

# Leveraging Flexibility for Inventory Management of Fashion Items in Retail Chains

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# Agenda

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- Introduce Retail Management Institute (Santa Clara University)
- Motivation for the research
- Description of the environment & the model for the base case
- Results
- Insights and conclusion

# Retail Management Institute Vision Statement

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- A partnership committed to the development of leaders (individuals) proficient in the use of consumer information and technology and capable of managing (leading) in a dynamic and complex multi-channel retail environment.



Santa Clara University

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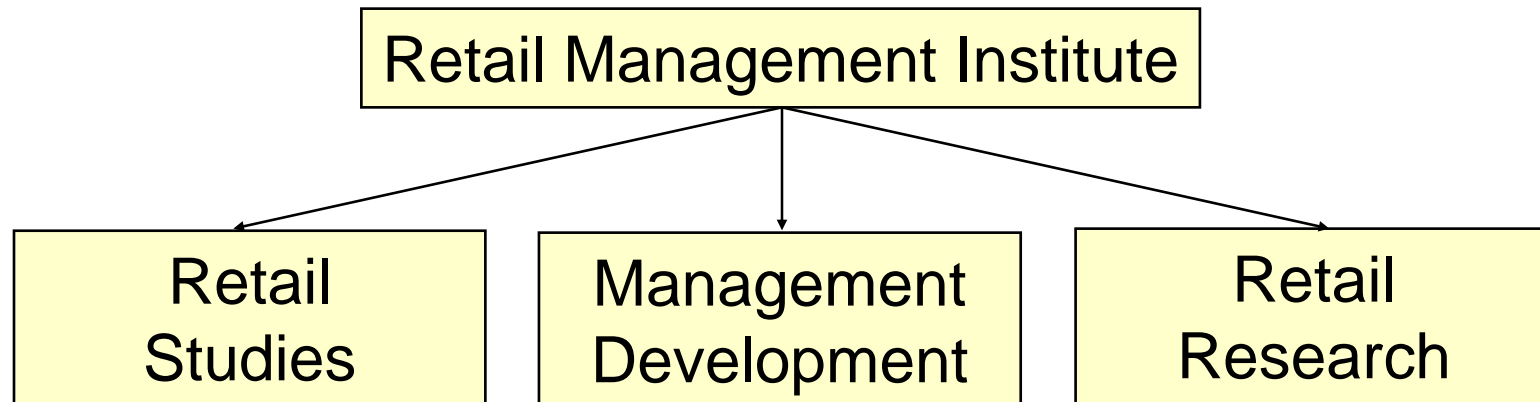
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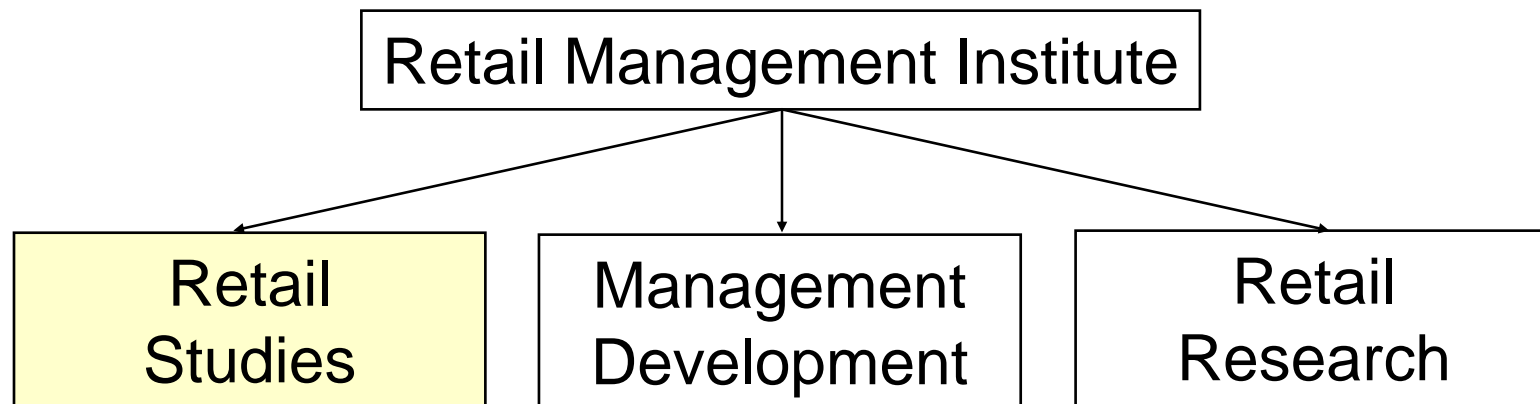
## Organized Around Three Major Program Areas

