

Supply Chain Execution & Retail Performance

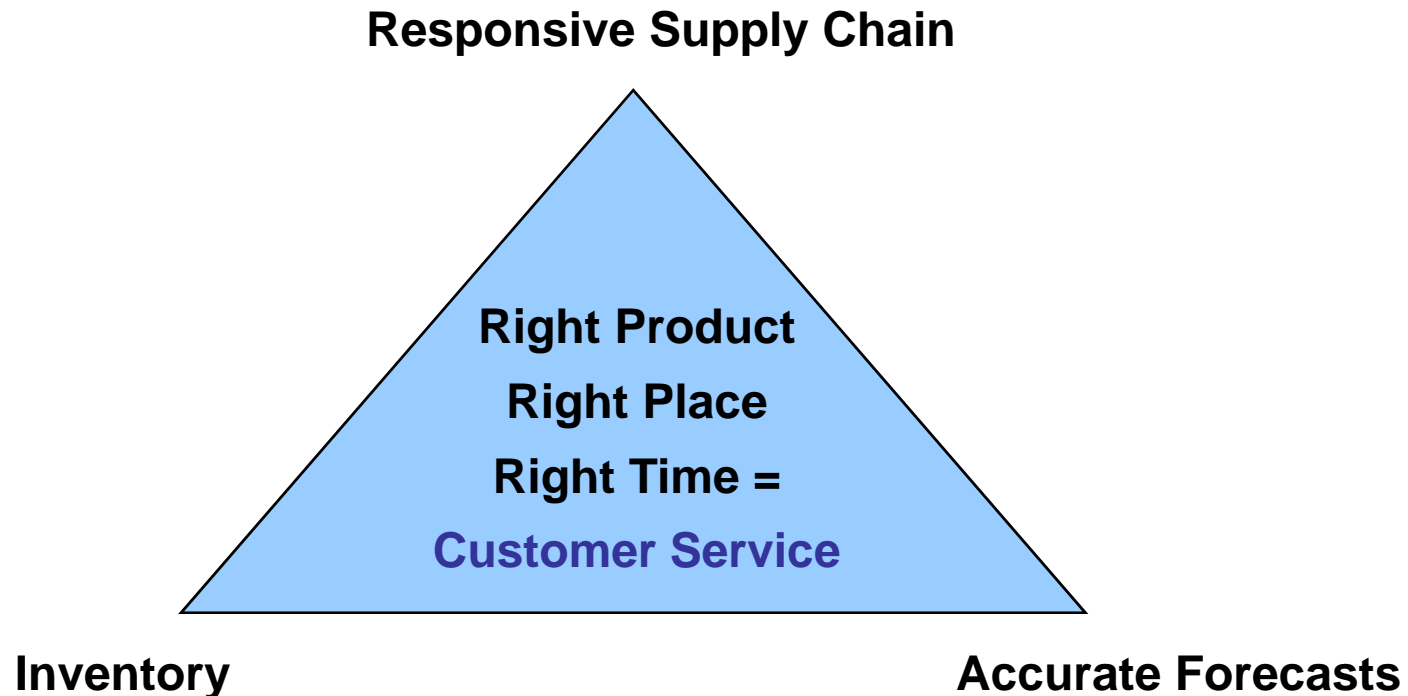
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Center of Retail Studies, University of Chile

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Supply Chain Execution

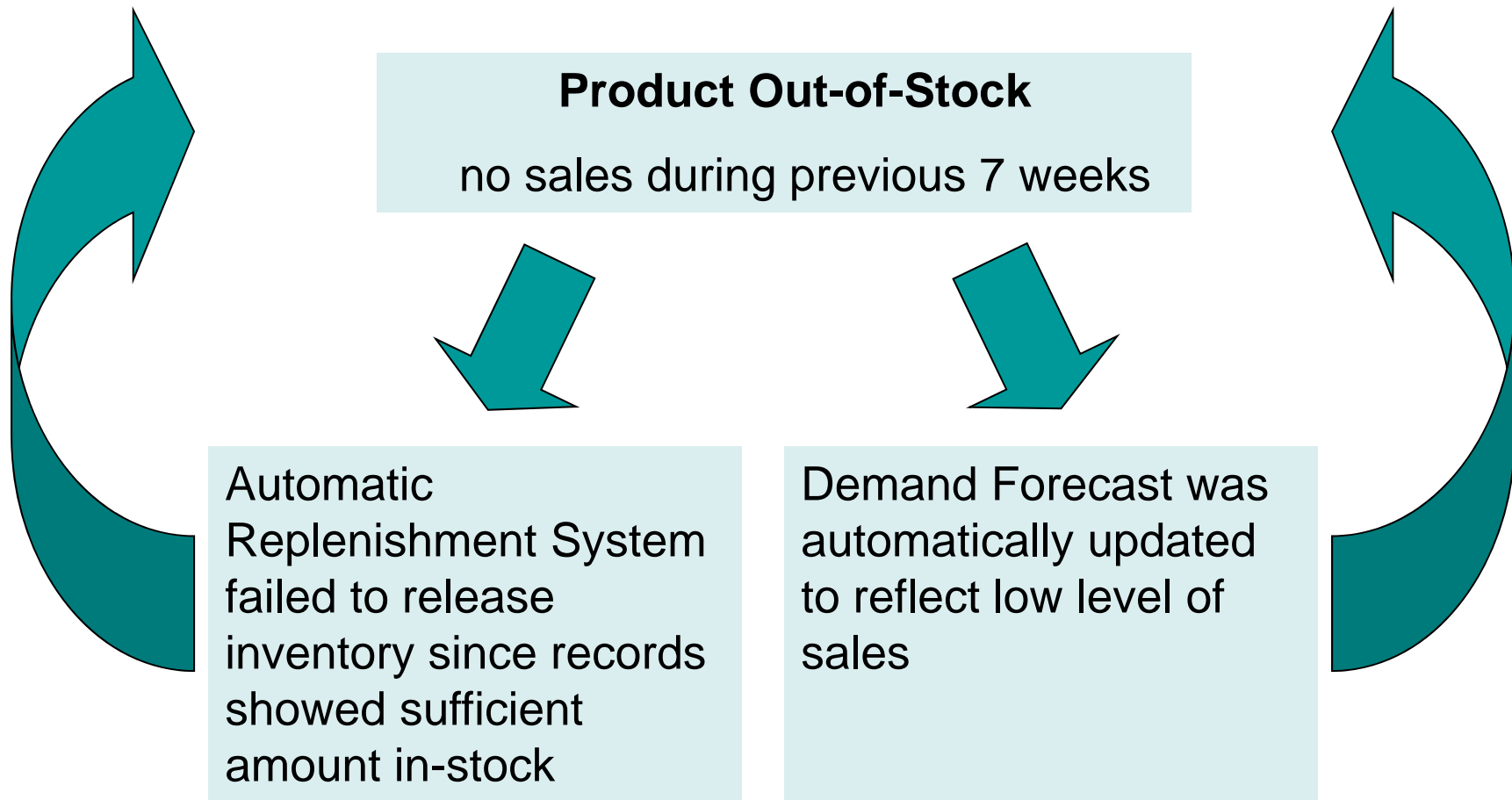


Supply Chain Execution and Planning Requires:

- (1) Incentives for merchants, suppliers, and store employees.
- (2) Accurate, easily accessible data on sales and inventory.

