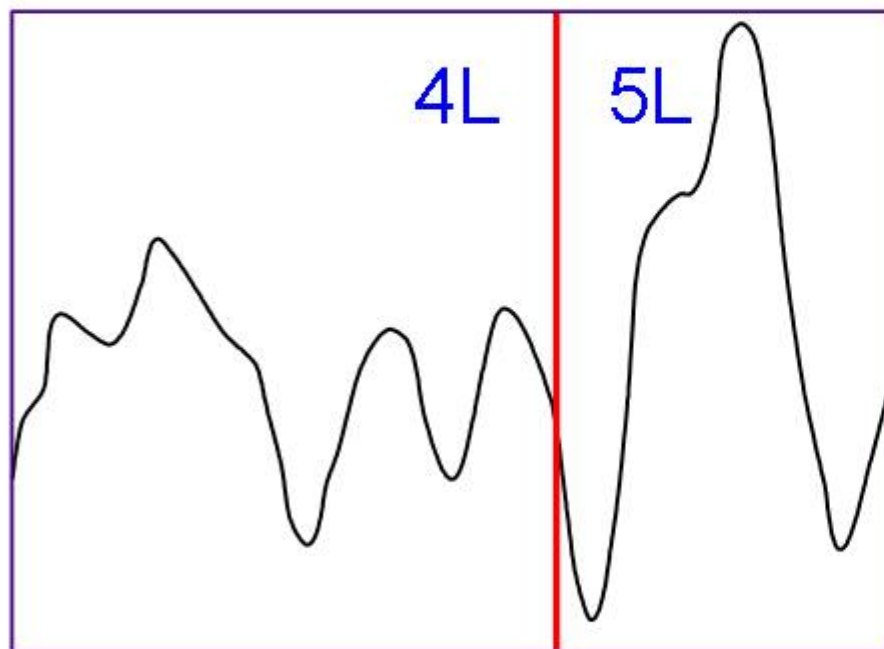
Upstream variability at CDC is much higher



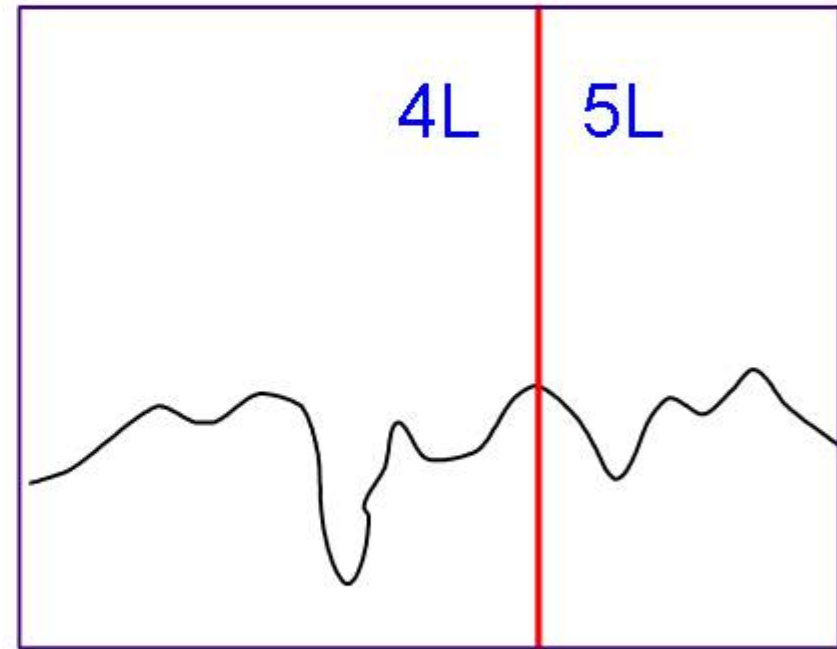
Downstream variability at DC: mean demand is about 300, the standard deviation is about 75