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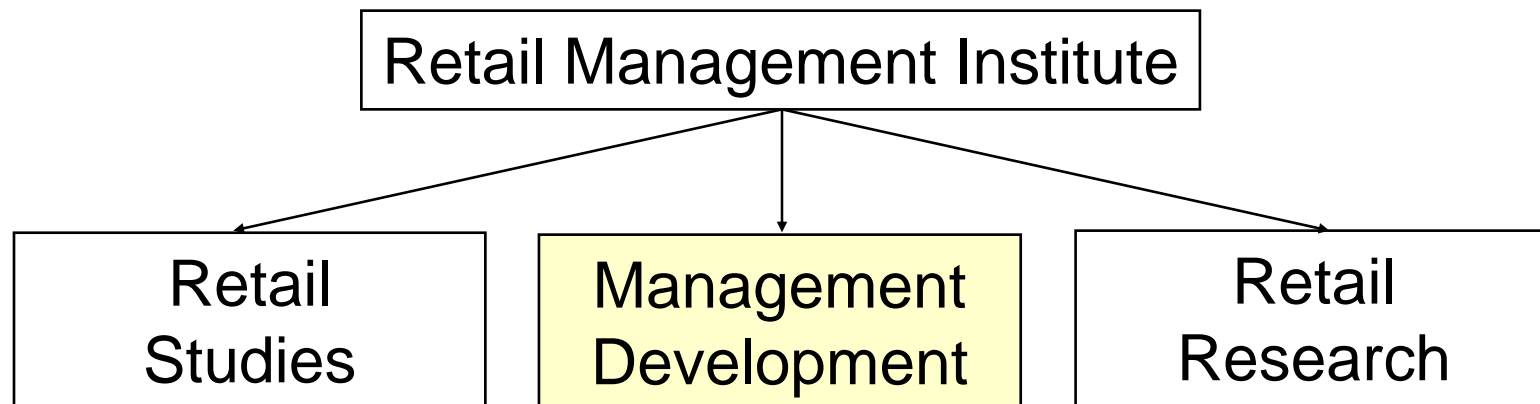
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- University approved minor
- Approximately 60-80 students participating from across the University
- Award \$30-35,000 / year in Scholarships
- Currently graduate +/-20-25 students / year
  - Receive Multiple Job Offers at Competitive Salaries
  - Enter Junior Executive positions across the U.S.
- Over 650 alumni since 1982

## Organized Around Three Major Program Areas

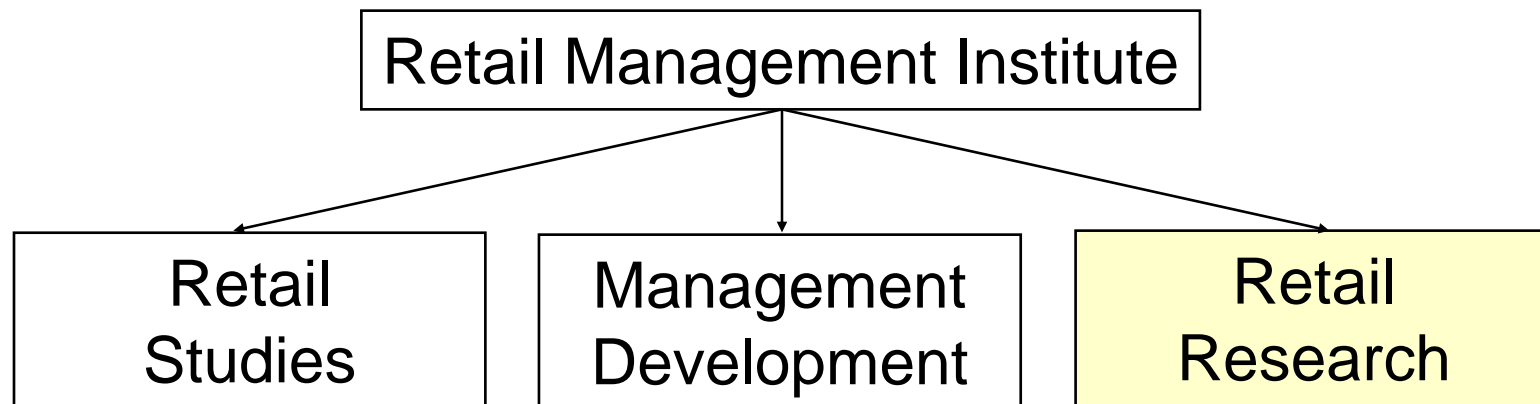
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- Retail Consortium for Management Education (RCME)
- RMI Retail Masters Class (11 years)
- RMI / TIAS - Annual Seminars (7 yrs)
  
- Custom In-Company Programs
  - J C Penney, AAFES, JUSCO, Gap, Hallmark

## Organized Around Three Major Program Areas

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- To sponsor research addressing significant problems facing the retail industry
- To advance the knowledge of retailing practices through sound empirical and theoretical research.
- Through research and other activities, to develop outstanding faculty knowledgeable about the opportunities and salient problems in the retail industry

## Example RWB Decision Support Prototype Application Areas

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- Sales Forecasting (Pricing + Advertising Effectiveness)
- Clearance Markdown Planning
- Retail Testing System (Designing & Executing Tests)
- Seasonal Planning System
- Estimating Lost Sales Due to Stock outs
- Supply Chain Management (Multi-Vendor Sourcing)
- Micro-Marketing / Merchandising
- Assortment Optimization

# The Retailing Challenge: Matching Supply and Demand

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- Matching supply and demand is particularly challenging for fashion and seasonal merchandise because of
  - Long lead times with minimal in-season reordering
  - Significant store differences
  - High levels of demand uncertainty
  - Substantial over- and under- stocking costs
  - High service level requirements

# But there are notable exceptions!

- **Zara**

- Spanish retailer
- Approx. 300 stores
- Final design to sales cycle time:  
22-30 DAYS !!