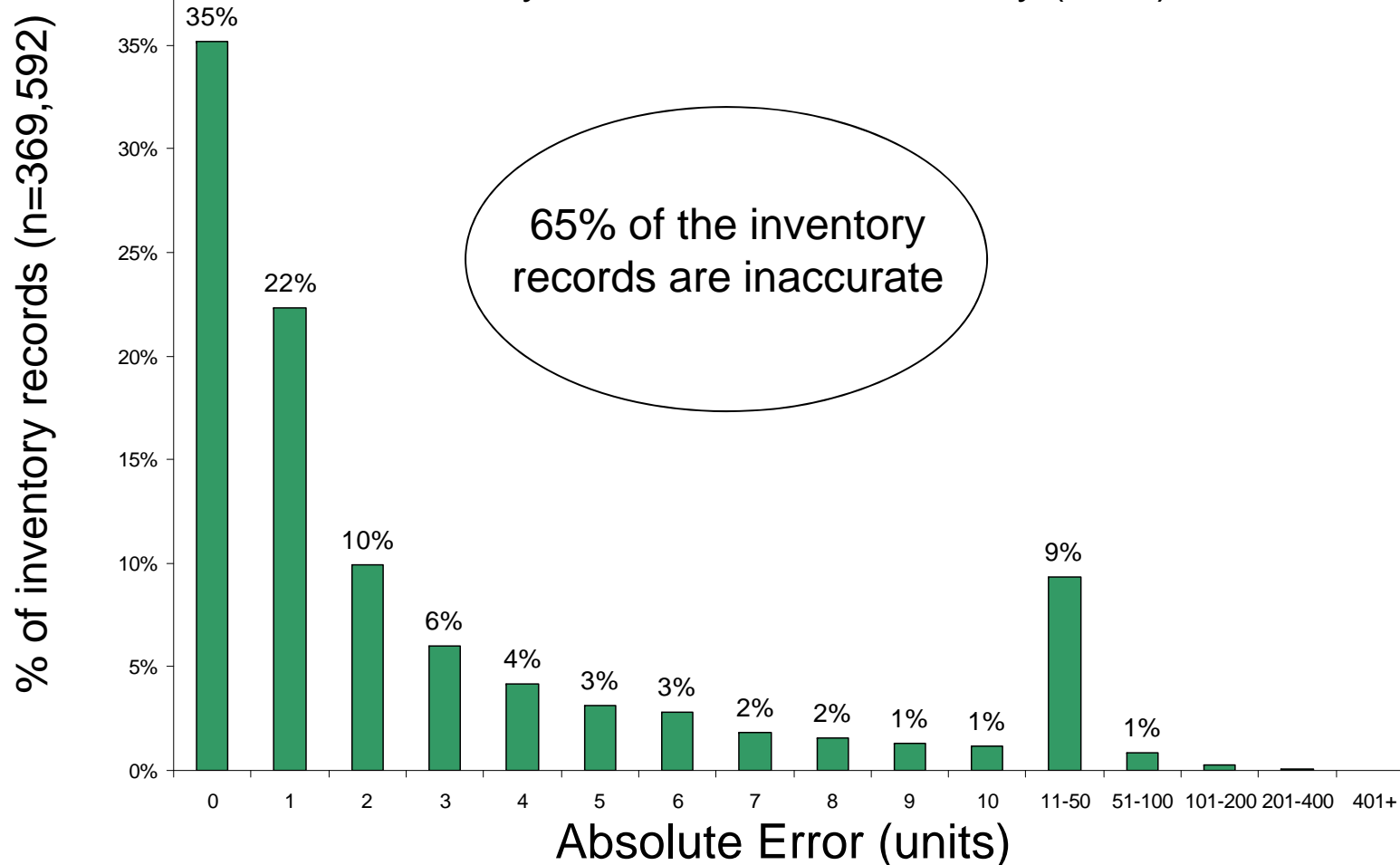
So What?

Store Inventory Records Showed 42 Units On-hand

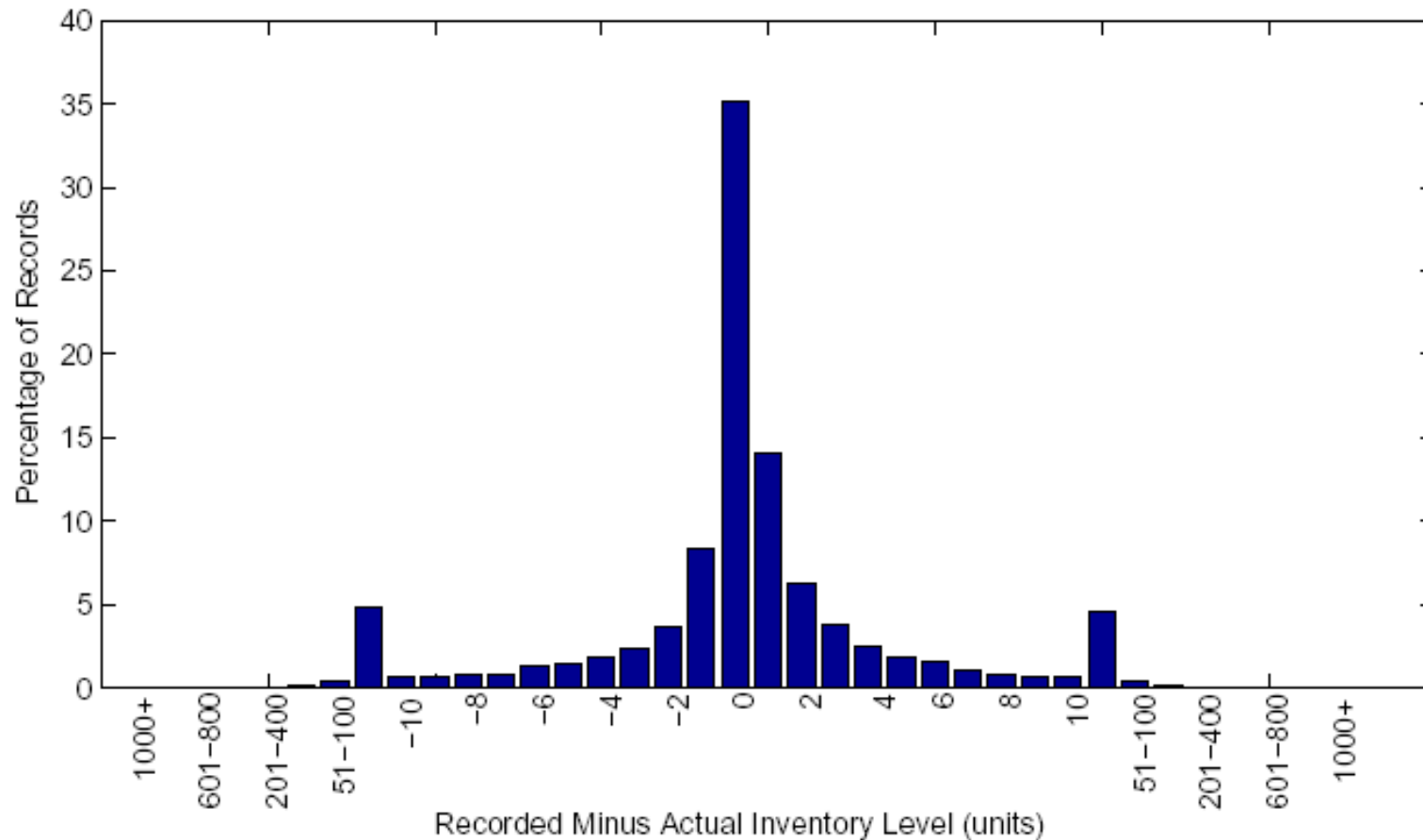


Data from Gamma: Magnitude of Inaccuracy

Histogram of the absolute value difference between system and actual inventory (units)



