Optimal Inventory Redistribution

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Outline

● Problem Statement
● Approach
  ○ Models:
    ■ Linear Regression
    ■ Time Series
    ■ Advanced Time Series
  ○ Redistribution
● Business Value
● Summary and Conclusions
Problem Statement

- Be able to forecast future sales
- Use these forecasts to determine the optimum inventory for the various branch locations
- Look at current inventory and to see where improvements can be made in earns and turns performance
- Use product rationalization to remove redundant product from inventory
Our Approach to the Problem

● Narrow the data to something we can study

● Forecasting Models
  ○ *Linear Regression*
  ○ *Time Series*

● Engineer our own Forecasting Model
  ○ *ADVANCED TIME SERIES*

● Tackle Product Redistribution by applying Predictive Model
Summary of Our Process

1. Linear Regression
   - Good Fit
   - Bad Fit

2. Time Series
   - Good Fit
   - Bad Fit

3. Advanced Time Series
   - Good Fit
   - Bad Fit

Redistribution Evaluation
How We Narrowed Our Scope

● Hub Cut
  ○ Computational constraints (too much for our 2.0/4.0 GHz processors)
  ○ Redistribution Costs remain reasonable (avoid transporting to a hub across the country)

● Traits of the Smallest Hub
  ○ Only 9 Branches (Fastenal’s Hubs average at ~171 Branches)
  ○ 100,000 products

● Final Decision
  Of these 100,000 products we chose to analyze the top 4,000 products by volume
Linear Regression
What is Linear Regression?

Line of Best Fit: Relationship Between Variables

![Diagram showing a line of best fit with variables Item Usage vs. Time (Months). The slope of the regression line is denoted as 'b'. The distance from the line to a typical data point is described as the error between the line and this y value.]
How Do We Measure Usefulness?

Measured Error (using $R^2$)

Good Fit ($R^2 = 0.9$)

Bad Fit ($R^2 = 0.2$)
Simulated Accuracy

Branch: qpqcr | Item: !{~}

$R^2 = 0.000$

BAD FIT
Simulated Accuracy

Branch: qpzdt | Item: >>{>!>{&

$R^2 = 0.8036$

GOOD FIT
Usefulness of Linear Regression

- **Efficiency**
  - 15 minutes to run with 100,000+ items

- **Effective**
  - 25% of the top 4000 items **Accurately Modeled**
  - The rest funneled to **Time Series**

Linear Regression

100,000+ Products

Top 4000

75%

Time Series

3000 Products
Time Series
What is Time Series? Why Use It?

TIME SERIES

- Data with respect to Time
  \[ X = \text{Time} \quad Y = \text{Data} \]

- Accounts for **SEASONALITY**
What Is A Good Time Series?

**Good**

RED = ACTUAL DATA  
BLUE = PREDICTION

**Bad**

RED = ACTUAL DATA  
BLUE = PREDICTION
● We created an **Advanced** Time Series model

● How it is better than Basic Time Series:
  ○ Previous-20-month Training Sets
  ○ Predicts Sales AND get **ERROR**
  ○ Smaller Confidence Intervals
Evidence of Improvement

- Tested Models Against Real Data
- Simulated Predictions for Months 30 to 48
  - Training sets: previous-20-month steps

Confidence Level

<table>
<thead>
<tr>
<th>Training (months)</th>
<th>Test (month)</th>
</tr>
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<tbody>
<tr>
<td>10 - 29</td>
<td>30</td>
</tr>
<tr>
<td>11 - 30</td>
<td>31</td>
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<tr>
<td>12 - 31</td>
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<tr>
<td>17 - 46</td>
<td>47</td>
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<table>
<thead>
<tr>
<th>Advanced Time Series</th>
<th>Basic Time Series</th>
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</thead>
<tbody>
<tr>
<td>Accuracy: 80.5%</td>
<td>78.1%</td>
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<tr>
<td>Interval: Smaller</td>
<td>Bigger</td>
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</tbody>
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How Advanced Time Series Collects Error
Result of Advanced Time Series

Example Simulation

Smallest Hub:
Branches: 9; Products: Top 69; Item usage: 39,468; Month: 48

--------------MATCHED AGAINST ACTUAL DATA FOR MONTH 48--------------

Predicted Item Usage with Minimum Error = 16,412 items
Redistribution

Move Products to Satisfy the Local Branches’ Needs

- Move overstock to a location where they are more likely sell
Business Value

● Reduce chance of running out of stock
● Maximize sales while simultaneously reducing overhead
● Reduce risk when investing capital
  ○ Our Advanced Time Series is more accurate than Time Series used by other companies by 2.4%
Conclusions

- We developed a process to forecast future sales
- Our Advanced Time Series model gives a competitive edge
- Our process can be used on any hub
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