- **The World Co.**

- Japanese retailer
- Approx. 1500 stores
- Product design = 6 weeks,  
replenishment LT = 2 weeks



# Strategies for enhancing supply chain flexibility

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- External flexibility
  - Flexible vendors (ability to react with short lead times)
    - VMI, Postponement
- Internal flexibility
  - Read early season sales to update demand forecasts
  - Flexible and adjustable store stocking and allocation policies

# Motivation of our research

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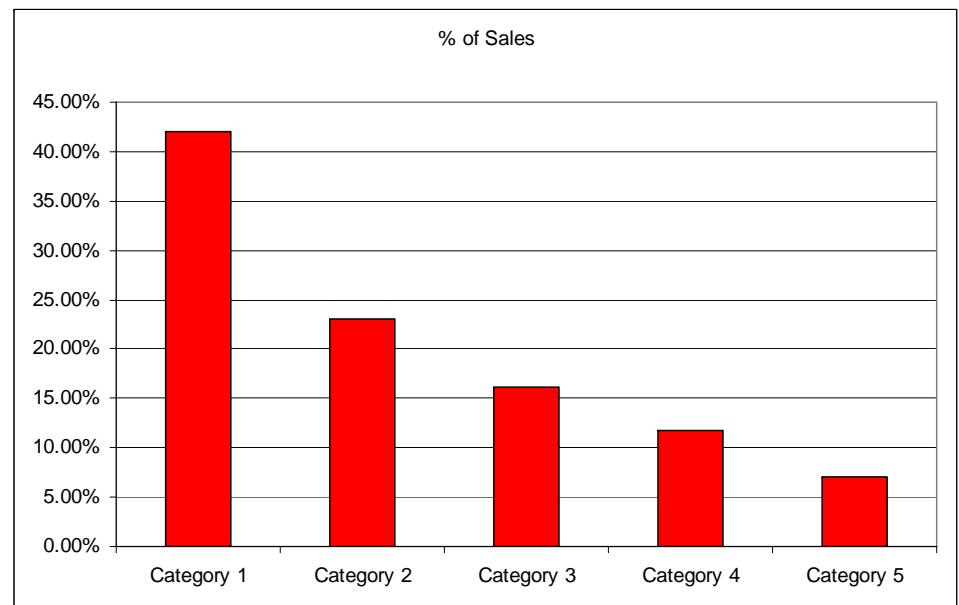
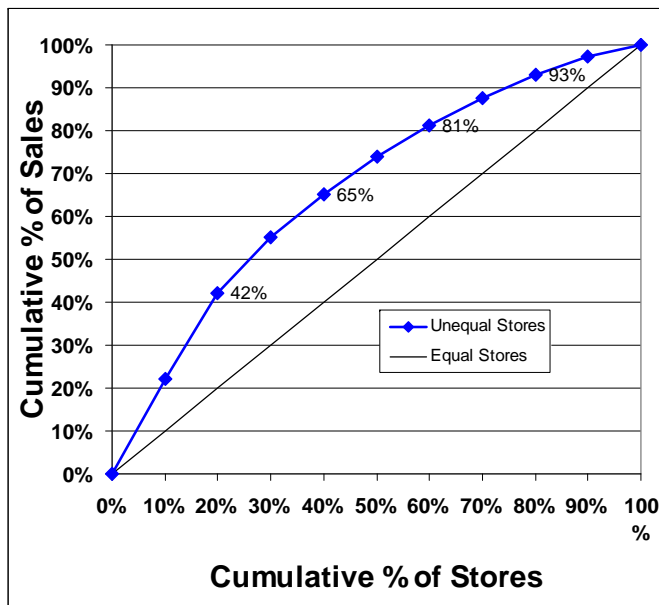
- What is the value of internal and/or external flexibility?
  - What is the value for flexible supply arrangements that allow in-season reordering?
  - What is the benefit of developing flexible store stocking policies that can react to observed sales?

# Environment

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- Large retail chain with different store selling rates
  - Therefore, store specific stocking policies are needed (*micro-merchandising, micro-replenishment*)
- Seasonal or fashion merchandise with high demand uncertainty
  - Single ordering opportunity prior to the beginning of the selling season