Data from Gamma: Distribution of Errors



Gamma Corporation

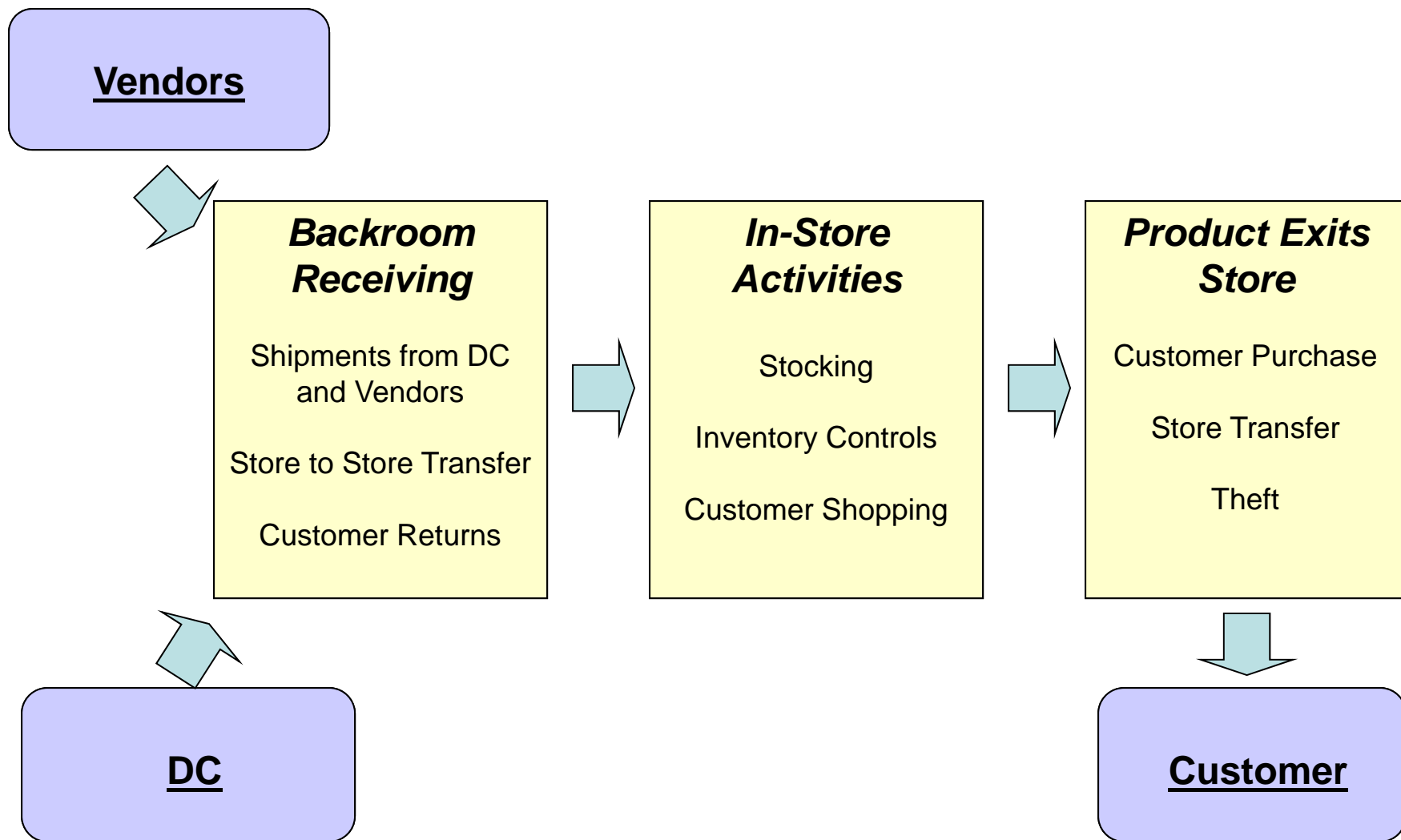
Gamma Corp.

- Specialty retail chain with over 1,000 stores.
 - Self-service shopping environment
 - Broad range of products (~10,000 SKUs per store)
- Advanced user of technology
 - Automated replenishment
- Product Characteristics
 - Item cost: avg. \$20.42 (range \$0.01 - \$3,474)
 - Annual units sold: avg. 72 (range 0 - 40,229)
- Store Characteristics
 - Size: avg. 17,000 ft² (range 6,519 - 22,227)

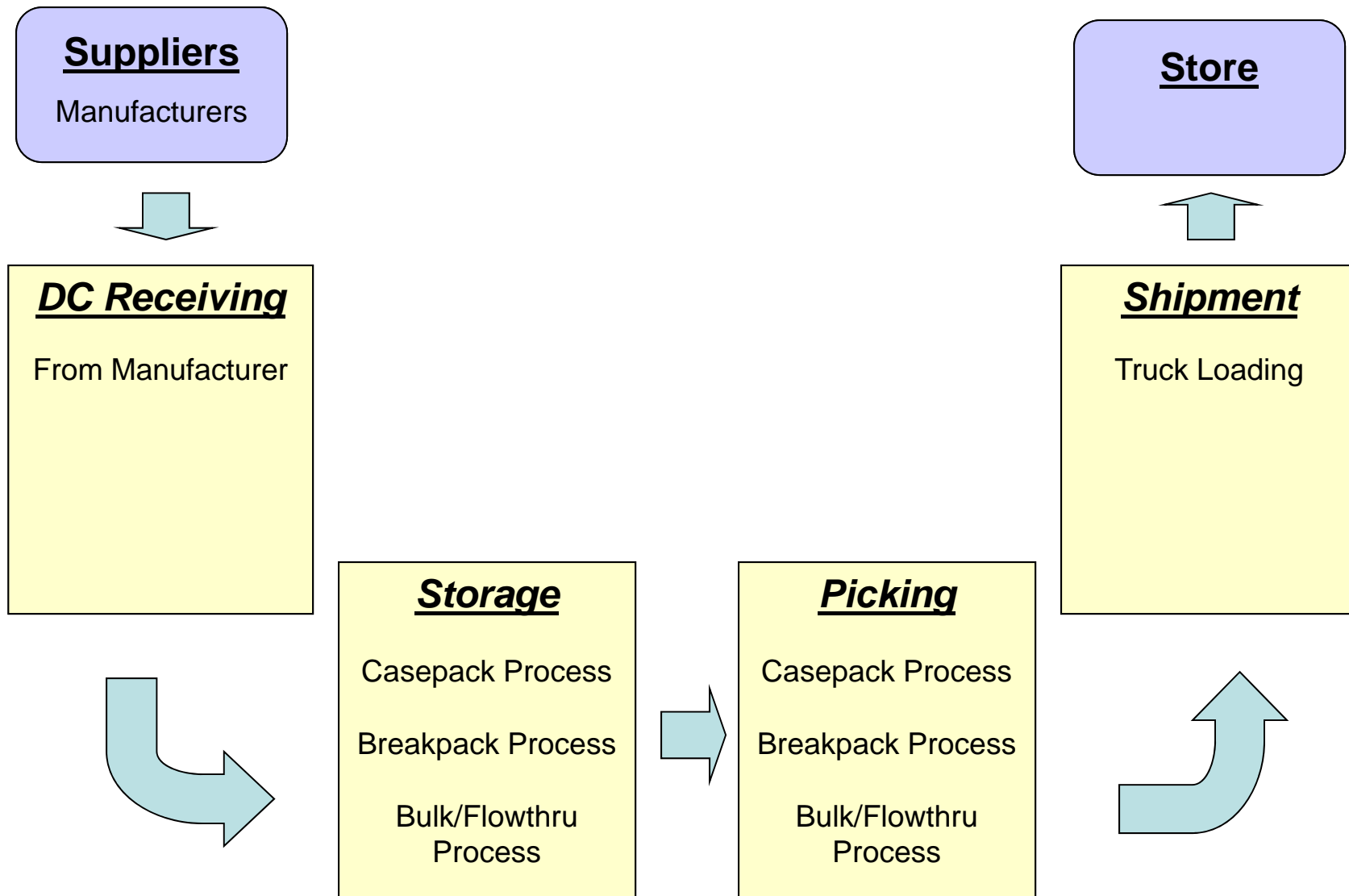
“Freezing”