Demand Variability -- Bullwhip Effect in *LaserJet L Series*

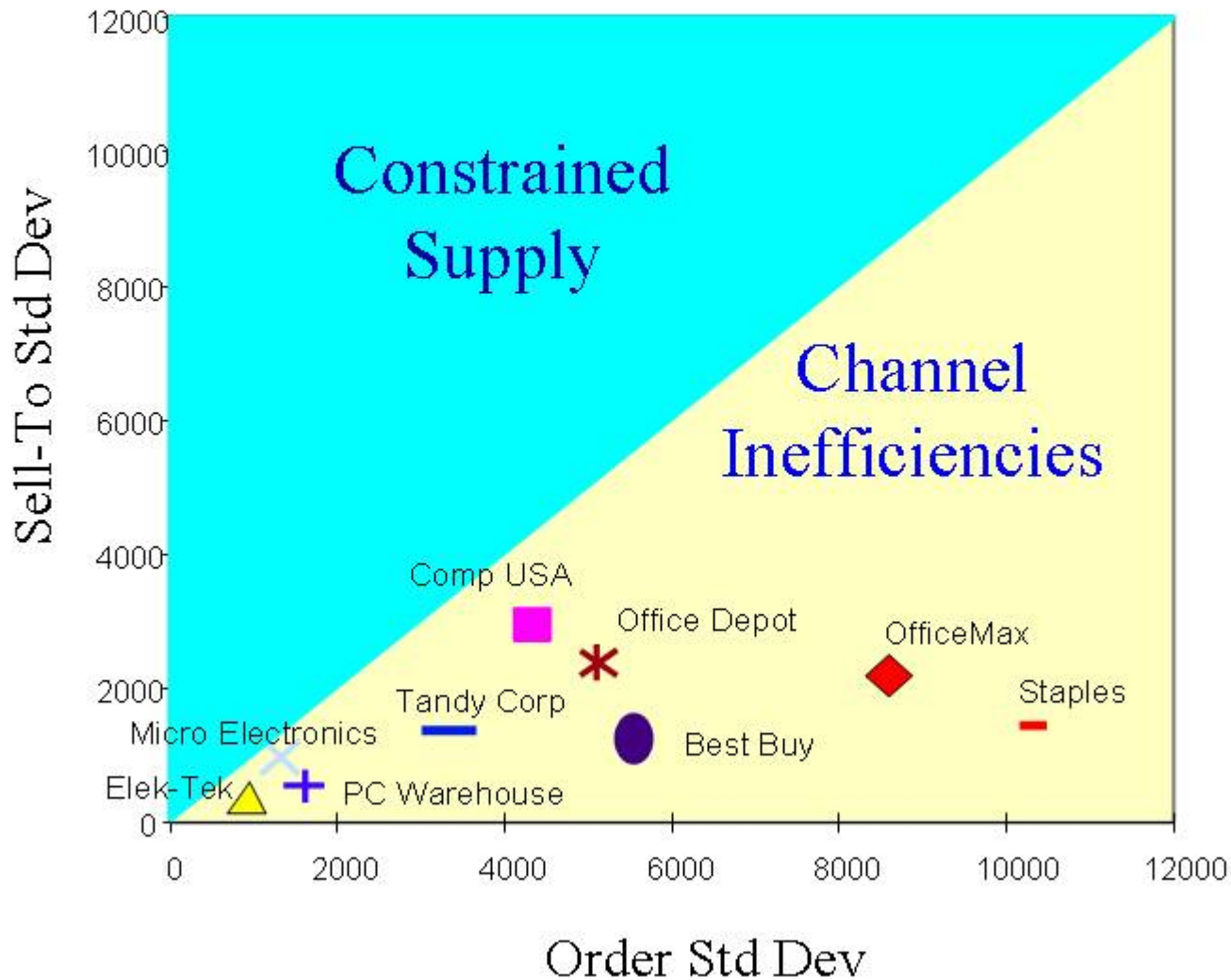


Shipments

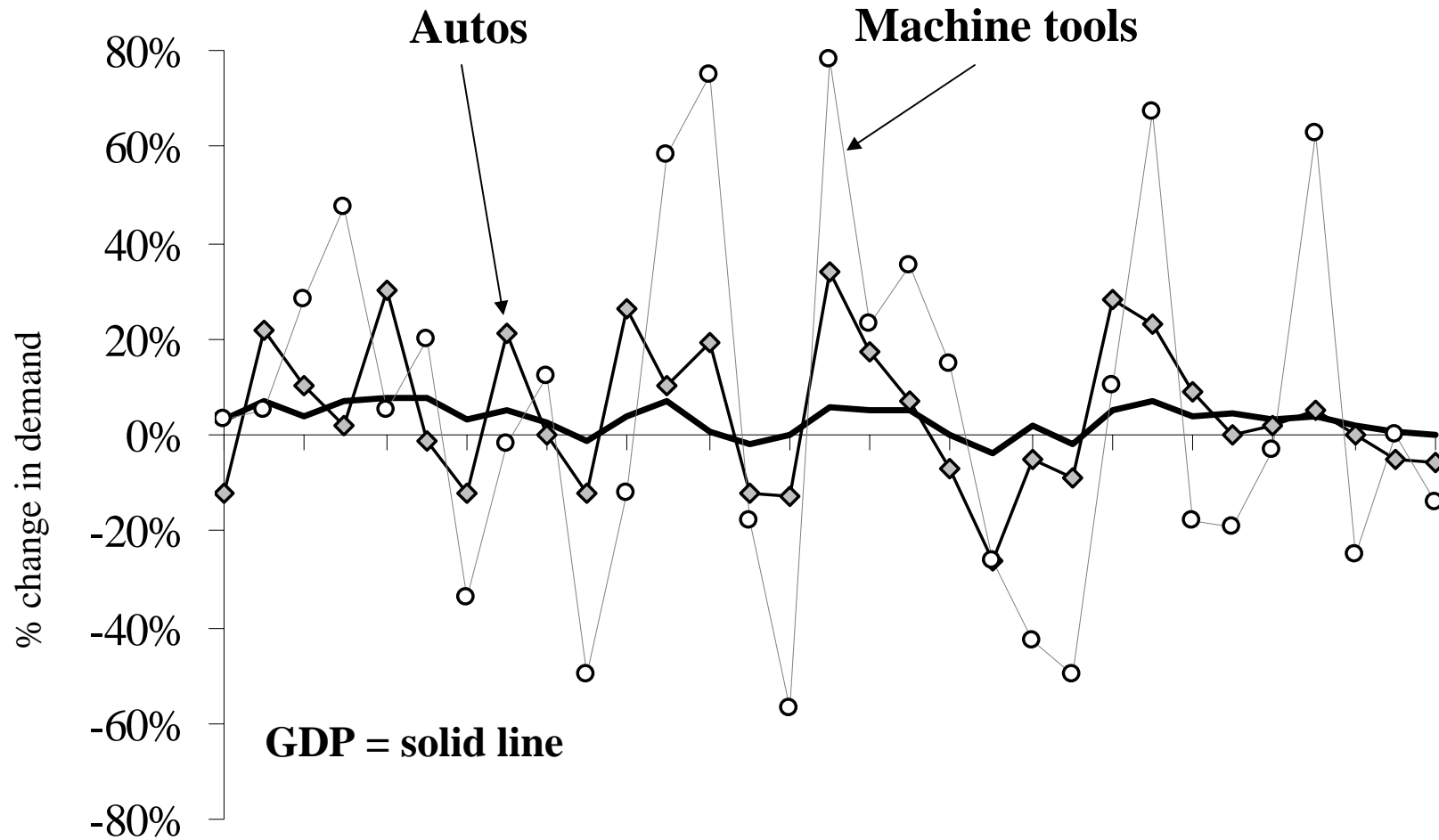


Sell Thru-To

Reseller Order Bullwhip -- 5L



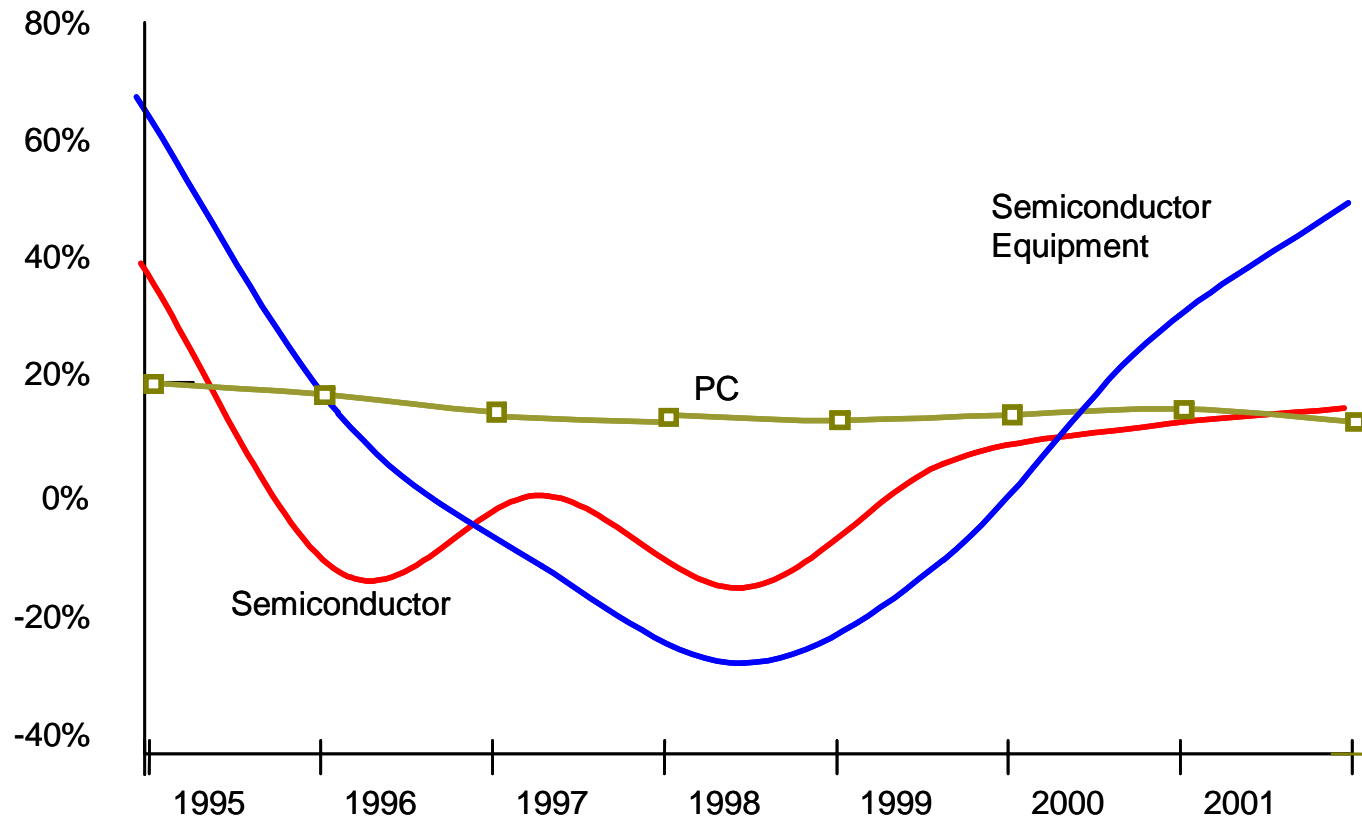
Autos to machine tools



Source: Anderson, Fine and Parker (1996)