# Store Categories Assumed for Analysis

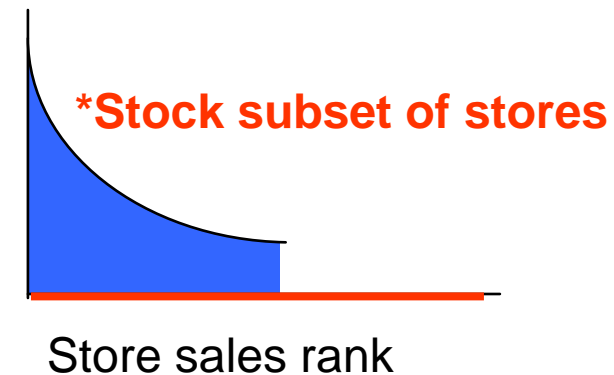
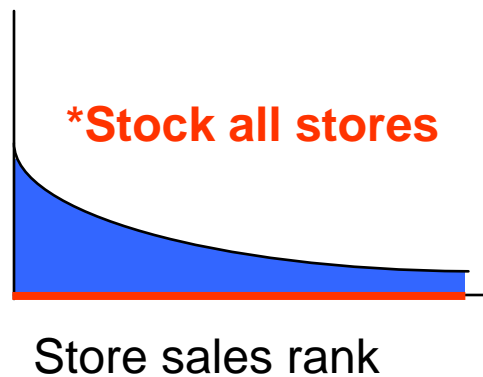
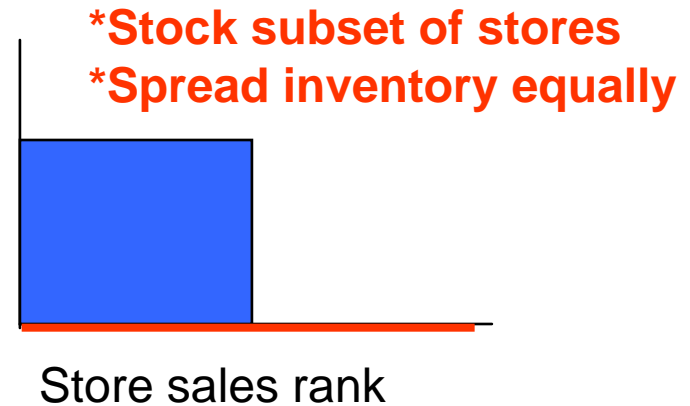
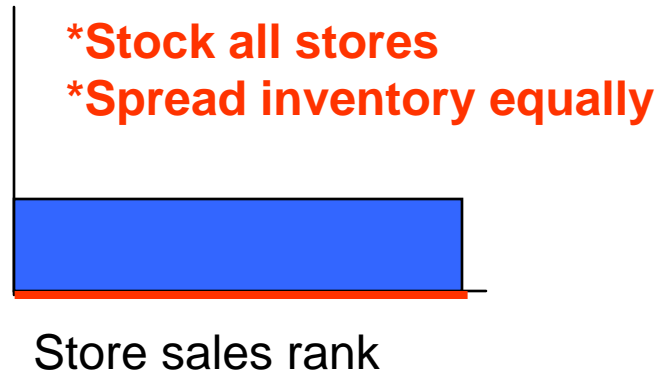


# Timeline and Key Decisions



# The allocation decision strategies

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Stores are ranked by sales volume

# Problem Formulation

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MAX [PERIOD 1 PROFITS + PERIOD 2 PROFITS]

PROFIT = REVENUE – {PURCHASE COST +  
INVENTORY HOLDING COST +  
LOST SALES COST +  
FIXED COST }

## COMPLEXITY:

1. Demand uncertainty
2. Period 1 \$ depends upon store stocking and allocation policies
3. How to update demand forecasts based on observed sales
4. Period 2 \$ depends upon period 1 decisions & period 2 decisions

# Mathematical formulation: Stochastic dynamic program with generalized Bayesian updating

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$$\max_{W_1, \mathbf{s}_1, S_1} \left\{ \Pi_1(\mathbf{s}_1, S_1) + \int_{\mathbf{d}_1} \pi_2(\mathbf{d}_1, \mathbf{s}_1, S_1, W_1) P\{D_1 = \mathbf{d}_1\} - HW_1 \right\},$$

$$\text{where } \pi_2(\mathbf{d}_1, \mathbf{s}_1, S_1, W_1) = \max_{\mathbf{s}_2, S_2} \Pi_2(\mathbf{s}_2, S_2 | \mathbf{d}_1, S_1),$$

$$\text{subject to } \sum_{x \in S_2} s_2(x) = I_2 = \sum_{x \in S_1} [s_1(x) - d_1(x)]^+ + W_1.$$

where

$$\Pi_t(\mathbf{s}_t, S_t) = \sum_{x \in S_t} \left\{ c_u s_t(x) - (c_u + c_{ot}) \int_{\{d \leq s_t(x)\}} P_t(d, x) - K_t \right\} - G_t$$

# Optimal allocation strategy

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- If the cost of excess inventory and lost sales are same at all stores, then allocate inventory such that the target in-stock probability is the same at all stores that are stocked
  - this implies that the inventory level (in units), as well as target fill rate, should be higher at larger stores
- Optimal store stocking policy is nested