- “Freezing” (Gershwin and Kang, 2005)
 - No sales, so we never trigger orders.
 - No physical inventory to sell, so no sales.
- At Gamma, 12% of items had no inventory on shelf, yet recorded inventory was positive.
 - Typical store \$1347 in lost revenue per week
 - 1.1% of retail sales, 3.3% of gross profit
- Coupled with automated ordering systems, this is a troublesome situation.

How? Failures in Store Processes



How? Failures in Replenishment Processes



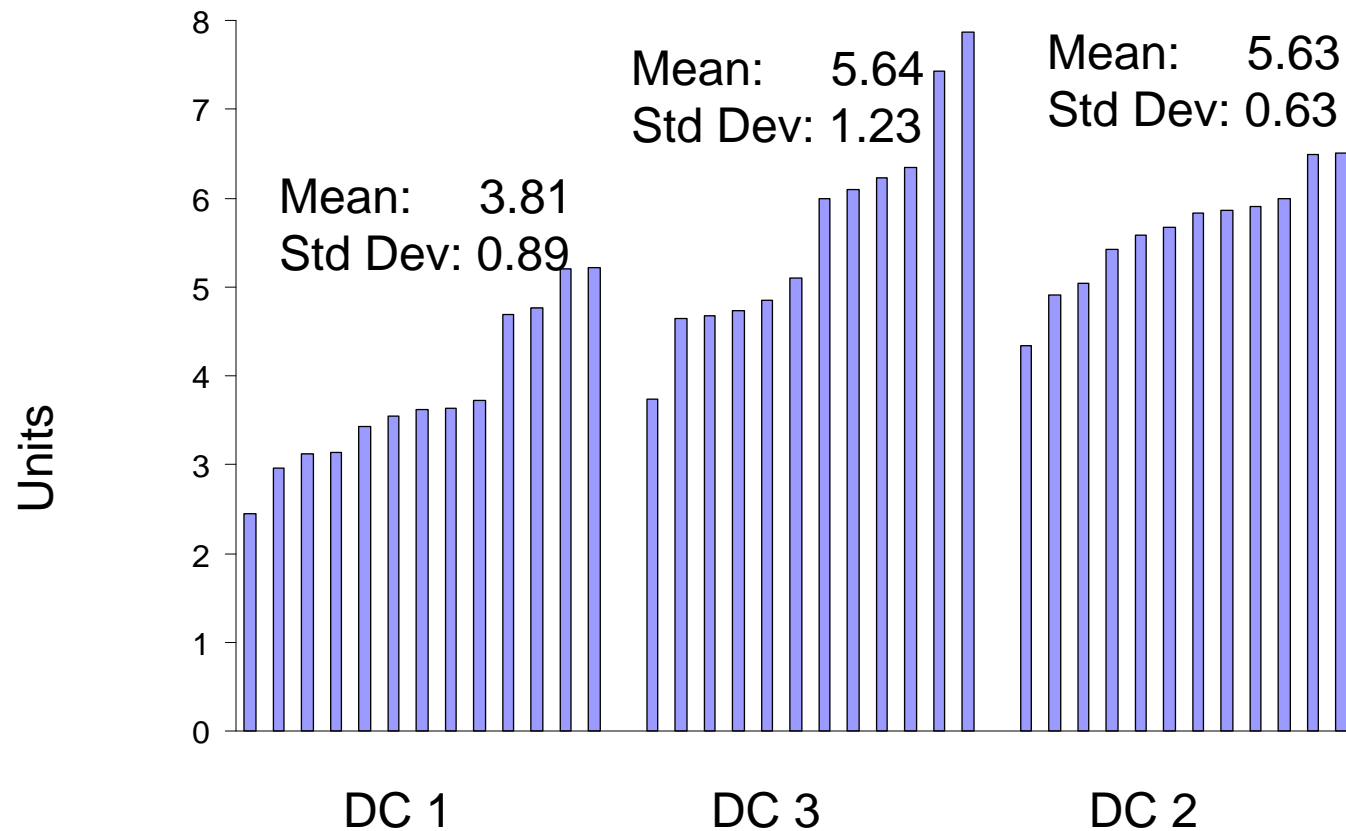
Distribution Center Performance

Experimental Audit

- Gamma scheduled new store opening
 - DC delivered inventory
 - Store employees stocked shelves
 - Store DID NOT OPEN
-

