How Can Industry Work with Business Schools?

• Small Projects Within a Class (ad-hoc)
• Semester-Long Student Projects (typically formalized process)
• Sharing Data With Research Faculty For Specific Analysis
• Partnering With Research Faculty For Multi-Year Project (often involves cutting-edge methodologies)
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• Management Science Department
  – Several undergraduate programs but with few students
  – Job placement not a Key Performance Indicator
  – Little impact on the business community
Operations and Supply Chain: focused on creating job-ready professionals

- Teach the dual disciplines of Operations Management and Supply Chain Management
- Emphasis on Process Improvement
- Teach business students to think analytically and use industry-valued analytical tools
- Provide real (high stakes) work experience and industry level certifications for all students
The Center

Students
- Undergraduate & MBA
- Broad academic experiences
- Analytical
- Hard-working and career-focused

Faculty
- Unique: Can “teach” and “do”
- Practical immersion into industry
- Cutting-edge curriculum
- Capacity to lead 18-20 projects per semester
- Top-Ranked leadership in applied and scholarly research

Partner Firms
- Diversified by industry
- Prominent global and/or SC footprint
- Can identify, resource, and manage 2 Projects/year
- Advisory Board Membership
- Desire to hire students as interns and full-time employees
Our 19 Industry Partners

Working with us to drive academic relevance and provide industry experience

Adidas
Atrium Health (CHS)
Continental Tire
Daimler Mercedes Benz
Textron
McLeod Health
Schneider Electric
Smith & Nephew
Trane-Ingersoll/Rand
UTC Aerospace Systems

BMW
Coca-Cola Bottling Co.
Cummins Engine/Turbo
Electrolux
Johnson & Johnson
Nephron Pharmaceutical
Siemens
Sonoco
UPS
Undergraduate Student Project Example

• Adidas: https://www.youtube.com/watch?v=LnonxNrSC1g&feature=youtu.be
Student Industry projects by University of Auckland ISOM Department
Price Optimization at Red Cross Retail 2016
Optimization of Production Schedules at Douglas Pharmaceuticals
Inventory management at United Steel 2018
Inventory management at United Steel 2017
Warehouse optimization at T&G 2016
More of the recent projects ...

- ASB Bank (Staff Training Recommendation system)
- ASB Bank (Online Customer Referral system)
- AsureQuality (Inventory Management process improvement)
- Beca (Asset Management Expert system)
- Computer Fanatics Ltd (vetlinkSQL Stock Management system)
- Datacom (Redevelopment of the Managed Asset Reconciliation system)
- DB Breweries (Reduction of packaging material losses in production process)
- Deloitte (CallPlus Public Data Explorer)
- Foodstuffs North Island
- Fonterra (Increasing warehouse efficiency)
- Hansen Technologies (Enterprise System data mining)
- Hansen Technologies (Social Media system development)
- Health Benefits Limited HBL (Developing decision criteria for non-critical clinical consumables inventory management)
- KPMG (Data Analytic Engine refinement)
- LSG Sky Chefs Auckland (Optimisation of warehouse processes)
- Mainfreight (Optimisation of inwards to outwards consignments process)
- OneNet (Measurement of Client Profitability)
- OneNet (Partnership Relationship Management system)
- OneNet (LiveVault Management and Business Intelligence tool)
- Orion Health (Synthetic Health Data Generator)
- PwC (Visualisation & CAATs Efficiency set)
- Ports of Auckland (Storeroom and Inventory Management process improvements)
- Tru-Test (Developing segmentation criteria to improve the Order Fulfilment process)
- Vista (Development of the Vista Usher Point system)
- Vista (Mobile Cinema Manager)
Join University of Auckland in 2020

Visit our 2019 project exhibition
• 26/09/2019 from 12:00 to 16:00

Get in touch
• Valery Pavlov v.pavlov@Auckland.ac.nz
• Koro Tawa k.tawa@Auckland.ac.nz
How Can Industry Work with Business Schools?

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Retail Science

Estimating and Optimizing Promotional Displays: A Grocery Perspective
In collaboration with the University of South Carolina

Oracle Retail
October 2018
Promotional Displays

Major

End-of-aisle display

Lobby

Island

and Minor

Dump table
Promotional Displays

Courtesy of VideoMining’s Grocery Shopper Insights
Promotional Displays

Exposure is the Key

On average, Grocery displays are seen by nearly twice as many store visitors as aisle locations.