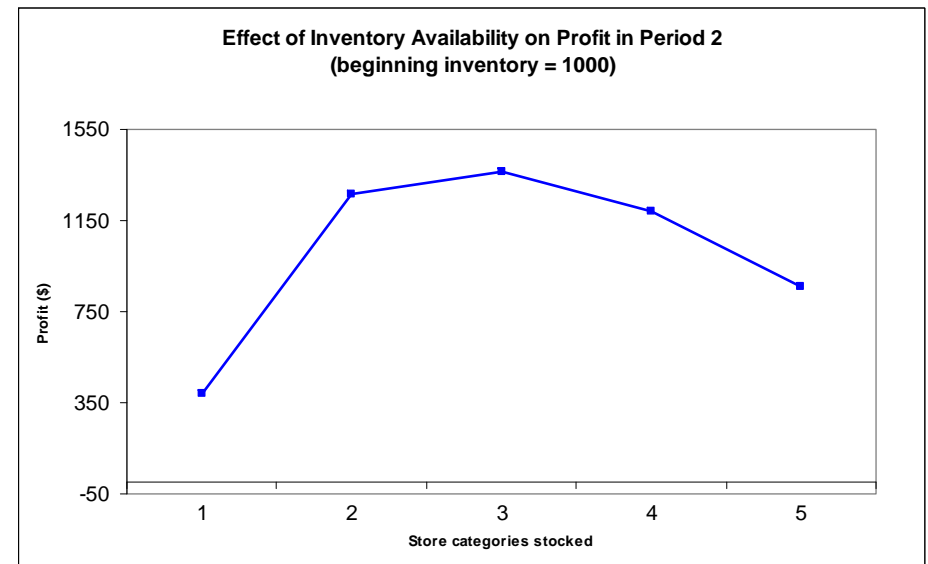
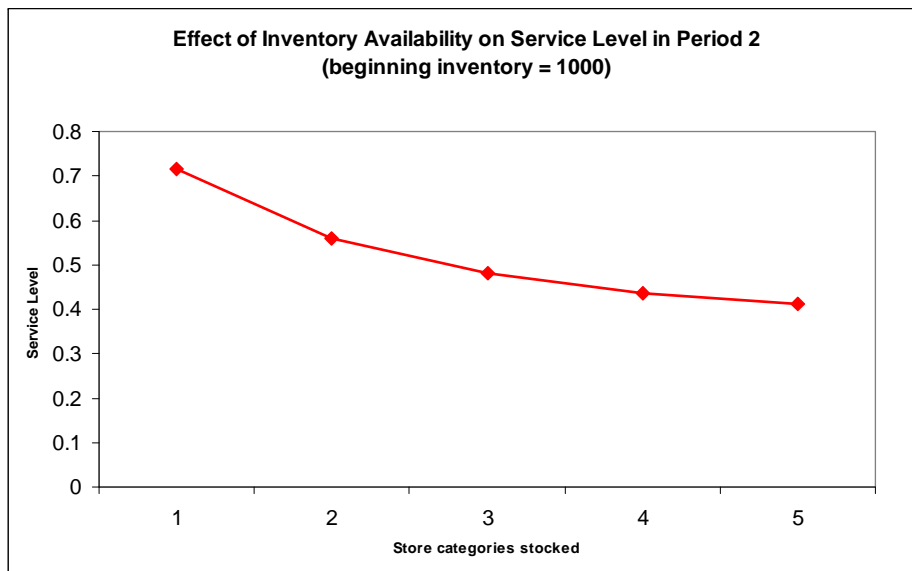
Note:

In-Stock prob.: Probability of no shortages

Fill Rate: Fraction of demand met from inventory on hand



# Service level & profit impact of allocation strategies



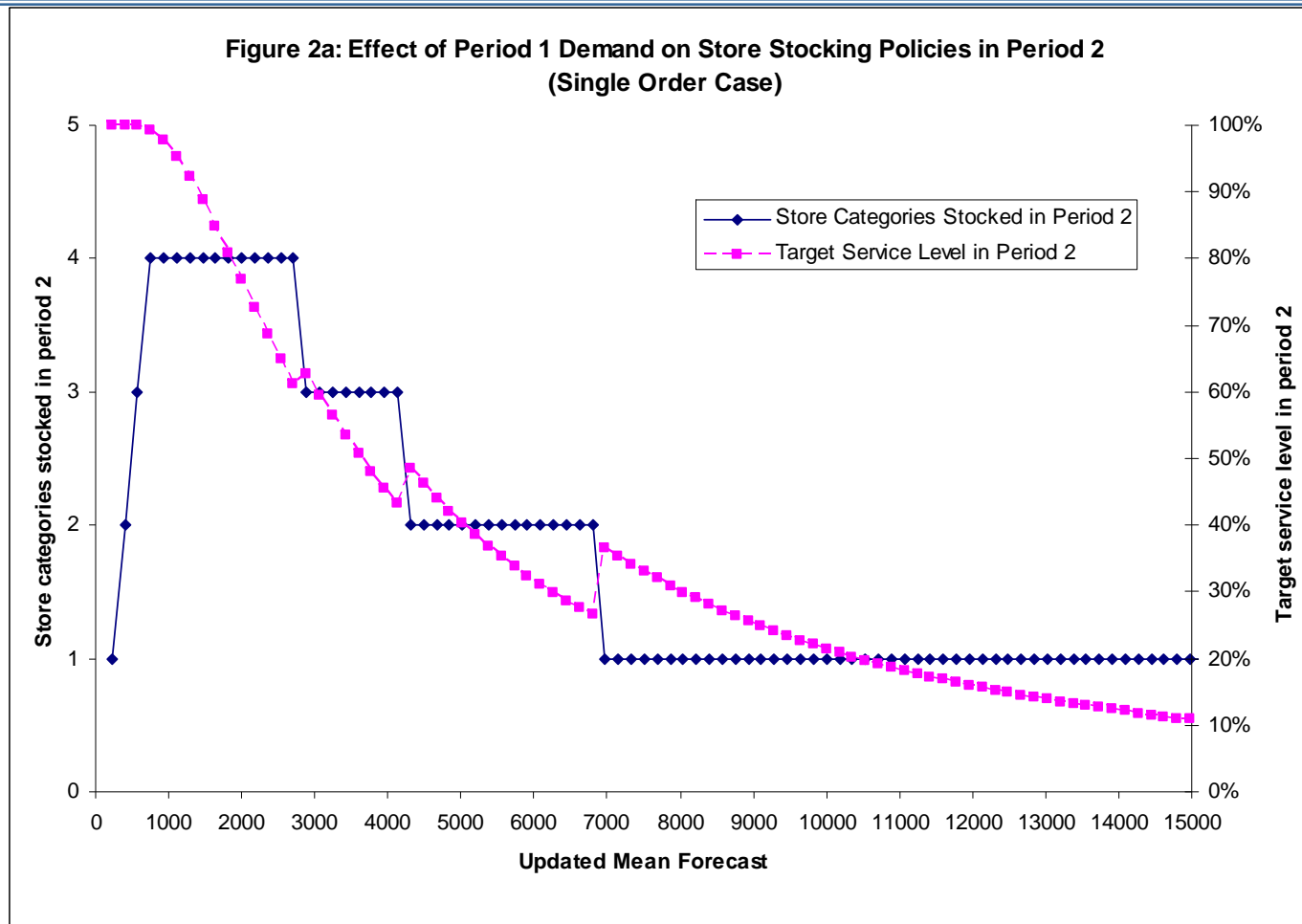
- Stocking a subset of stores may be optimal!!
- Optimal allocation and stocking policies in period 2 depend upon what happens in period 1
  - Need dynamic policies, not preset, one-size-fits-all strategy

# Ordering and stocking decisions for period 1

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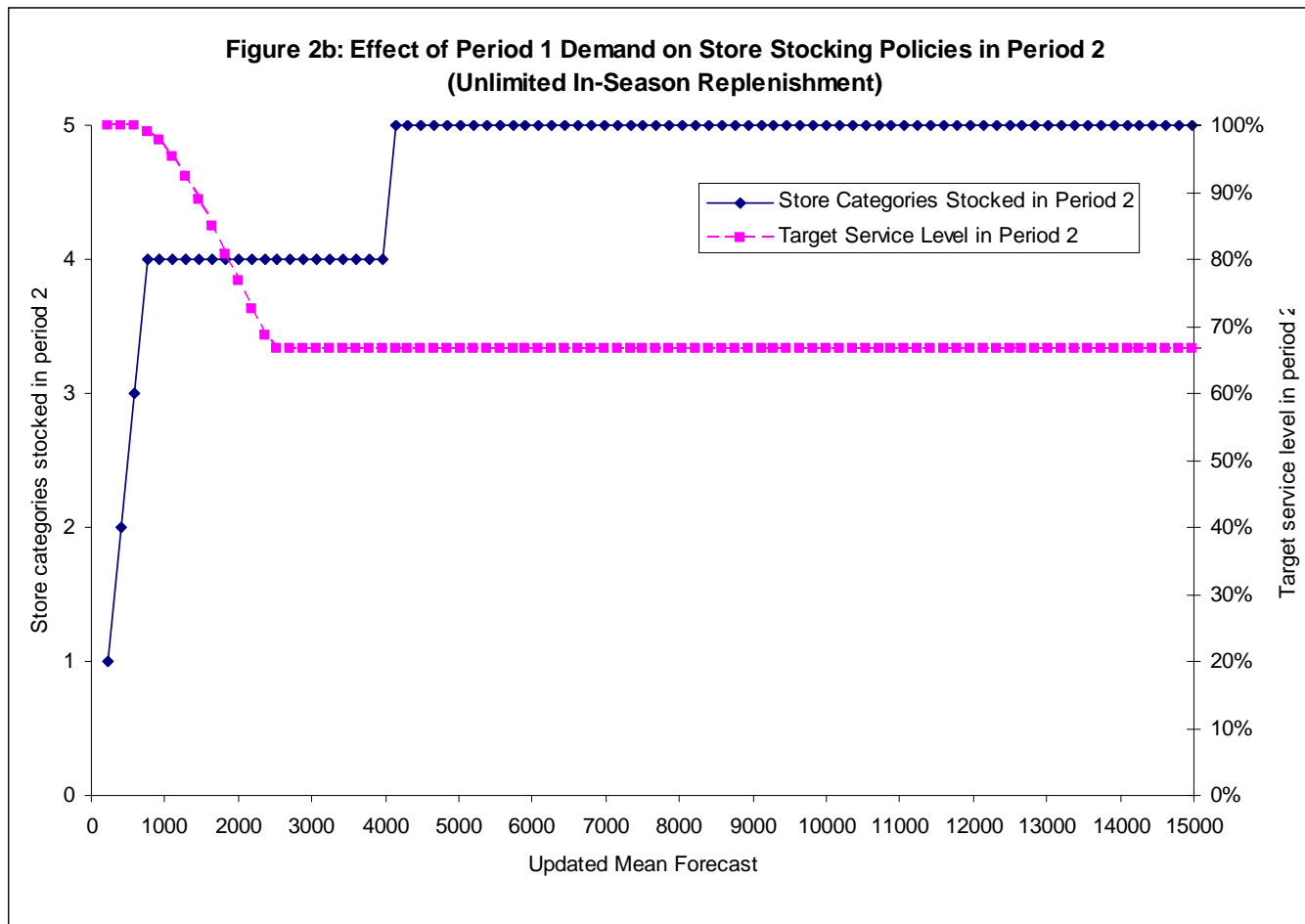
- The order size should be a function of the cost of excess inventory or lost sales
- If more store categories are stocked in period 1
  - + More information about demand is possible, which reduces demand uncertainty for period 2
  - But, stocking lower volume stores may be unprofitable