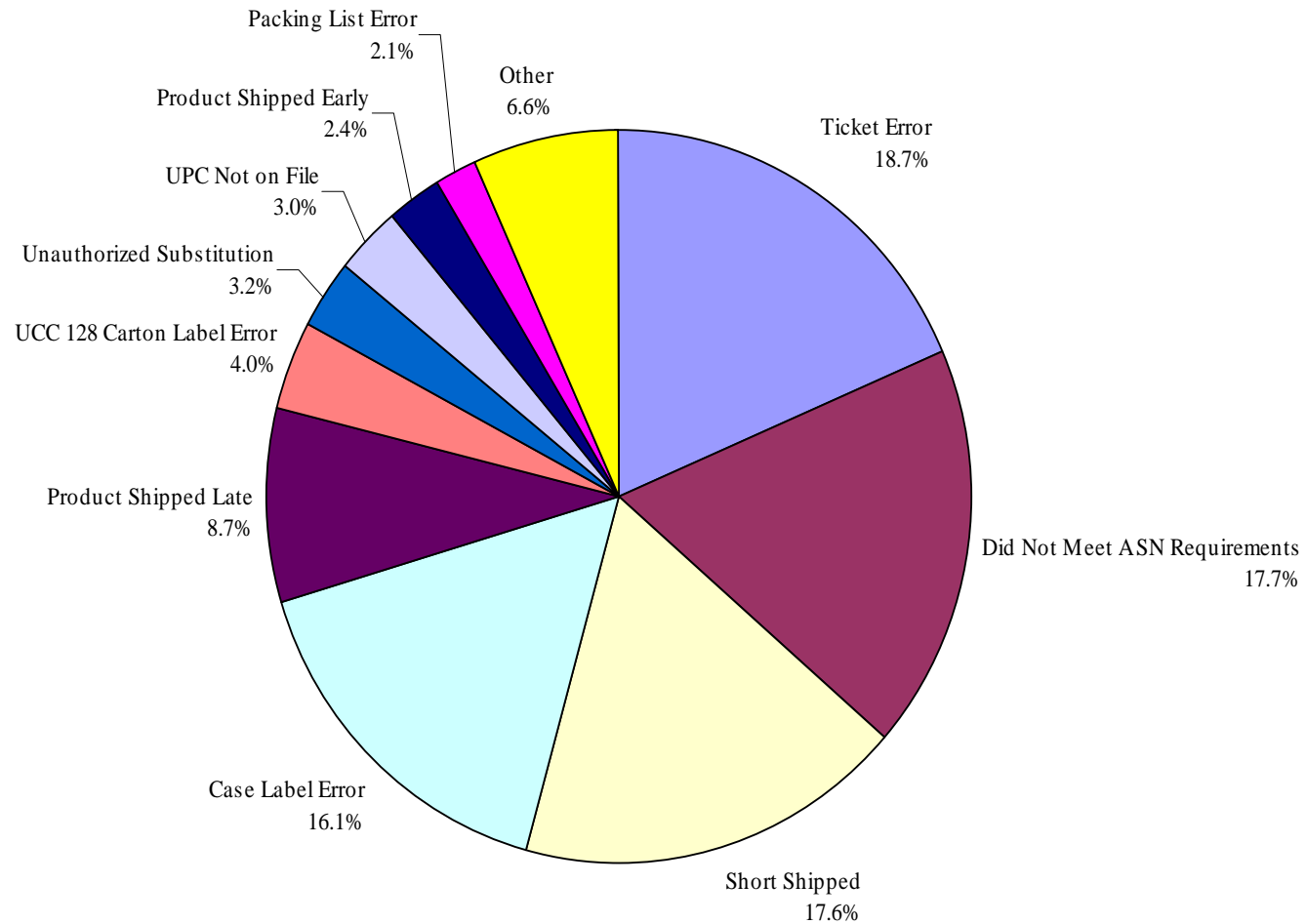
Before a Single Customer Had Walked the Store -
System and Actual Inventory Levels
Did Not Match for 29% of the SKUs

Distribution Center Performance



In Addition: Trucks Departing from DC 1 Report Far Less Inventory Variance when Audited

Receiving “Defects”



One in Ten Purchase Orders Arrives at the DC Incorrect –
Errors Cascade Through System Causing Record Inaccuracy

Days of Delay Due to “Rework”

Error Type	Annual Days	Average Days
Ticket Error	373.1	3.5
Case Label Error	100.5	2.0
Short Shipped	80.1	0.8
Did Not Meet ASN	52.5	1.2
Packing List Error	26.6	4.4
Product Shipped Late	25.6	0.9
UPC Not Scan Legible	24.1	2.4
UPC Not on File	20.2	3.7

- 52% of the vendors had at least a one day delay
- 2 days (average), 77 (max)
- Stochastic lead times between DC and Store

Empirical Evidence

- **Inventory record inaccuracy:** Discrepancy between recorded inventory and what is actually on a retailer's shelf.
- **Reasons for discrepancy:**
 - Replenishment errors
 - Employee theft
 - Customer shoplifting
 - Damaged merchandise
 - Imperfect inventory audits
 - Incorrect recording of sales
 - Others?

Inventory Accuracy is a Function of...

(1) Number of Transactions (-)

- inventory records are more likely to be accurate for items which sells fewer units

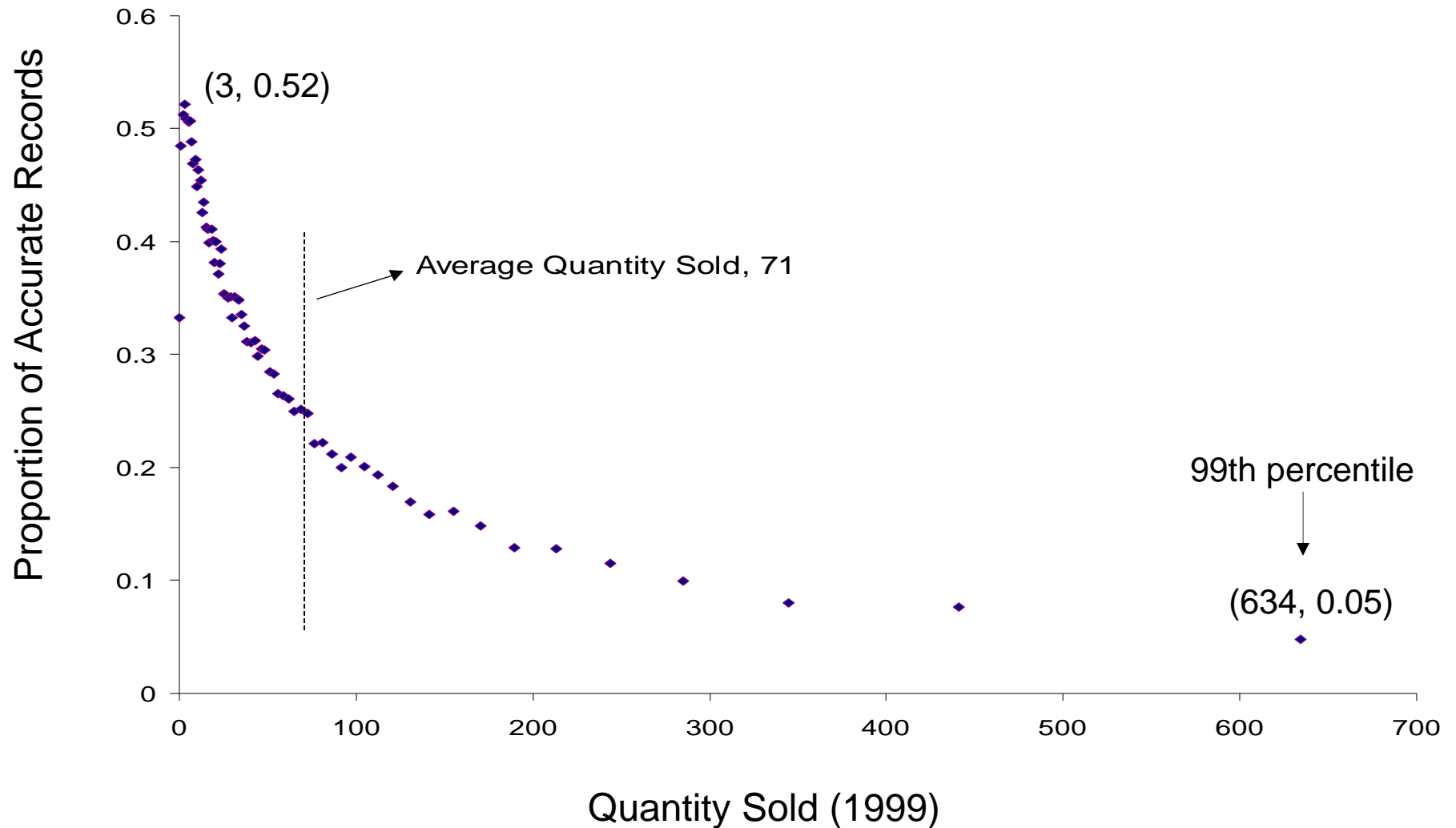
(2) Dollar Value of Item (+)

