Financial Returns to Household Inventory Management

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Financial Returns to Inventory Management

- Households can reduce cost of acquiring goods by allocating assets to *working capital*
- We define working capital as the sum of two components:
  - Value of stored household goods (inventory)
  - Cash

Working capital reduces costs by allowing households to:

1. Stock up when items are on sale, or buy in bulk.
2. Make larger, less frequent trips and save on trip fixed costs.

Marginal Return to Working Capital

- Allocating extra \$1 to working capital generates \$$x$ in additional in-store savings (net of holding costs) and lower trip fixed costs.
- We think of this as a marginal return of $x \times 100\%$.

Gross return: reflects in-store savings only.

Net return: takes into account holding costs and trip fixed costs (which we do not observe directly). We measure this using a calibrated model.

Main Results

- Data results (Nielsen Consumer Panel):
  - Households hold inventory worth on average around $1100.
  - The relationship between inventory and $ savings in store suggests gross marginal returns of around 30%.
- Model:
  - We calibrate the model using Nielsen data, and use it to compute marginal returns to working capital.
  - Marginal returns:
    - High at low levels of working capital, $>$ typical stock returns.
    - Rapidly diminish as working capital increases.

Literature

- Can ↑ savings by allocating more time (Aguiar & Hurst, 2007).
  - We show another way to ↑ savings: invest in working capital.
- Measure savings as a % of the purchase price (Griffith, Leibtag, Leicester & Nevo, 2009).
  - We show how savings are related to working capital, and compute net marginal returns.
- Models of strategic deal shopping (Hendel & Nevo, 2013; Boizot, Robin & Visser, 2001)
  - We aggregate over all products the household consumes and incorporate trip timing choice.
- Stock-market participation puzzle/consumption smoothing
  - Returns to working capital > stock market at low levels of working capital, and are less risky.
  - Working capital is an important investment for poor households.

Data

- Nielsen Consumer Panel
  - Participating households record purchases (mostly grocery).
  - Product-level information (UPC, quantity bought, price paid).
  - Neither inventory nor the value of savings are directly reported. We make some assumptions to compute these.
- Nielsen Retail Scanner Panel
  - Stores report sales-weighted avg. price for each UPC each week.
- Survey of Consumer Finances
  - Detailed information on assets of U.S. households.

Computing Inventory

- Can observe the flow of purchases for each household.
- Can't observe the stock of inventory.
- Two problems:
  1. The rate of consumption is not observed.
  2. The starting level of inventory is not observed.

Computing Inventory

Approach:

- Aggregate products to a level where it is appropriate to assume a constant consumption flow.
- Back out initial inventory using the requirement that inventory should never be negative.
  - Lower than the true level of inventory if true inventories of that product category did not hit zero at some point during the year.

Trade-off: Too little aggregation means inventory overstated; too much aggregation means inventory understated.