+93% Exposure

Courtesy of VideoMining's Grocery Shopper Insights

Courtesy of Dr. Eric Bradlow
According to 2014 Mass Merchant survey (POPAI), 62% of purchases are unplanned.

62% of purchases are unplanned, with shoppers not consulting any kind of pre-store media, such as television advertisements, store circulars, newspapers etc, to plan their trip.
How can retailers plan and schedule efficient assortments on limited promotional display?
Proposed Methodology

1. **Estimate Category Level Sales Lifts:**
   Beer vs Detergent

2. **Solve for the Optimal Product Categories to put on Display**

3. **Estimate Subcategory Level Sales Lifts Within Chosen Categories:**
   - Import and Craft
Proposed Methodology (Cont.)

4

Solve for the Optimal Product Subcategories to put on Display

5

Estimate Individual Product Level Sales Lifts Within Chosen Subcategories:

6

Solve for the Optimal Products to put on Display

Heineken vs Fosters
The vast majority of…

…commercial and academic research focus only on optimizing the center store shelf-space and product assortments.
Current Methodologies Used in Practice

- Using weekly nationwide planograms with a historically best-selling item to put on display (same across all stores, except some locations)
- Using past sales period to put the same items on display as last year
- Using the best-selling, most popular items of the current period
Our Research Goals

1) Help a manager of a particular store estimate the relative lift of stocking a category, subcategory, and SKU on a promotional display space

2) Optimize the store’s profit by choosing the most profitable products to stock on these display spaces on a weekly basis

Problem Complexity

- 60,000-300,000s SKUs but, e.g., only 36 endcaps
- Sales lift not static; it is seasonal and diminishes over time
- Highest sales item does not mean highest profit
- An individual store has limited data on the sales lift of a particular SKU
Let’s Focus on Beer
The Beer Dataset

- IRI Marketing Group Academic Dataset (Bronnenberg et al. 2008)
- Store-week-SKU level data
- 2011 (full 52 weeks)
- 50 US markets
- Originally 7.7M+ obs.
- 1258 grocery stores
- New England region approx. 500,000 obs.
- 6-, 12-, 18-, 24-pack purchases only

- 5 beer categories
  - 3,140 brands were assigned a beer category by using data from
    - Brewers Association (proprietary),
    - Department of Alcoholic Beverage Control (public), and
    - beeradvocate.com (public)
A single store only has 10-20K observations whereas a national dataset has 40X more.

### Table 2 New England Data Set Summary

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Observations count</th>
<th>Total unit sales</th>
<th>Unique SKU count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subpremium</td>
<td>35,653</td>
<td>149,554</td>
<td>59</td>
</tr>
<tr>
<td>Premium</td>
<td>80,699</td>
<td>720,379</td>
<td>75</td>
</tr>
<tr>
<td>Superpremium</td>
<td>70,830</td>
<td>332,791</td>
<td>85</td>
</tr>
<tr>
<td>Craft</td>
<td>116,008</td>
<td>632,439</td>
<td>352</td>
</tr>
<tr>
<td>Import</td>
<td>84,038</td>
<td>432,586</td>
<td>159</td>
</tr>
<tr>
<td>Hard Apple Cider*</td>
<td>6,165</td>
<td>27,567</td>
<td>17</td>
</tr>
<tr>
<td>Malt/Nonalcoholic*</td>
<td>20,680</td>
<td>73,889</td>
<td>21</td>
</tr>
<tr>
<td>Liquor-style*</td>
<td>21,275</td>
<td>74,548</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>435,348</strong></td>
<td><strong>2,443,750</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Other types of beer sold in New England but not considered in this analysis do not contribute to the data set.*

### Table 3 Single Store Sales Data

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Observations count</th>
<th>Total unit sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subpremium</td>
<td>1,050</td>
<td>6,110</td>
</tr>
<tr>
<td>Premium</td>
<td>2,007</td>
<td>53,999</td>
</tr>
<tr>
<td>Superpremium</td>
<td>1,947</td>
<td>21,233</td>
</tr>
<tr>
<td>Craft</td>
<td>3,392</td>
<td>21,601</td>
</tr>
<tr>
<td>Import</td>
<td>2,637</td>
<td>19,336</td>
</tr>
<tr>
<td>Hard Apple Cider*</td>
<td>242</td>
<td>896</td>
</tr>
<tr>
<td>Malt/Nonalcoholic*</td>
<td>487</td>
<td>3,046</td>
</tr>
<tr>
<td>Liquor-style*</td>
<td>767</td>
<td>3,309</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12,529</strong></td>
<td><strong>129,530</strong></td>
</tr>
</tbody>
</table>
Finding the Optimal Products from the Entire Store

• Typically, any merchandise from the entire store can go on a promotional display

• Selecting merchandise from across the entire store is difficult because the number of possible items can be quite large, resulting in unreasonable solution times

• Two approaches:
  • Limit the number of SKUs considered
  • Hierarchical approach
There are many factors that effect weekly sales of a SKU that we control for but the display effect is the one of interest.