- more expensive items are more likely to have accurate inventory records than inexpensive items

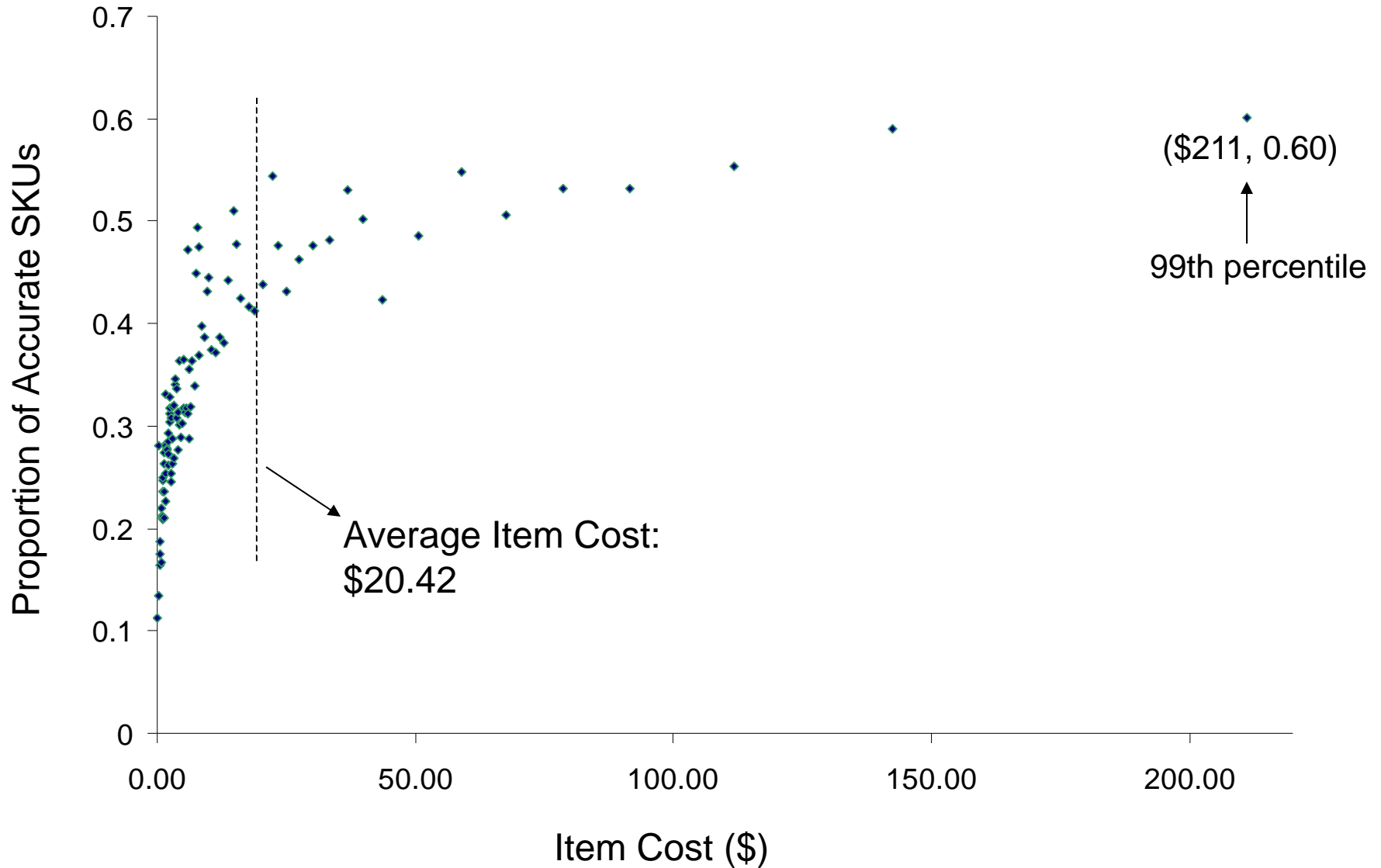
(3) Shipment Source

- inventory records are more likely to be accurate for items shipped direct to the store from the vendor

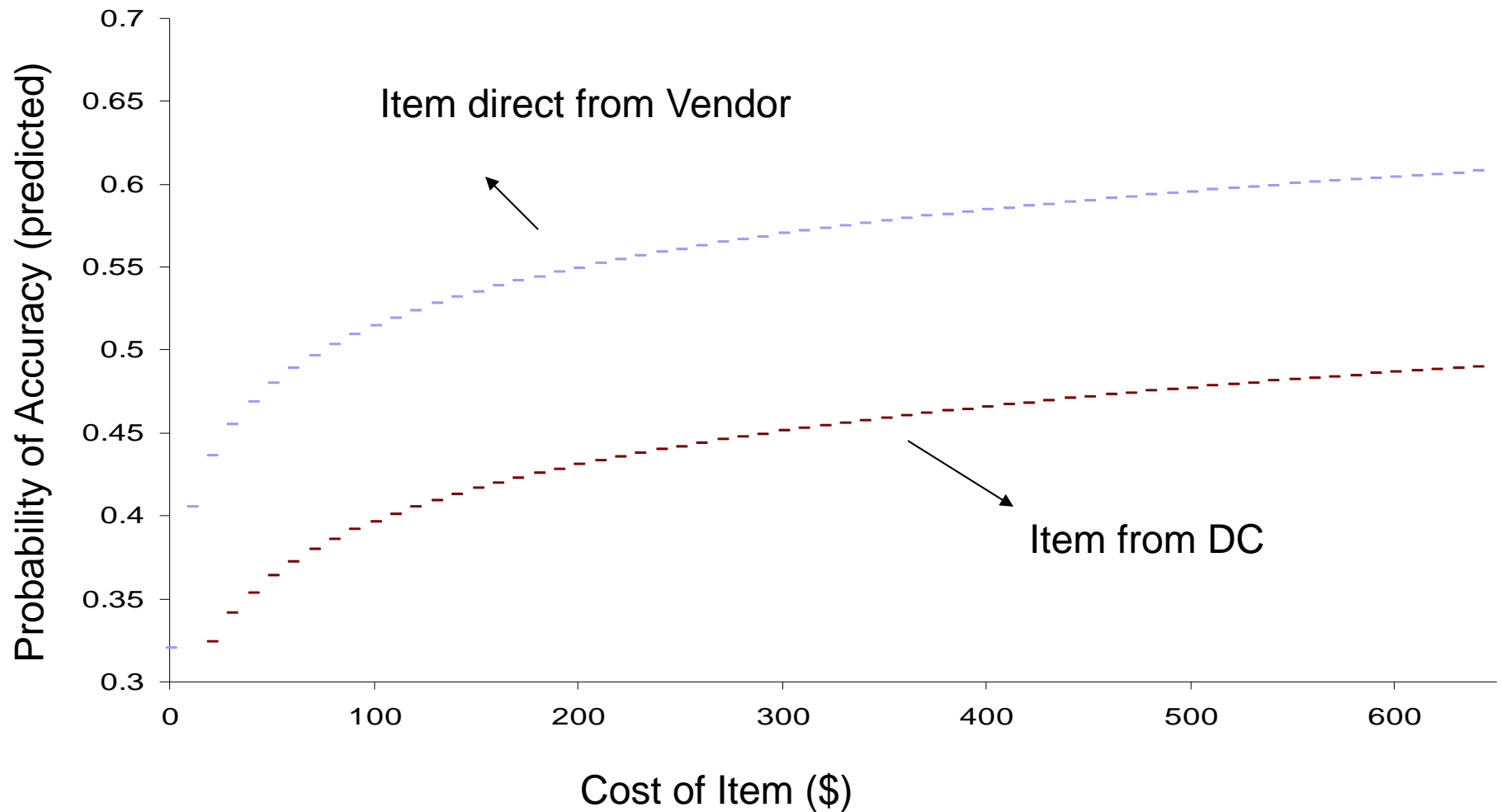
Relationship Between Record Accuracy and the Annual Quantity Sold Per Item