Inventory by Level of Aggregation

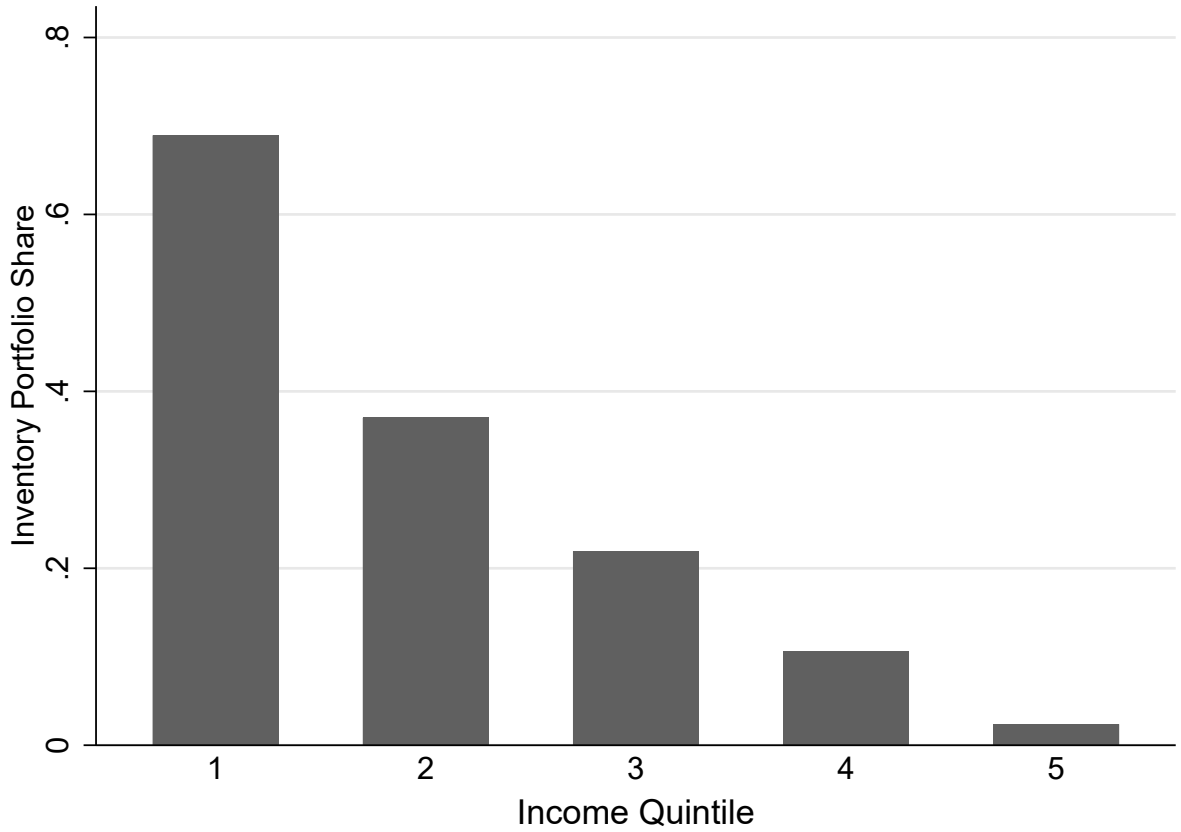
Nielsen product categories:

- 10 Departments (e.g. dairy)
  - 118 Product groups (e.g., cheese, milk, eggs, yogurt)
    - 1305 Product modules (e.g. grated cheese, natural American cheddar, processed cheese slices, cheese variety packs)
- We use product groups. Here are the average inventory values under alternative approaches:

Average Inventory ($)			
Department	Product Group	Product Module	UPC
726	1132	1398	1870

Inventory Share of Assets

- Do not observe household assets in Nielsen data.
- Match Nielsen households to comparable SCF households.



$$\text{Inventory Portfolio Share} = \frac{\text{Inventory}}{\text{Financial Assets} + \text{Inventory}}$$

Computing Savings

1. **Coupon savings:** If the respondent used a coupon (value of the discount is recorded directly).
2. **Deal savings:**
   - *Self-reported deals:* Nielsen deal indicator equal to one if consumer perceives the item to be a deal.
   - *Alternative definition:* Compare unit price paid with average unit price in same ZIP3 for identical product.
3. **Bulk savings:** Buying a larger than typical pack size.
   - 1, 10, 12, 24, 48, 72 pack Snickers bars have different UPCs.
   - We want a new product code which corresponds to Snickers.
   - We group UPCs by:
     - Common consumer name (e.g. "CHOCOLATE BAR")
     - Brand code (e.g. "M&M MARS SNICKERS")
     - Product module code (e.g. "CANDY-CHOCOLATE")

Relationship Between Inventory and Savings

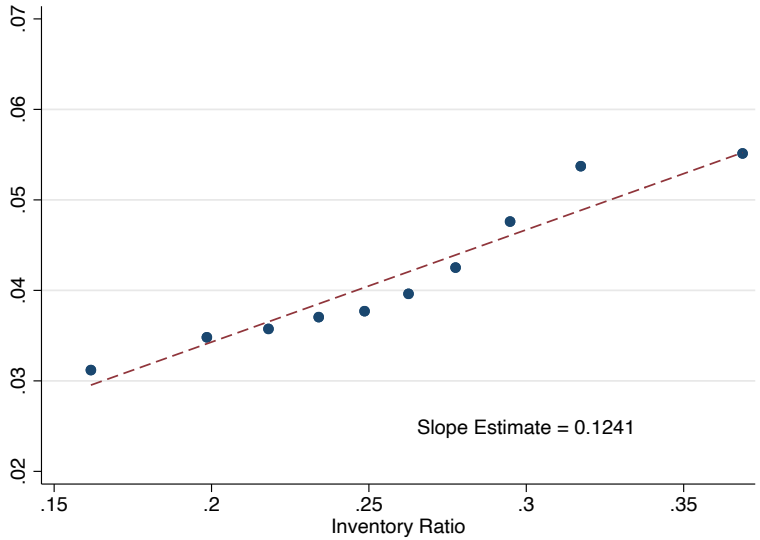
Ideally, want to know how much $ savings increase if working capital is increased by $1:

- One approach: relationship between inventory and savings.
- This approach is suggestive but not ideal, and does not incorporate trip fixed costs or holding costs.
  - Some sources of inventory variation would be problematic:
    - e.g. If temporary sales drive brand/product choice for some, inventory may be overstated for households with high savings.
    - Aggregating to product groups helps to address this.
- Ultimately we will compute returns using a calibrated model.

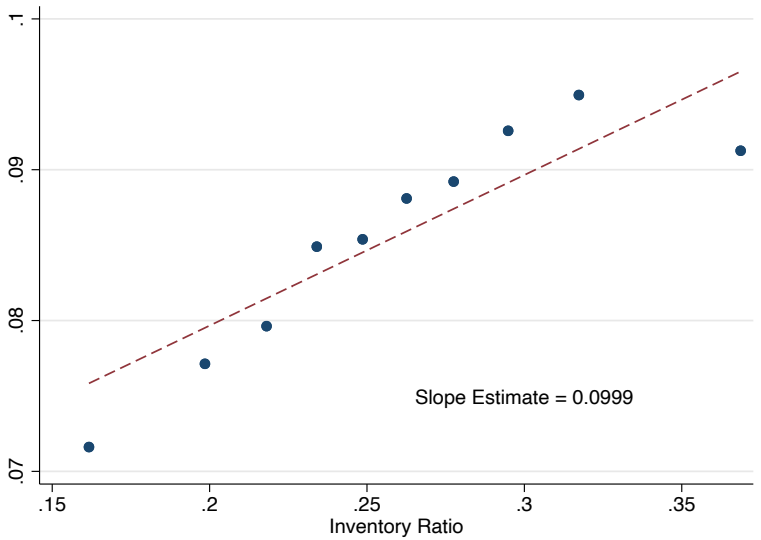
Relationship Between Inventory and Savings

Households with high annual average inventory (as a % of annual spending) also have higher % coupon and deal savings:

Coupon Savings



Deal Savings



Both figures control for the # of trips each household makes.

Relationship Between Inventory and Savings

- Broadly flat relationship between bulk savings and inventory.