U.S. PC industry

Changes in demand



Annual percentage changes in demand (in \$s) at three levels of the semiconductor supply chain: personal computers, semiconductors and semiconductor manufacturing equipment.

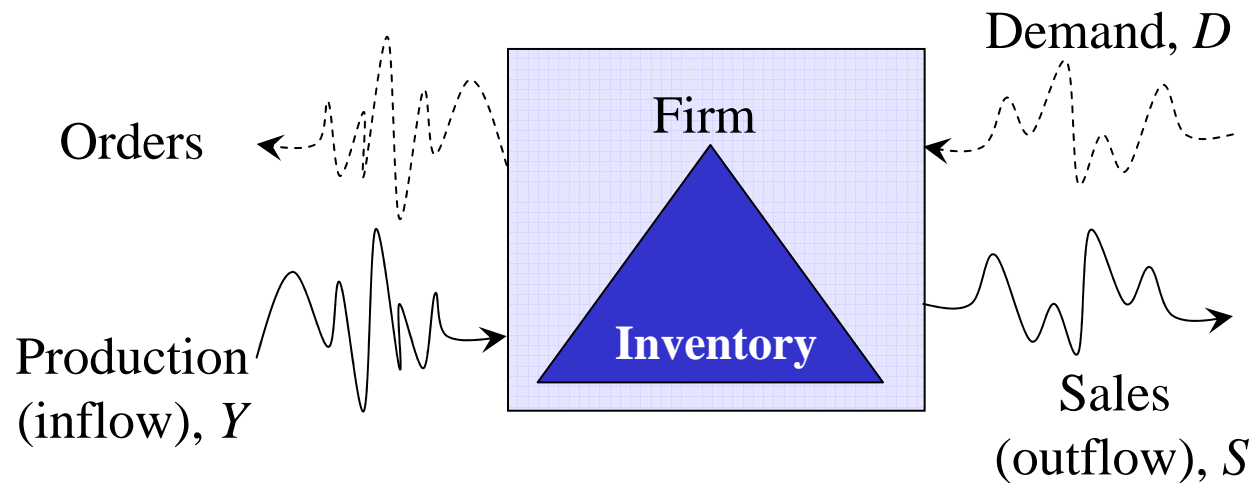
Explanations for the bullwhip effect ...

