What is Operations Management?

- Operations Management (OM) is an area of business that deals with:
  - Designing and controlling manufacturing and service processes
  - Two broad areas:
    - Strategic: Supply Chain Management
    - Tactical: Logistics
  - Related to Operations Research (OR)
    - More about problems and less about methods
OM in the 60’s and 70’s used to be Logistics, and mostly about central planning

- Supply Chain Design
- Job-shop scheduling
- Lot Sizing
- Queuing Systems
- Inventory Management
- ...
The scope of OM
Operations Management Evolution

- 1980s-1990s: decentralized models (Game Theory)
  - Incentives
  - Contract Negotiation
  - Social Norms
  - Trust
- Requires a model of individual (firm) decision-making.
Decentralized Model

Raw materials → Suppliers → Manufacturing → Distribution → Customers

Retailer → Warehousing
Behavioral Operations Management (BOM)

- Understand what decision-makers are doing
- Develops behaviorally-robust models

**The Goal**: to explain, predict and improve operations.
Decentralized Model

Raw materials

Suppliers

Manufacturing

Distribution

Customers

Retailer

Warehousing
The case of the newsvendor problem

The profit: \( \pi(q, D) = p \min(q, D) - cq \)

The expected profit to be maximized:
\[
\mathbb{E}[\pi(q, D)] = (1 - F(q))(p - c)q + \int_0^q f(x)\pi(q, x)dx
\]

The optimal order quantity \( q^* \) must satisfy:
\[
F(q^*) = \frac{p - c}{p}
\]

Critical Ratio (CR)

Arrow (1951)
Decision Bias in the Newsvendor Problem with a Known Demand Distribution: Experimental Evidence

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Fuqua School of Business, Duke University, Durham, North Carolina 27708
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In the newsvendor problem a decision maker orders inventory before a one period selling season with stochastic demand. If too much is ordered, stock is left over at the end of the period, whereas if too little is ordered, sales are lost. The expected profit-maximizing order quantity is well known, but little is known about how managers actually make these decisions. We describe two experiments that investigate newsvendor decisions across different profit conditions. Results from these studies demonstrate that choices systematically deviate from those that maximize expected profit. Subjects order too few of high-profit products and too many of low-profit products. These results are not consistent with risk-aversion, risk-seeking preferences, Prospect Theory preferences, waste aversion, stockout aversion, or the consequences of underestimating opportunity costs. Two explanations are consistent with the data. One, subjects behave as if their utility function incorporates a preference to reduce ex-post inventory error, the absolute difference between the chosen quantity and realized demand. Two, subjects suffer from the anchoring and insufficient adjustment bias. Feedback and training did not mitigate inventory order errors. We suggest techniques to improve decision making.

(Behavioral Operations; Newsvendor Inventory Decisions; Decision Bias; Anchoring; Minimizing Ex-Post Inventory Error)
Findings

① The “Pull to Center“ Bias
② Asymmetry: low CR is further from optimal (closer to mean demand)
③ Little learning

Low profit: CR = 0.25
High profit: CR = 0.75
These results cannot be explained exclusively by risk aversion, risk-seeking preferences, loss aversion, waste aversion, stockout aversion, or underestimation of opportunity costs.
The “Pull to Center“ Bias Appears to be Generally Persistent…

High profit: CR = 0.75

Low profit: CR = 0.25

Source: Bolton and Katok (2008)
The “Pull to Center” Bias Appears to be Generally Persistent…

Source: Bostian, Holt and Smith (2008)
The asymmetry result is less robust: this dataset does not show much of an asymmetry.

![Box-and-whisker plot and standard optimal order quantities](image)

**Figure 3:** Box-and-whisker plot and standard optimal order quantities

**Source:** Zhao, Geng, Chao and Zhang (2011)
Robustness to framing and somewhat robust to gender

Source: Stangl and Katok and Thonemann (2017)
…while this one shows low CR is better (closer to optimal than high CR)

Source: Ockenfels and Selten (2013)
Asymmetry persists with the Buy-back contract

Source: Becker-Peth, Katok and Thonemann (2013)
Hypothesis Tree

Branches are hypotheses addressing questions at the base. Cut branches indicate hypotheses found “unsatisfactory.”

What explain newsvendor behavior?