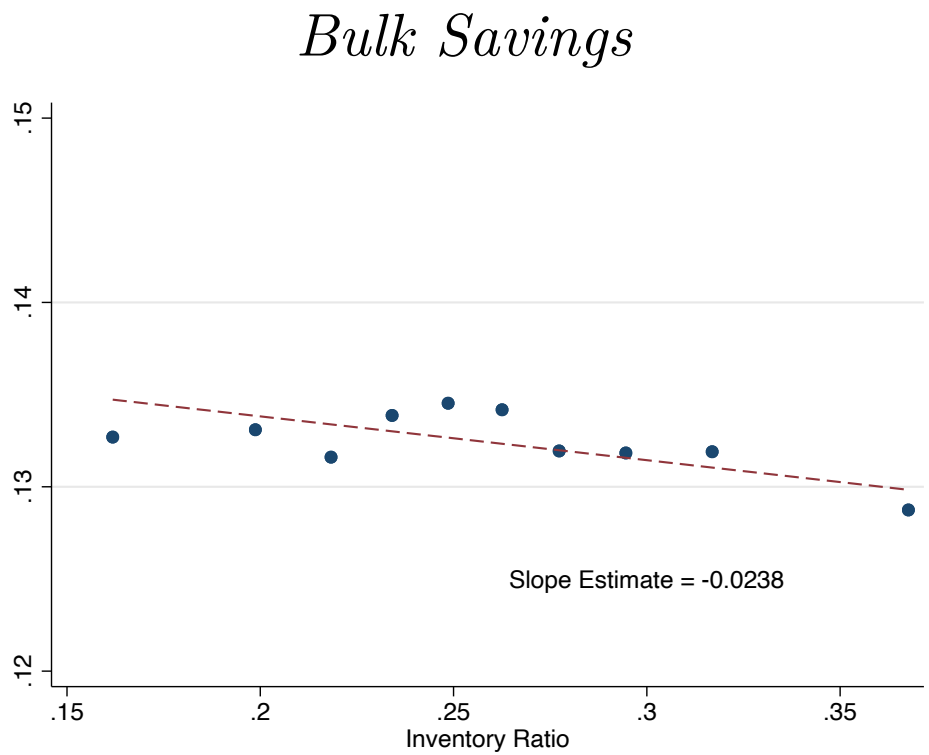
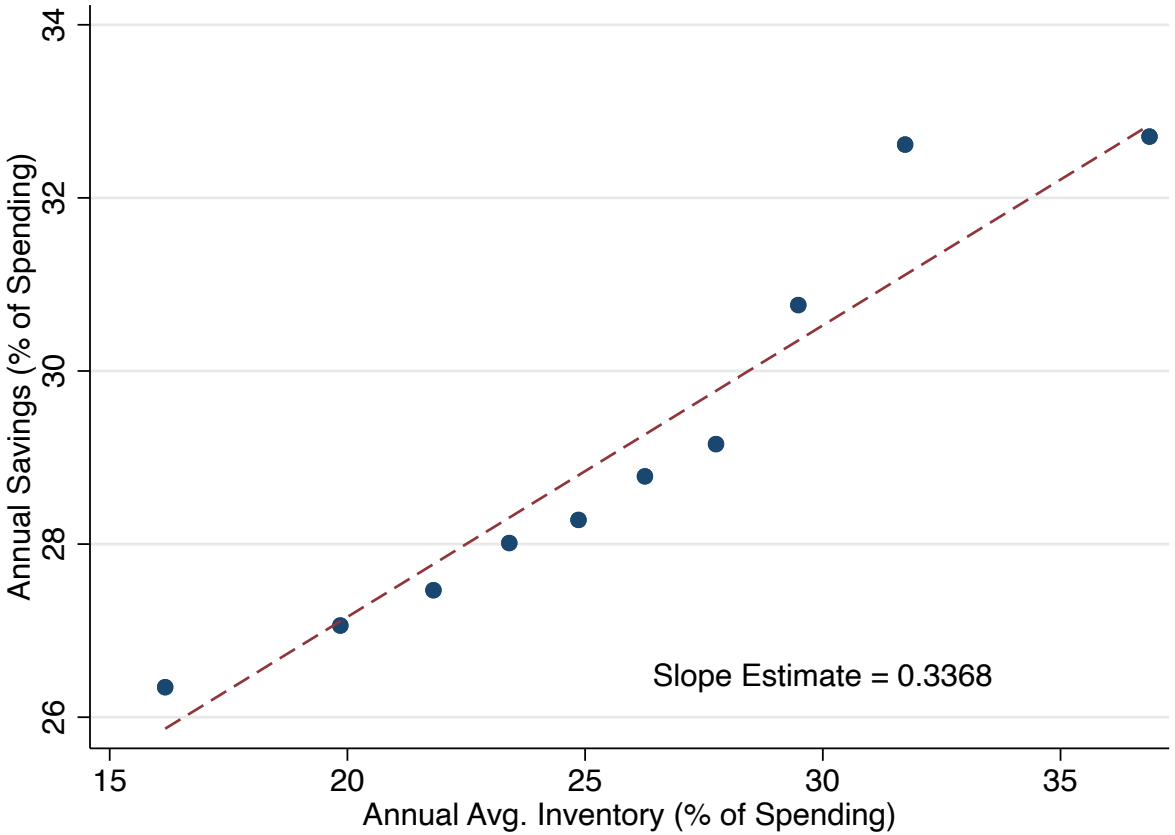


Figure controls for the # of trips each household makes, and potential bulk savings (availability of bulk savings for products the household buys).

Gross returns

- Total savings $= \frac{\text{\$Coupon Savings+\$Deal Savings+\$Bulk Savings}}{\text{Total Spending}}$
- We compute gross returns to inventory of around 33%.



Model

Households:

- Choose a shopping strategy to minimize the cost of providing an exogenous consumption stream.
- Are subject to a working capital constraint.