- Fixed cost to produce/order, (s, S) models, order synchronization: Blinder (1981), Caplin (1985), Caballero and Engel (1999), Mosser (1991), Lee, Padmanabhan and Whang (LPW) (1997), Cachon (1999)
- Positive serial correlation of demand shocks: Kahn (1987), LPW (1997), Graves (1999), Chen, Drezner, Ryan, Simchi-Levi (2000).
- Price fluctuations/cost shocks: LPW (1997)
- Non-convex production: Ramey (1991)
- Demand can be backlogged: Kahn (1987)
- Shortage gaming: LPW (1997), Cachon and Lariviere (1997)
- Misperception of feedback/irrational behavior: Sterman (1989)

Empirical evidence of production smoothing

- **Blinder and Maccini (91,92):**
 - Data: 1959-1986, monthly, seasonally adjusted, constant 1982 dollars
 - Production is more variable than sales in 17 of 20 two-digit manufacturing industries
 - “... the basic facts to be explained are ... 1) production is more variable than sales in most industries”.
- **Blanchard (1983):**
 - “... in the automobile industry, inventory behavior is destabilizing: the variance of production is larger than the variance of sales.”
- **Miron and Zeldes (1988):**
 - “...The overall assessment of this model ... is quite negative: there is little evidence that manufacturers hold inventories of finished goods ... to smooth production.”
- **Eichenbaum (1989):**
 - “We find overwhelming evidence against the production-level smoothing model ... we conclude that the variance of production exceeds the variance of sales in most manufacturing industries.”
- **Other negative results:**
 - West (1986), Ramey (1991), Mosser (1991), Kahn (1992)

A measure of the bullwhip effect: the amplification ratio



- Amplification ratio = $V[Y] / V[D]$.
- If demand is not available, use sales as a proxy for demand.
- We say the bullwhip effect is present in an industry if its amplification ratio is greater than 1.