# Effect of period 1 demand on period 2 decisions (NO EXTERNAL FLEXIBILITY)



Low ← PERIOD 1 DEMAND → High

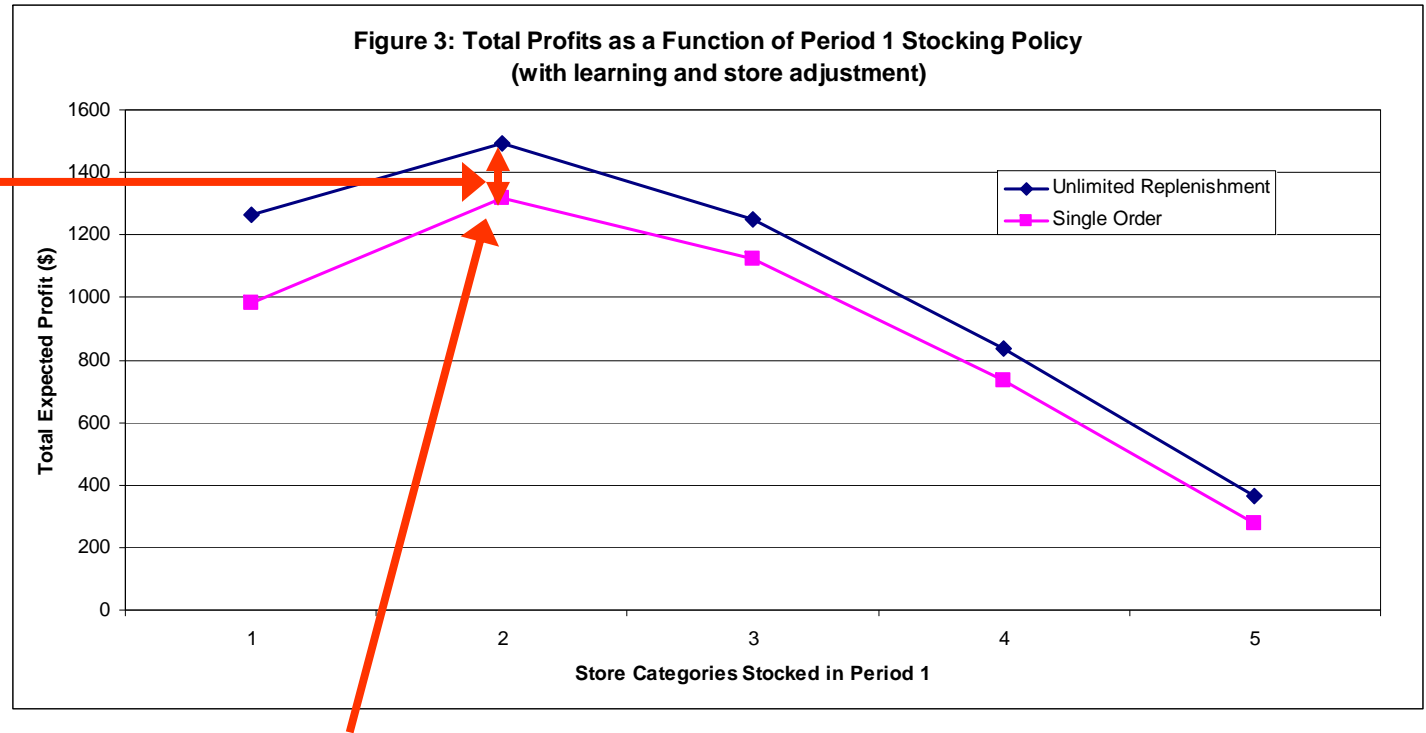
# Effect of period 1 demand on period 2 decisions (WITH EXTERNAL FLEXIBILITY)



Low ← PERIOD 1 DEMAND → High

# Optimal period 1 decision

External Flexibility increases profit



Stock only category 1 & 2 stores

# So, what type of flexibility matters more?

Expected Profits Under Different Scenarios		EXTERNAL FLEXIBILITY	
		YES	NO
INTERNAL FLEXIBILITY	YES	1491	1320
	NO	890	888