Estimating the Sales Lift from Placing a SKU on Display

There are many factors that effect weekly sales of a SKU that we control for but the display effect is the one of interest.

\[
\ln S_{ijt} = \delta_0 + \sum_{z \in U} \delta_1 Z_{jz} + \delta_2 D_{ijt} + \delta_3 H_{ijt} + \sum_{t' = 1}^T \delta_4 W_{it} + \sum_{m \in M} \delta_5 M_{ijmt} + (1)
\]

- **Product effect**
- **Discount effect**
- **Week effect** (seasonality)
- **Marketing mix effects** (temporary price reduction, feature, advertising excluding promotional display)
- **Display effect**
- **Display-SKU effect**
- **Display-Week effect**
- **Subcategory-Week effect**
- **Random Store Effect**
- **Error Term**

SKU level sales

Interaction: display with SKUs

Interaction: display with weeks

Interaction: subcategories with weeks
Estimating the Sales Lift with Cross Effects

\[
\ln S_{jiti} = \delta_0 + \sum_{z \in U} \delta_{1z} Z_{jz} + \delta_2 D_{jiti} + \delta_3 H_{jiti} + \sum_{t' = 1}^T \delta_{4t'} W_{t't'} + \sum_{m \in M} \delta_{5m} M_{jmti}
\]

\[\sum_{z \in U} \delta_{6z} (D_{jiti} Z_{jz}) + \sum_{t' = 1}^T \delta_{7t'} (D_{jiti} W_{t't'}) + \sum_{a = 1}^C \sum_{t' = 1}^T \delta_{8at'} (A_{jat} W_{t't'}) + \sum_{m \in M} \sum_{g \in G} \sum_{j' = 1 / \{j\}}^J \delta_{9gm} \sum_{j' = 1 / \{j\}}^J SIM_{jj'gti} M_{j'mti} (1 - M_{jmti}) + \sum_{g \in G} \sum_{j' = 1 / \{j\}}^J SIM_{jj'gti} D_{j'ti} (1 - D_{jiti})
\]

\[\sum_{t' = 1}^T \delta_{10t'} + \epsilon_{jiti}\]

Our model can also include cross-display effects – how does putting a SKU on display affect the sales of similar SKUs.
Regression Results

Table 5  Sales Response Function Estimates For Direct and Hierarchical Approaches

<table>
<thead>
<tr>
<th></th>
<th>Direct</th>
<th>Subcat 1</th>
<th>Subcat 2</th>
<th>Subcat 3</th>
<th>Subcat 4</th>
<th>Subcat 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(Unit sales)</td>
<td>1.182***</td>
<td>1.131***</td>
<td>1.230***</td>
<td>1.230***</td>
<td>1.232***</td>
<td>1.233***</td>
</tr>
<tr>
<td>Constant</td>
<td>0.009***</td>
<td>0.009***</td>
<td>0.009***</td>
<td>0.009***</td>
<td>0.009***</td>
<td>0.009***</td>
</tr>
<tr>
<td>$M_{ijt}$</td>
<td>0.078***</td>
<td>0.104***</td>
<td>0.100***</td>
<td>0.100***</td>
<td>0.085***</td>
<td>0.115***</td>
</tr>
<tr>
<td>Discount</td>
<td>0.255***</td>
<td>0.431***</td>
<td>0.395***</td>
<td>0.428***</td>
<td>0.369***</td>
<td>0.375***</td>
</tr>
<tr>
<td>Price Reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D_{ijt}$</td>
<td>0.334***</td>
<td>0.550***</td>
<td>0.506***</td>
<td>0.563***</td>
<td>0.529***</td>
<td>0.514***</td>
</tr>
<tr>
<td>Display</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 SKUs$^\circ$</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 SKUs$^\circ$</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$W_{ut}$</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$A_{jt}W_{ut}$</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$D_{ijt}Z_{jt}$</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$D_{ijt}W_{ut}$</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>-37768.44</td>
<td>-41537.56</td>
<td>-39751.84</td>
<td>-41237.84</td>
<td>-40365.81</td>
<td>-40230.93</td>
</tr>
<tr>
<td>AIC</td>
<td>756510.9</td>
<td>831755.1</td>
<td>796045.7</td>
<td>825761.7</td>
<td>808233.6</td>
<td>805633.9</td>
</tr>
<tr>
<td>BIC</td>
<td>762728.7</td>
<td>837258.1</td>
<td>801636.5</td>
<td>831330.5</td>
<td>813846.4</td>
<td>811235.7</td>
</tr>
<tr>
<td>Wald $\chi^2$</td>
<td>189041.54***</td>
<td>89761.07***</td>
<td>134672.09***</td>
<td>97055.19***</td>
<td>118939.65***</td>
<td>122256.92***</td>
</tr>
</tbody>
</table>