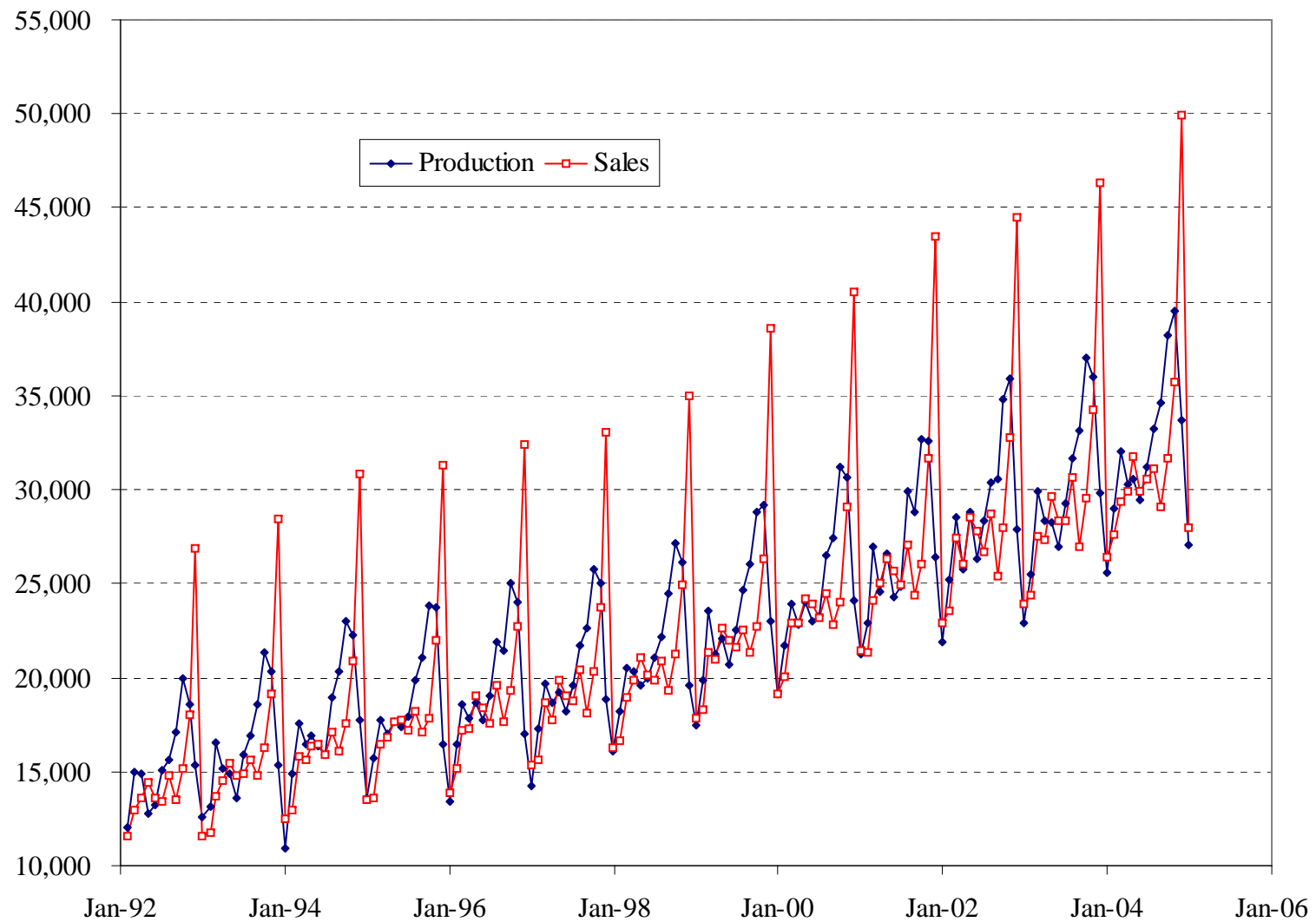
Our data

- Sources:
 - Census Department, Bureau of Economic Analysis.

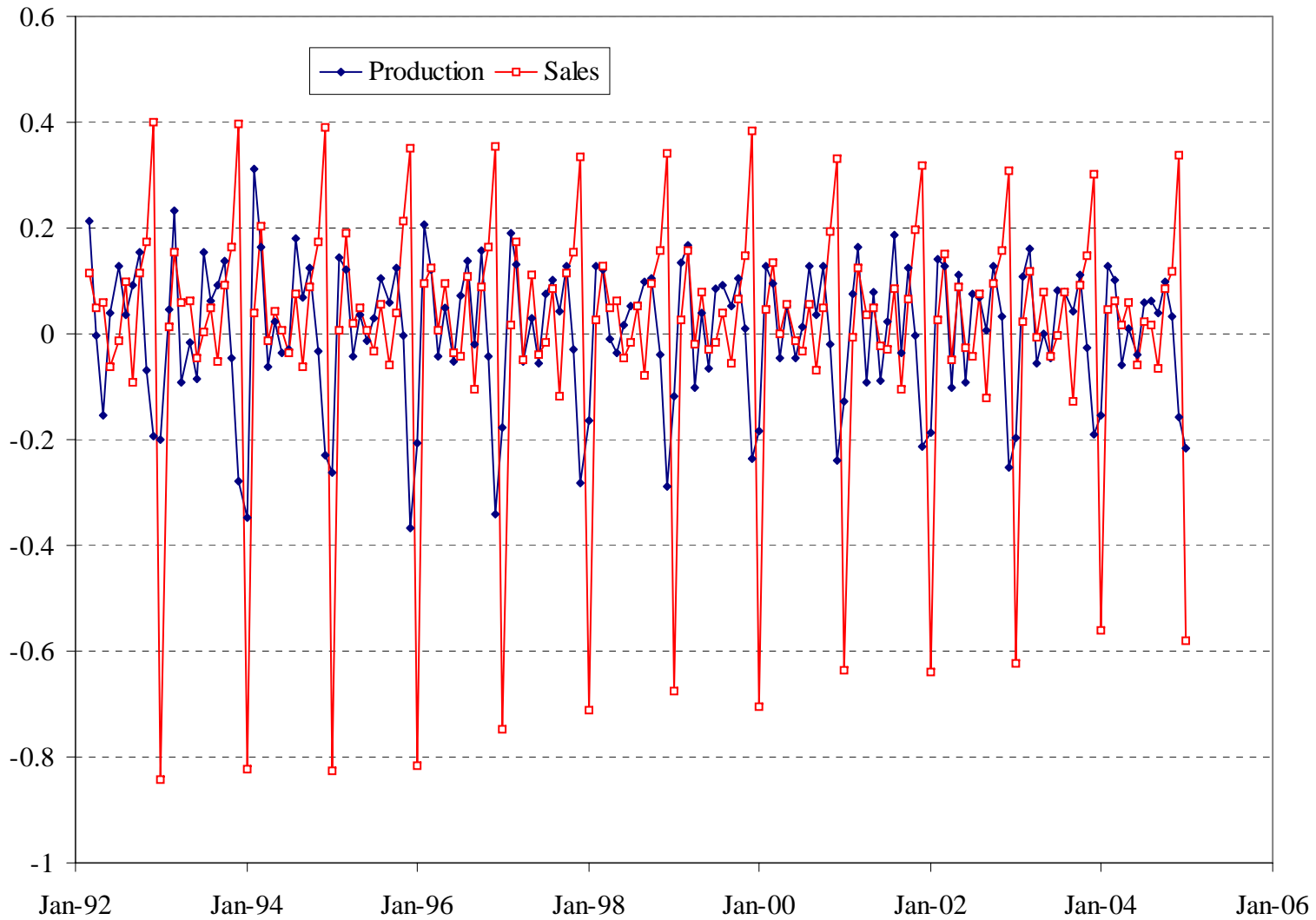
- Data:
 - U.S., 1992-2006, monthly.
 - 50 manufacturing industries: Sales, inventory.
 - In a subset of 23 manufacturing industries: Demand.
 - 16 wholesale industries: Sales, inventory.
 - 6 retail industries: Sales, inventory.

- Data manipulations:
 - 1) Adjust Demand and Sales series for margins and price.
 - 2) Adjust Inventory series for price.
 - 3) For each industry evaluate a Production series: $Y_t = S_t + \Delta I_t$
 - 4) Log and first difference the Production, Demand and Sales series.