Relationship Between Record Accuracy and Item Cost



Fitted Probability of Vendor Shipped Item vs. DC Shipped Item



Store Inaccuracy is a Function of....

(1) Distribution Center Performance

(2) Inventory Density (+)

$$\frac{\text{total inventory amount (units)}}{\text{selling area of store}}$$

(3) Product Variety(+)

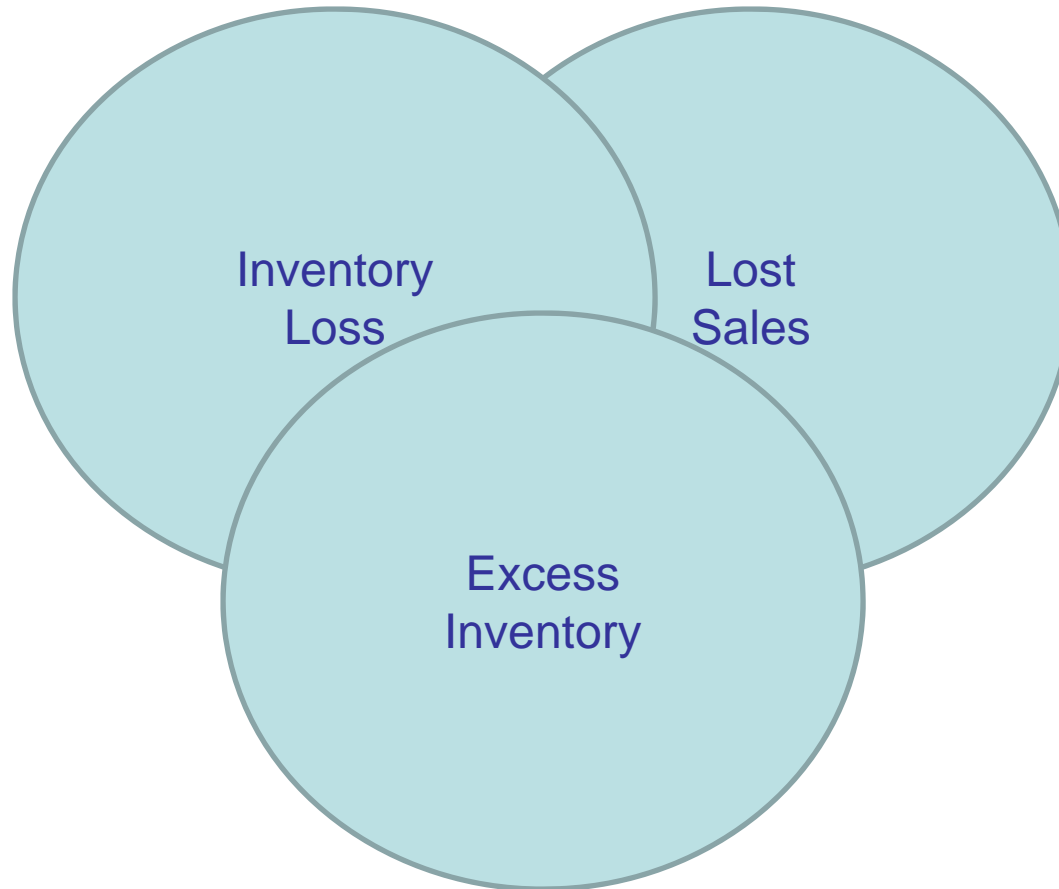
number of different SKUs per store

(4) Days Since Last Physical Audit (+)

What Does Not Account for Observed Store Differences?

- Firm Ownership
 - single retail chain
- Technology
 - entire chain shares same IT system
- Monetary Incentives
 - employees rewarded according to plan designed by corporate

Cost of Inventory Record



Retailer incurs 20% additional inventory holding costs to meet target service level
Lost revenue at a typical store amounts to 3.3% of gross profit
Inventory loss estimated to be 2% of sales
Retailer IT investment of \$30 billion annually

What to do?

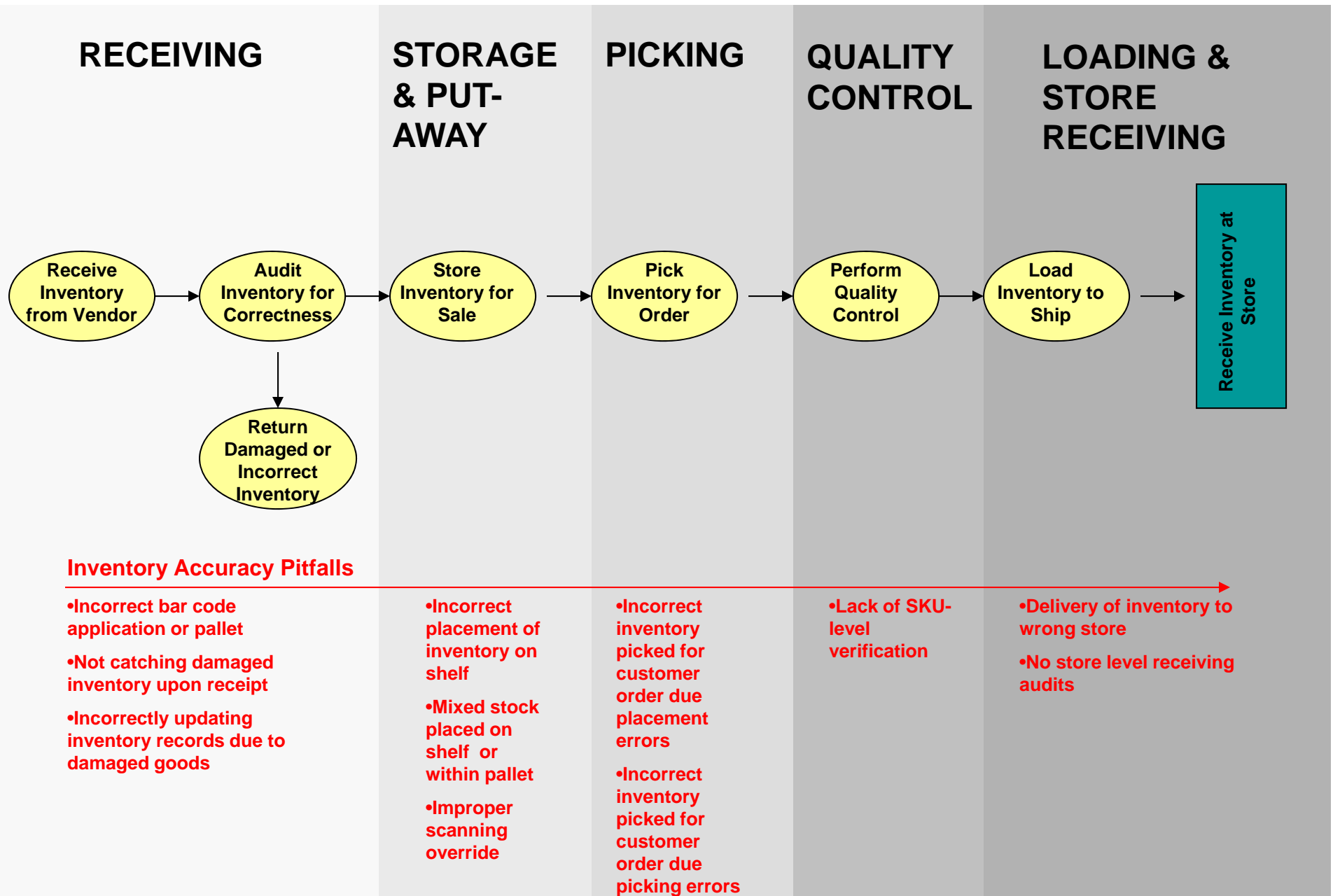
1. *Prevention*: Reduce incidence of inventory inaccuracy.
 - Process quality and conformance.
 - Improved tracking technology (e.g. RFID)
2. *Correction*: Perform frequent inventory audits.
3. *Integration*: Use decision tools that account for inventory inaccuracy.