- External flexibility, **without** internal flexibility is worth very little
- Internal flexibility, even by itself, can improve profits substantially
- External + internal flexibility leads to the maximum profit improvement

# How does the distribution of sales across the chain matter?

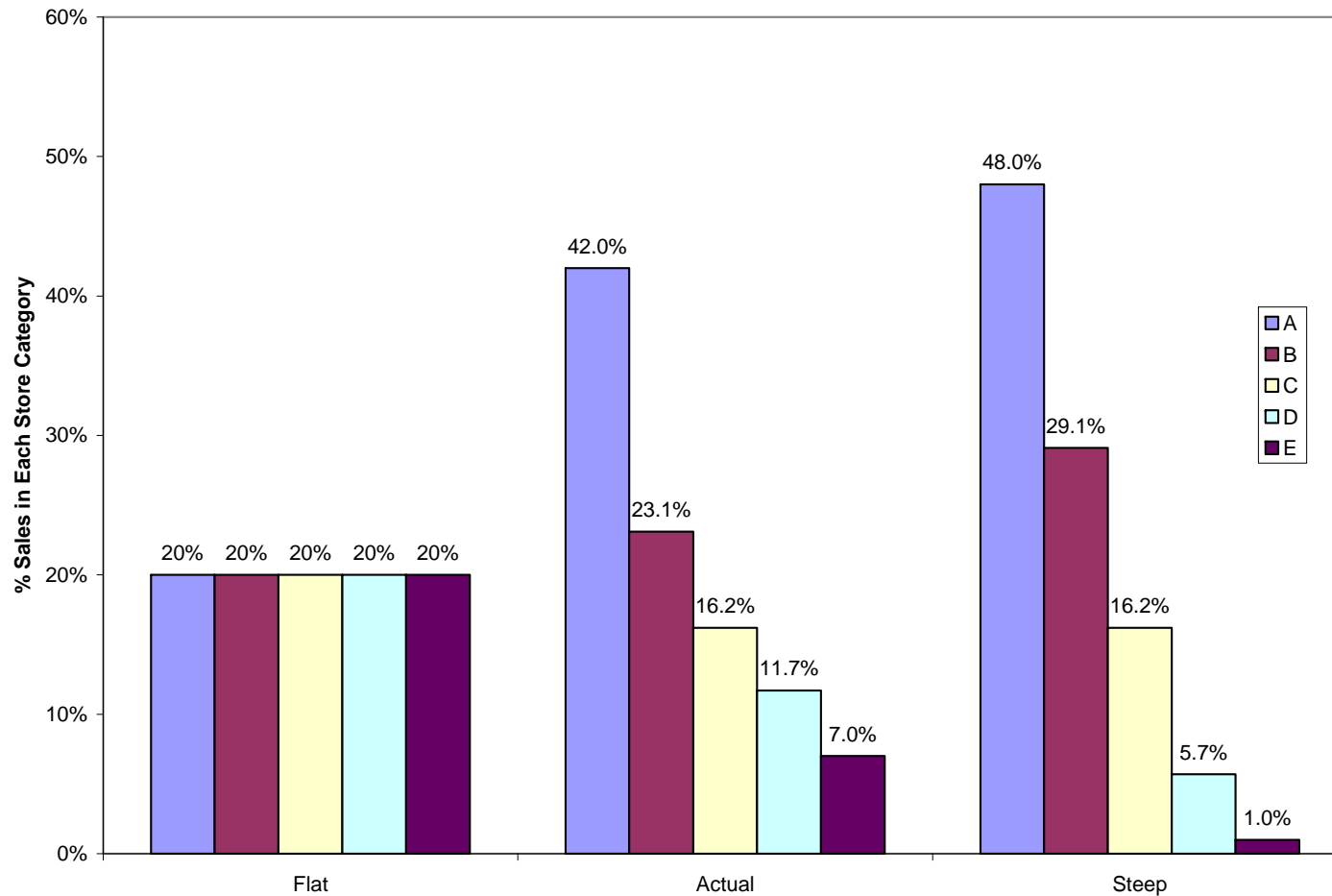


Figure 4: Sales Rate Curves

# Effect of sales distribution

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- Profits are generally higher for steeper sales curves
  - Stocking fewer stores leads to higher profits and better information
- % benefit of store adjustment is higher for flatter chains

# Key Implications for Inventory Management

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- Stocking only some stores initially can be a cost effective strategy.
  - Need effective “testing” methodologies
  - Localized stocking policies are necessary
  - Stocking all stores, all the time, may not be the most profitable strategy
- Internal flexibility can significantly enhance profitability
  - Need data driven, dynamic forecasting methodologies
  - In-season adjustment of store stocking policies is valuable
  - These benefits must be traded off against costs arising from possible logistical or assortment related constraints
- External flexibility can increase profitability even more, but internal flexibility is important to maximize the benefit
  - Price premium or investments required for external flexibility may be highly worthwhile
- Store adjustment/learning can act as a substitute for external flexibility if the latter is unavailable, or very expensive
- The relative value of internal and external flexibility depends upon a variety of factors, so care must be exercised before committing scarce resources to gain flexibility

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Thank You!

Q& A

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