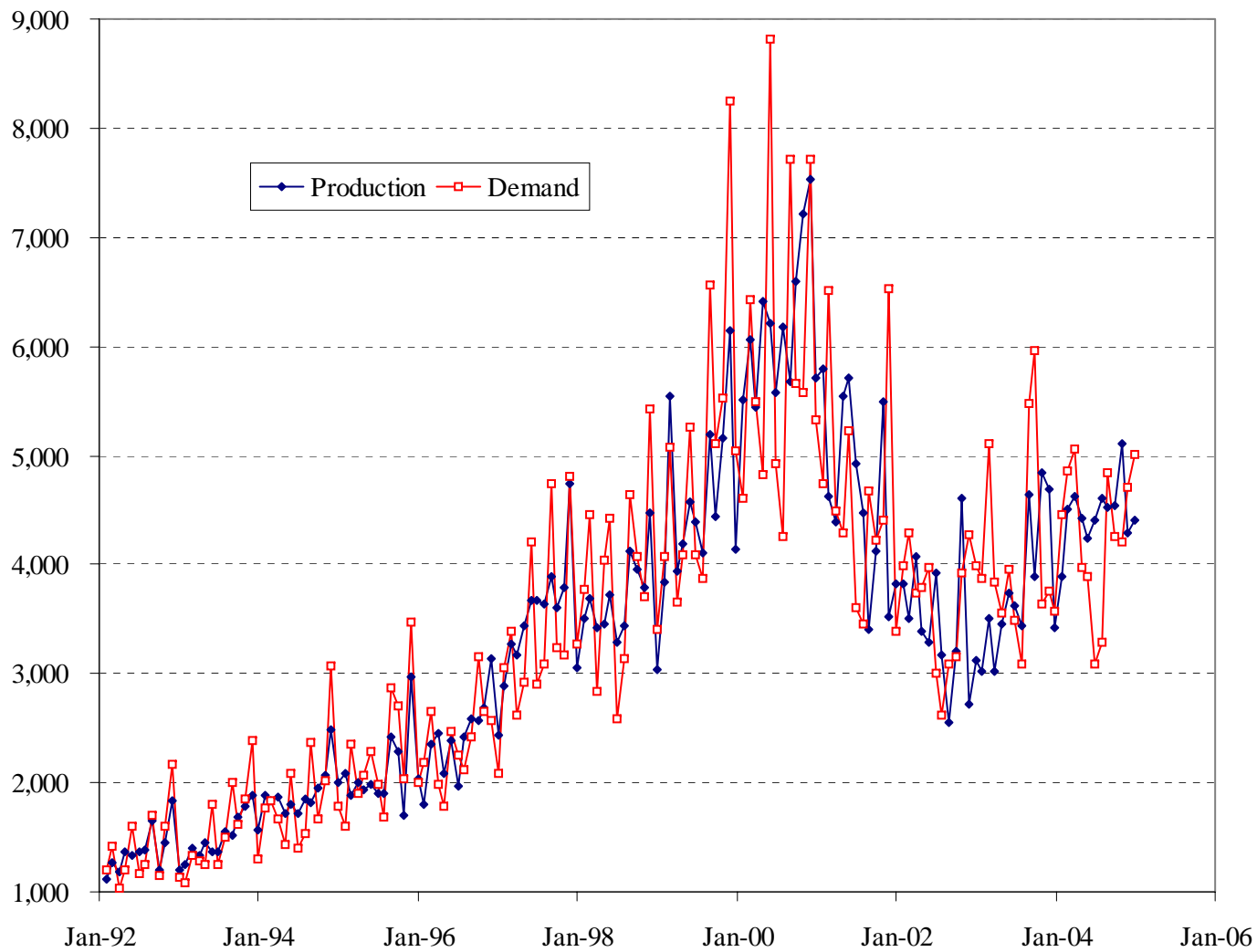
General merchandise stores – margin and price adjusted