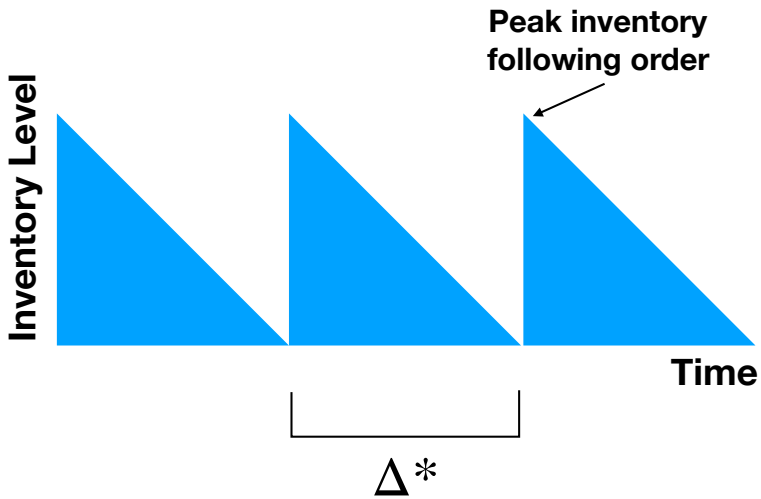
In a higher level problem, constraint is something the household can adjust by allocating more to the working capital investment.

We study how relaxing the working capital constraint reduces the cost ($\rightarrow$ marginal return to working capital).

Model

Like firm inventory problem (Arrow, Harris & Marschak, 1951):

- Firm decides when to place orders for inventory to minimize cost of meeting exogenous demand.
- Firm chooses an order interval Δ:
  - Order size fully determined by time between orders.
  - Optimal to run inventory down to zero before ordering.



Model

Our model has some additional features:

- Working capital constraint.
- Households choose a bargain-hunting policy m in addition to Δ.
- The bargain-hunting policy means that inventory is not necessarily run down to zero before a trip:
  - Households stockpile items when they are on sale and may have some left when they next visit the store (to buy other items)
- Two goods: storable and perishable.

Problem

Minimize average monthly cost of supplying consumption:

$$\min_{\Delta,\{m_l\}} \frac{k + \sum_l P_l(\Delta, m_l) \cdot S_l(\Delta)}{\Delta}$$

subject to

$$\sum_l I_l(\Delta, m_l) < \bar{I}$$

- k is the fixed cost (e.g. opportunity cost of time shopping).
- Δ is the time between trips (in months).
- m_l is the bargain-hunting policy.
- $P_l \cdot S_l$ is the total price paid per trip on type l goods.
- $\bar{I}$ is working capital, I_l is the inventory of type l goods immediately after a trip.