$^*$included in the model
$^\circ$ with a reference category of all ‘other’ existing SKUs
**Incremental Display Profit**

\[
\Pi_{jti} = q_{jti}(l_{jti} - 1)\pi_{jti}\Delta + \sum_{j'\neq j} q_{j'ti}(CEL_{j'j'i} - 1)\pi_{j'ti}\Delta
\]

*Incremental display profit: additional profit from putting an item on display*

- **Profit margin for product j plus any trade promotion**
- **Base demand (at full price and no promotions) of product j**
- \(Ln(Base\ Demand) = Ln(Sales) - (Display\ Effects + Price\ Related\ Effects + Marketing\ Effects)\) from the model
- **Marginal lift for product j from being placed on promotional display**

\[
Ln(DisplayLift) = \text{Sum of All Display Effects from model}
\]
Static Optimization for Endcap $d$

Select most profitable product $j$'s for a given set of promotional display spaces $d$ such that incremental profit is maximized.

\[
\max_{x_{jd}} \sum_{j \in U, d \in I}(\Pi_j + o_{jd})x_{jd},
\]

subject to

\[
\sum_{j \in U} x_{jd} \leq 1, \quad \forall d.
\]

\[
\sum_{d \in I} x_{jd} \leq 1, \quad \forall j,
\]

\[
x_{jd} \in \{0, 1\}.
\]
Benchmark: Choose the Highest Selling SKU for the Week

Table 9  Benchmark selection: Top selling SKUs annually, for Store $i$

<table>
<thead>
<tr>
<th>Top</th>
<th>SKU</th>
<th>Annual unit sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bud Light, bottle, 18-pack</td>
<td>5,822</td>
</tr>
<tr>
<td>2</td>
<td>Bud Light, can, 18-pack</td>
<td>5,614</td>
</tr>
<tr>
<td>3</td>
<td>Miller Lite, can, 18-pack</td>
<td>4,166</td>
</tr>
<tr>
<td>4</td>
<td>Coors Light, can, 18-pack</td>
<td>3,560</td>
</tr>
<tr>
<td>5</td>
<td>Budweiser, can, 18-pack</td>
<td>3,315</td>
</tr>
<tr>
<td>6</td>
<td>Michelob Ultra, bottle, 18-pack</td>
<td>3,054</td>
</tr>
<tr>
<td>7</td>
<td>Miller Lite, bottle, 18-pack</td>
<td>3,025</td>
</tr>
<tr>
<td>8</td>
<td>Coors Light, bottle, 18-pack</td>
<td>2,956</td>
</tr>
<tr>
<td>9</td>
<td>Budweiser, bottle, 18-pack</td>
<td>2,815</td>
</tr>
<tr>
<td>10</td>
<td>Samuel Adams Seasonal, bottle, 12-pack</td>
<td>2,678</td>
</tr>
</tbody>
</table>
Our benchmark results in 8 different SKUs chosen for display during a year.
Results: Hierarchical and Static Optimization

Weekly Incremental Profit Obtained under the Hierarchical Approach

Our optimization says to switch between displaying three different products across weeks: Bud Light 18-pack, Sea Dog, and Shipyard.
The Direct and Hierarchical provide similar profit lifts. Both are almost 2X the benchmark! ($17.6K vs. $9.3K)
Summary

• The Promotional Display problem is too important to leave to a store manager’s intuition.

• An individual store, and even an individual chain, does not have the data to adequately solve this problem – need a large dataset.

• Applying data analytics to this problem offers significant profit improvement opportunities.