Our proposal: Account for inventory inaccuracy by tracking a probability distribution of inventory.

Store Format & Merchandising

- Product Variety Reductions
 - Fewer SKUs per store
- Inventory Reduction
 - Fewer facings per SKU
 - Integration of store “picks” with peg size
- Lower Shelving
 - Provides visual cues of out of stocks

RETAIL REPLENISHMENT PROCESS



Purchase Order Accountability

- Map the Purchase Order Process
 - goes through 16 different hand-offs
 - is “owned” by as many as three different departments within the firm
 - can be changed by any number of people
 - no accountability for changes and their accuracy

Mitigation: Distribution of Inventory

- Our proposal →
Keep track of an inventory distribution,
not just a single number .
- Old record:
Inventory Level = 5 units.

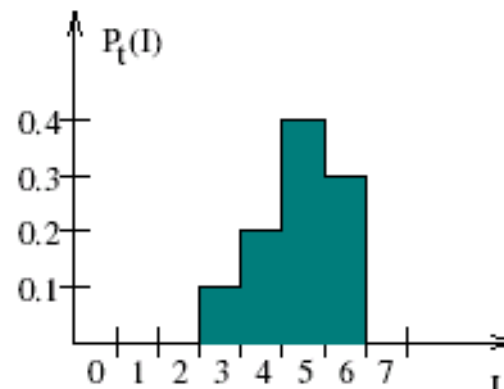
Example: Probability that inventory at time t
is 2, 4, 5, or 6 units

$$\Pr\{I_t=3 \text{ units}\} = 0.1$$

$$\Pr\{I_t=4 \text{ units}\} = 0.2$$

$$\Pr\{I_t=5 \text{ units}\} = 0.3$$

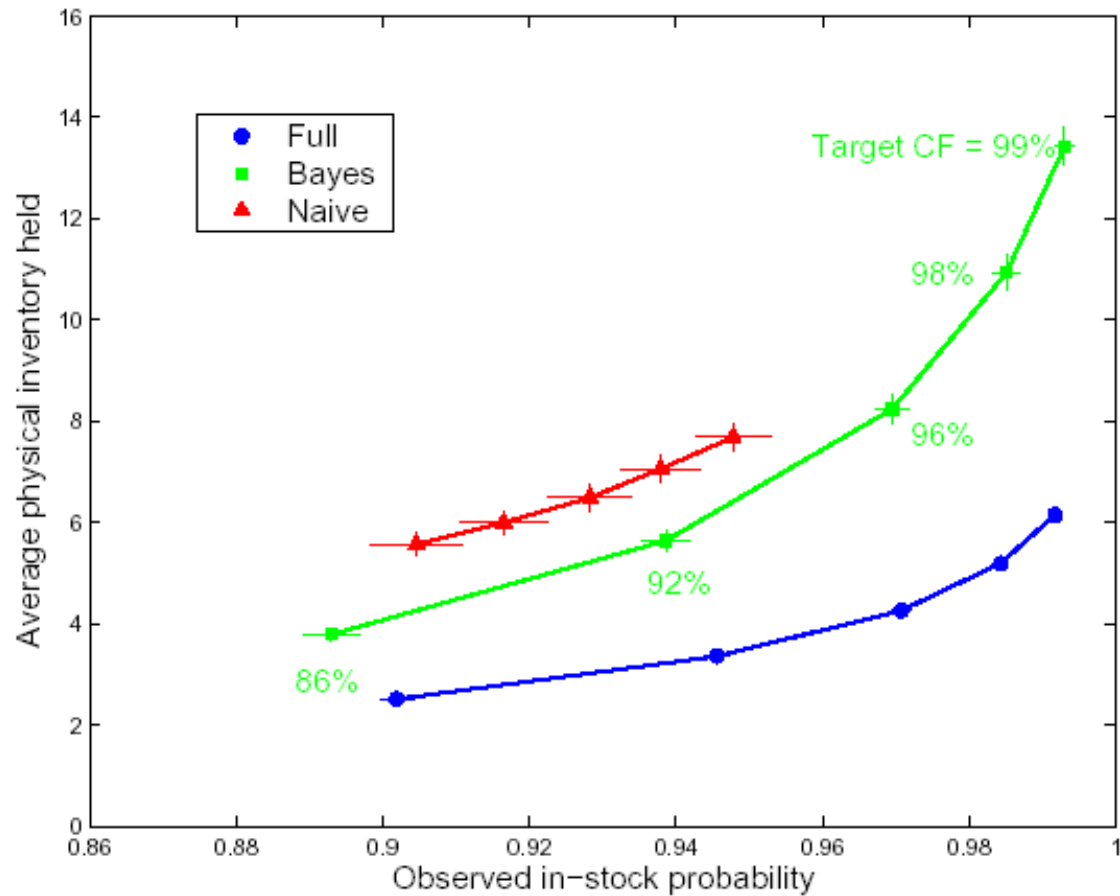
$$\Pr\{I_t=6 \text{ units}\} = 0.4$$



Simulated Replenishment Policies

- Replenishment policies based on target service levels: 99%, 98%, 96%, 92%, 86%.
- Three record-keeping methods:
 - Full info : based on physical inventory.
 - Naive : based on recorded inventory.
 - Bayes : based on updated inventory distributions.

Achievable Sales/Inventory Tradeoff



(— approx. 90% confidence intervals —)

Observations

- Policy using Bayesian updating achieves better sales/inventory tradeoff than Naïve policy
- Bayes policy permits more accurate fill rate targeting.
- For 93% fill rate for SKU modeled, Bayes policy saves 20% on inventory holding costs.
- $P_t(\cdot)$ -based policies provably avoid persistent “frozen” state

References

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Thank you!

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