Bargain-hunting Strategy

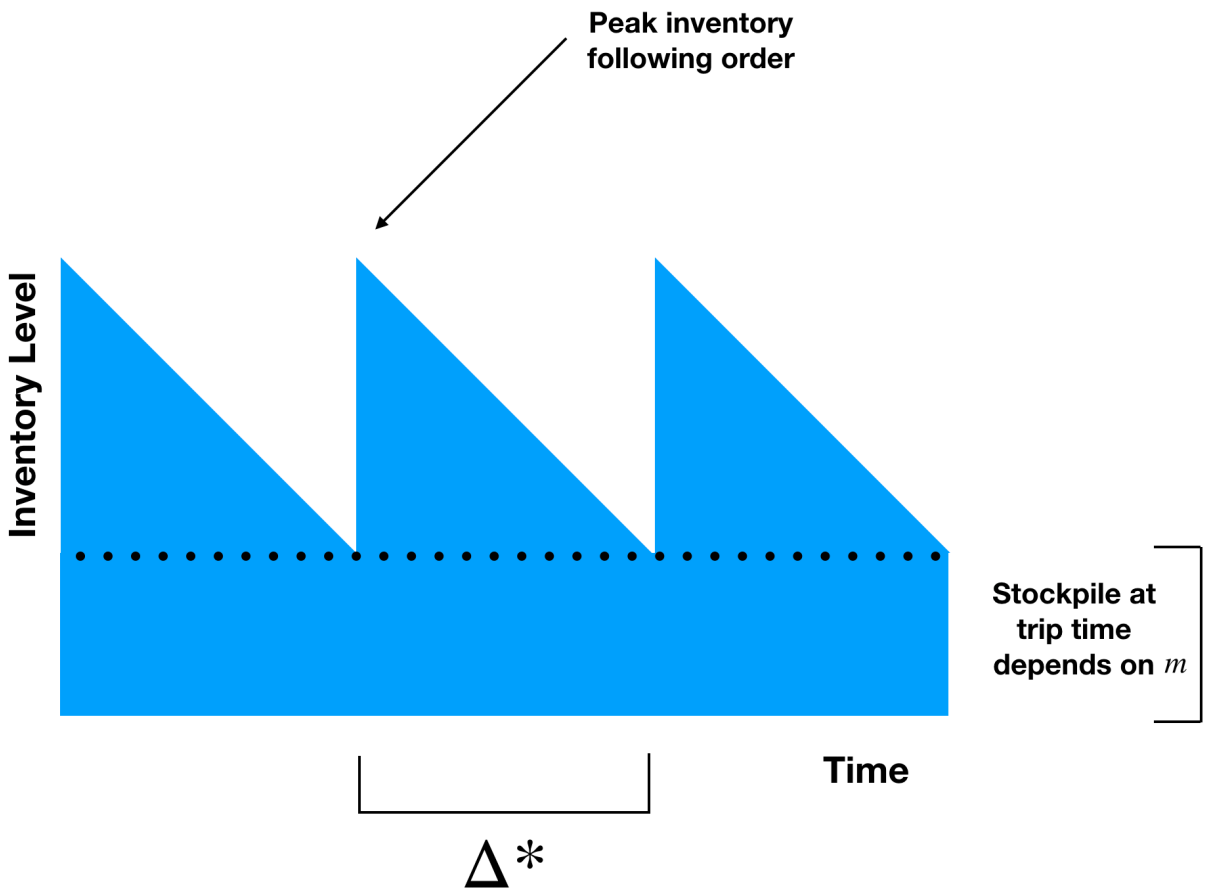
When arriving at the store, households observe prices for all goods in their basket:

- p_d with probability x (deal price)
- p_f with probability $1 - x$ (full price)

Strategy:

- Only buy at full-price if item required immediately.
- When observing the deal price, stock up to some chosen level:
  - m_l is the # of trips willing to buy in advance of consumption.

- We assume prices are iid over products and time (and household consumes a large number of different products).
- Problem is effectively static and deterministic:



Model Calibration

Name		Value	Source/target
Trip fixed cost	k	\$4.85	Baker, Johnson, Kueng (2020).
Full list price	p_f	1.064	Average discount size and
Deal price	p_d	0.794	$E[p] = xp_d + (1-x)p_f = 1$.
1 - max bulk savings %	α	0.85	Relationship between pack size and unit price.
Bulk savings parameter	β	0.89	
Bulk savings parameter	σ	1.80	
Monthly consumption	C	464.83	Average annual spending and inventory.
Storable depreciation	δ_0	0.003	
Deal probability	x	0.24	NCP deal share.
Perishable depreciation	δ_1	2.88	Average expiration date for products lasting $<$ 1 month (0.347 months)
Storable good share	s_0	0.769	Expenditure share of goods with expiration date $\geq$ 1 month

Results

Working Capital Ratio	Min. Inv. ($)	% Savings: Deal	% Savings: Bulk	Interval Δ^* (Months)	Net Return (%)
0.05	133.52	9.46	10.94	0.25	72.30
0.10	370.96	12.66	11.05	0.25	21.85
0.15	604.66	13.48	11.69	0.27	6.89
0.20	839.45	13.86	11.86	0.27	1.42
0.25	1069.60	14.03	11.86	0.27	0.00
0.30	1069.60	14.03	11.86	0.27	0.00

Marginal returns:

- Very high at low levels of working capital (relative to spending)
- Zero for working capital $>$ 3 months spending

Model fit:

- Trip interval, deal and bulk savings all match the data fairly closely.

Conclusion

- Households hold around $1100 of consumer goods inventory.
  - A substantial share of assets for poor households.
  - Relevant for ability of households to smooth consumption.
- Households can earn very high returns from (small) working capital investments.
  - Dominates stock returns at low levels of working capital.