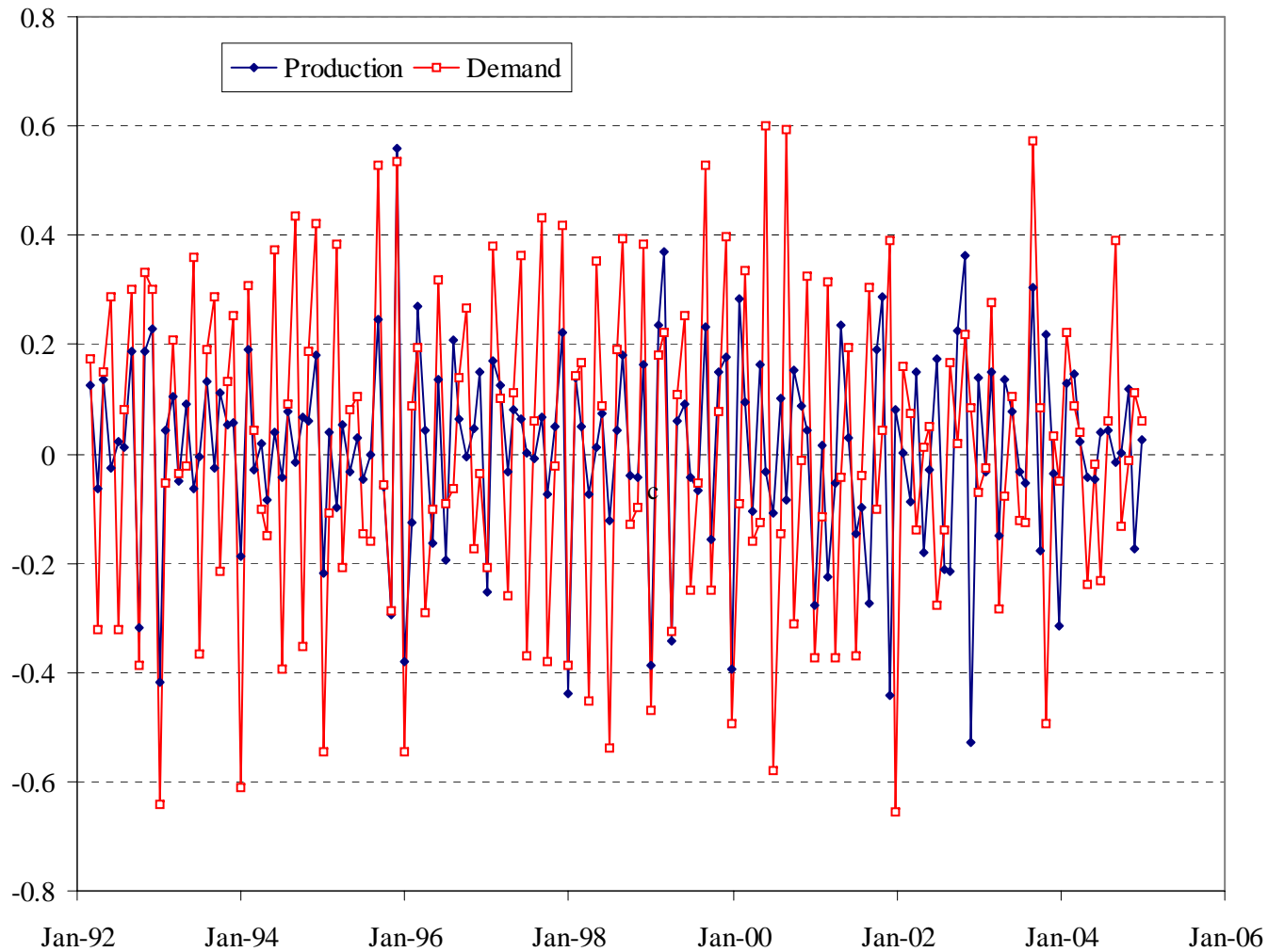
General merchandise stores – margin and price adjusted plus logged and first differenced



Telecom – margin and price adjusted



Telecom – margin and price adjusted plus logged and first differenced



Research questions

- To what extent does the bullwhip effect exist in U.S. industry level data?
 - Are amplification ratios greater than 1?
 - Do manufacturers experience the highest demand variability and retailers the lowest?
- Understand variation in the amplification ratios:
 - What explains variation in the amplification ratio across industries?
 - Have amplification ratios been decreasing over time?