- Risk Aversion/Risk Seeking
- Loss Avoidance
- Underestimating opportunity costs
- Waste Aversion
- Learning
- Cognitive Dissonance
- Prospect Theory with static reference point
- Prospect Theory with dynamic reference point
- Random errors
- Reference dependence
- Subject pool
- Mental accounting
- Overconfidence

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Decentralized Model

- Raw materials
- Suppliers
- Manufacturing
- Customers
- Retailer
- Warehousing
- Distribution
Supply Chain Contracting

This has the structure of the much-studied Stackelberg Game:

- Seller is the first mover: proposes a contract terms (eg. $w$)
- Buyer is the “Newsvendor” chooses order quantity ($q$)
Wholesale Price Contract

The Buyer pays the Seller $w$ for each unit ordered:

\[
\pi_{Supplier} = (w - c)q
\]
\[
\pi_{Retailer} = p \min(D, q) - wq
\]
\[
\pi_{Channel} = p \min(D, q) - cq
\]

Demand $D \sim F()$

Market price $P$
Double Marginalization

- The Buyer orders less than the efficient amount under the wholesale price contract.
- Contracts can be designed to “coordinate” the channel.
The Buyer pays the Seller $w$ for each unit ordered and the Seller return to the buyer $b$ for each un-sold unit:

\[
\pi_{Supplier} = (w - c)q - b \max(0, q - \min(D, q))
\]

\[
\pi_{Retailer} = p \min(D, q) - wq + b \max(0, q - \min(D, q))
\]

\[
\pi_{Channel} = p \min(D, q) - cq
\]
Automated Buyer

- Coordinating Contracts don’t work well
  - Buyback: Katok and Wu 2009,
  - Service Level Agreements: Davis 2014,
  - Advance Purchase discount: Davis et al. (2014)

Sellers do not take sufficient risk to coordinate the channel.
## Human Buyer and Seller

### Efficiency

<table>
<thead>
<tr>
<th>Contract Structure</th>
<th>Ultimatum Offer</th>
<th>Negotiating Price</th>
<th>Negotiating Price &amp; Order Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale Price (Davis &amp; Hyndman 2017)</td>
<td>63%</td>
<td>63%</td>
<td>77%</td>
</tr>
<tr>
<td>Buyback (Coordinating) Becker-Peth et al. (2017)</td>
<td>69%</td>
<td>76%</td>
<td>82%</td>
</tr>
</tbody>
</table>
Negotiation Contract Improves Efficiency
(Becker-Peth, Katok and Thonemann working paper)

<table>
<thead>
<tr>
<th></th>
<th>UB</th>
<th>N</th>
<th>HN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejected</td>
<td>163.12</td>
<td>57.29</td>
<td>156.69</td>
</tr>
<tr>
<td>Supplier</td>
<td>1,242.94</td>
<td>1,211.22</td>
<td>1,252.03</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>725.17</td>
<td>932.05</td>
<td>1,079.16</td>
</tr>
</tbody>
</table>

100% efficiency

69% 76% 82%

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Wholesale Prices and Buybacks: Observed and Efficient

Wholesale Prices ($w$) 

<table>
<thead>
<tr>
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<th>UB</th>
<th>RN</th>
<th>HN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>63.61</td>
<td>60.12</td>
<td>58.58</td>
</tr>
<tr>
<td>Efficient</td>
<td>71.92</td>
<td>66.75</td>
<td>65.62</td>
</tr>
</tbody>
</table>

Rebate ($b$) 

<table>
<thead>
<tr>
<th></th>
<th>UB</th>
<th>RN</th>
<th>HN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>18.06</td>
<td>23.95</td>
<td>25.04</td>
</tr>
<tr>
<td>Efficient</td>
<td>53.65</td>
<td>48.64</td>
<td>46.52</td>
</tr>
</tbody>
</table>

... but sellers still don’t accept enough risk to coordinate the channels.
BOM Studies of Contracting in the Bilateral Monopoly Setting

Coordinating contracts do not improve efficiency.
Examples of other BOM topics

The Handbook of Behavioral Operations Management

Edited by Donohue, Katok and Leider
To be published by Wiley (soon)
Supply Disruptions

• Hyndman, Kraiselburd & Watson (2013), Aligning capacity decisions in supply chains when demand forecasts are private information: Theory and experiment, Manufacturing & Service Operations Management 15(1), 102-117.
Distribution Networks

Retailing Issues

- Vorotyntseva, Hanhon, Katok, “Can Managers Plan Assortments? An Experimental Study” On-going project.
Queueing

Strategic Consumers

- Ovchinnikov and Milner Revenue management with end-of-period discounts in the presence of customer learning, Production and operations management 21 (1), 69-84.
- Kremer, Mantin and Ovchinnikov Dynamic Pricing in the Presence of Myopic and Strategic Consumers: Theory and Experiment, Production and Operations Management 26 (1), 116-133
Forecasting

Information Sharing (Trust)

Trusting the Forecast

- Stangl, Bolton & Katok, Trusting the Forecast: The Role of Numeracy, working paper
Conclusion

- Experimental Economics had a great deal of impact.
- These methods are successfully used in many disciplines.