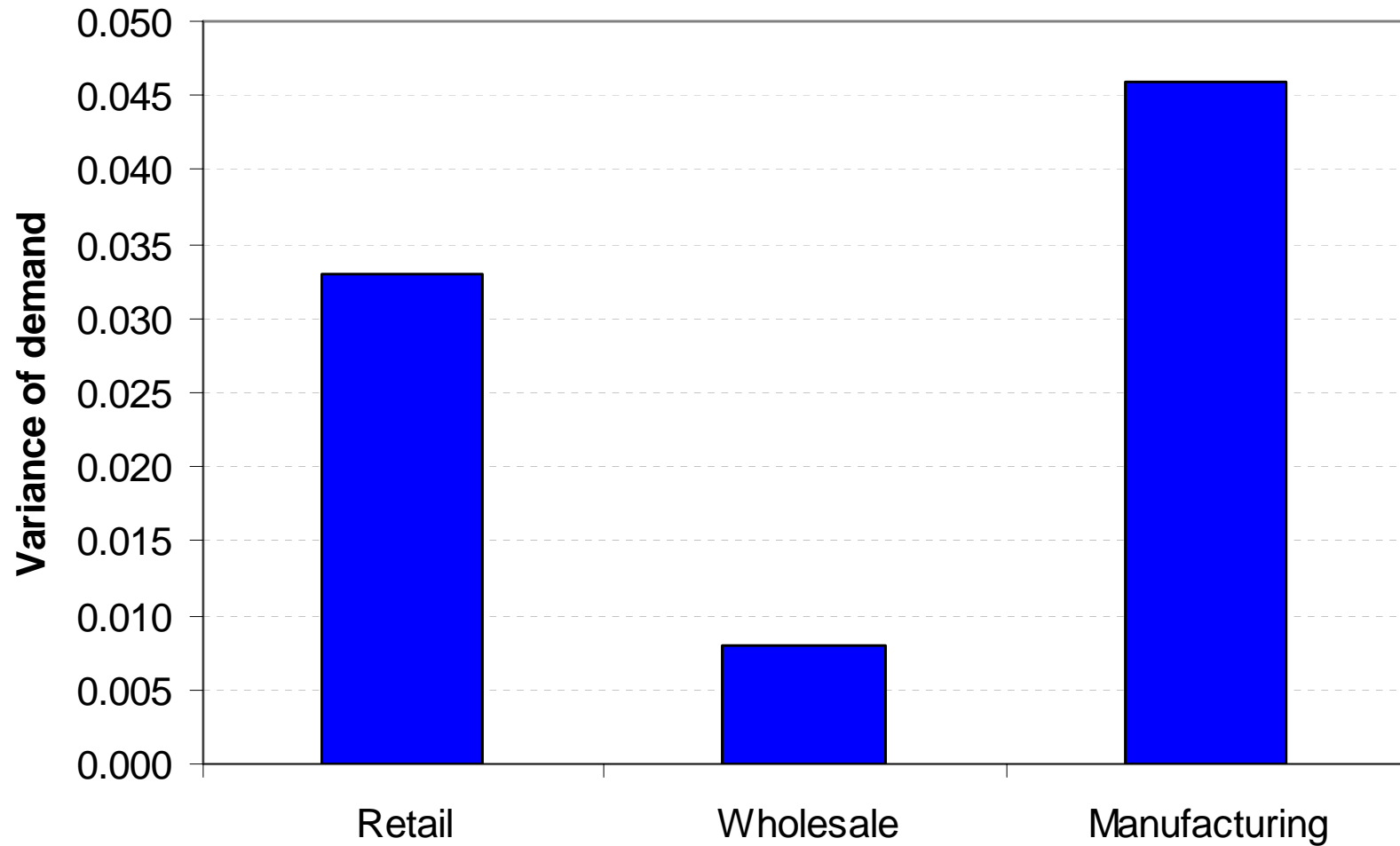
Prevalence of the bullwhip effect

Aggregate series	Amplification Ratio
Retail	0.50
Wholesale	1.14
Manufacturing	0.55

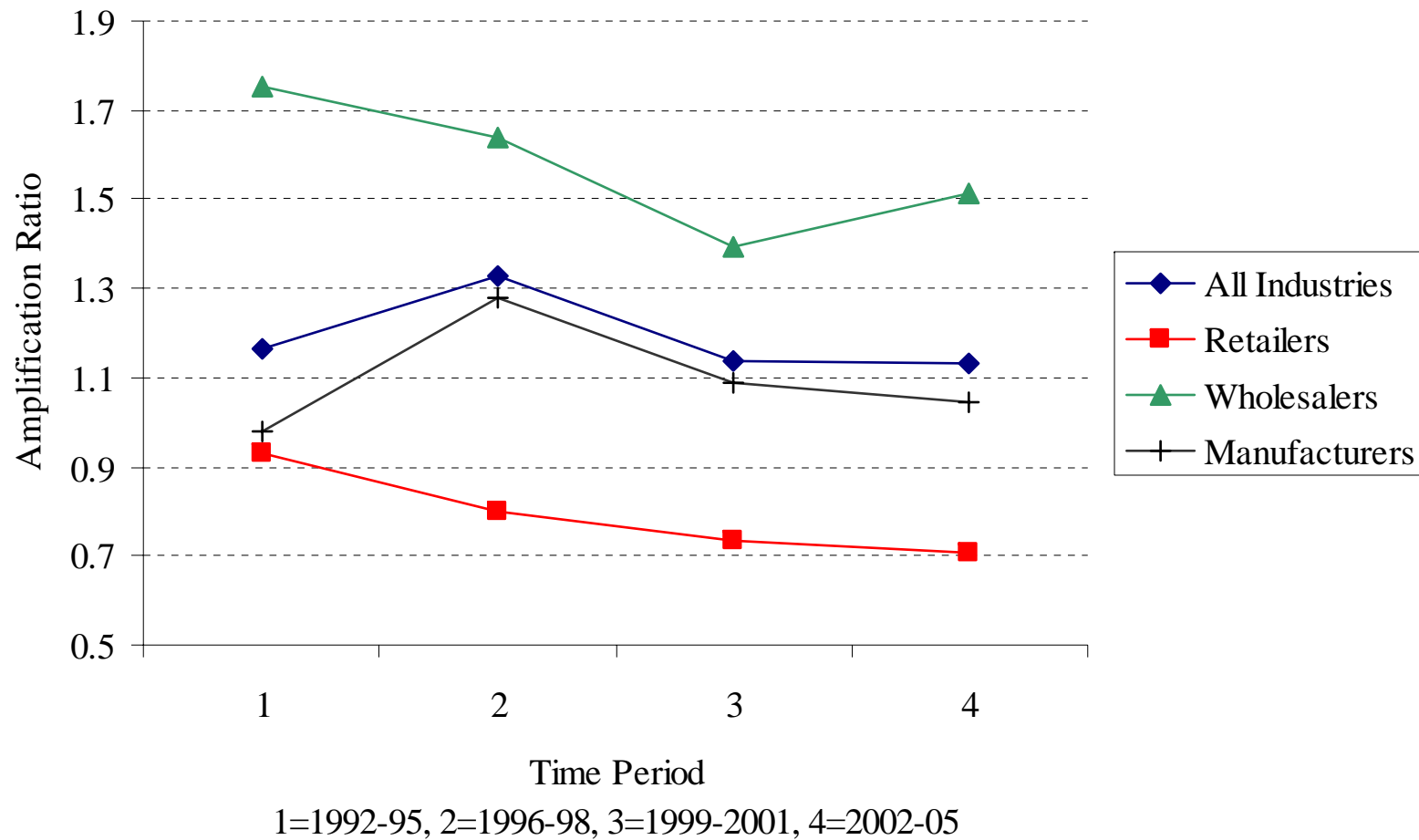
Percentage of industries that exhibit the bullwhip effect

	Seasonally unadjusted	Seasonally adjusted
Retail	16% (1 of 6)	100% (6 of 6)
Wholesale	88% (14 of 16)	100% (16 of 16)
Manufacturing	40% (20 of 50)	74% (37 of 50)

Demand variability at different levels of the supply chain



Trends in amplification ratios



Future research

- Investigate the bullwhip effect at different levels of aggregation – firm, category, sku.
- Investigate the bullwhip effect at different levels of time aggregation – daily, weekly, quarterly.
- Obtain better order and demand data.
- Do firms/supply chains that better manage the bullwhip effect perform better financially?