VIDEO 1
Kroger Overview
Simulation and Optimization Improve Pharmacy Inventory

Lincoln Lutz
Vice President, Pharmacy, The Kroger Co.
Pharmacy Overview

1,950 pharmacies located across 32 states

Fiscal 2012
Prescriptions: 160M
Revenue: $8.0B

Prescriptions Per Year

Year

2010
2011
2012

Prescriptions (millions)

130
135
140
145
150
155
160
165

Prescriptions

$8.00
$8.50
$7.50
$7.00
$6.50

Revenue (billions)
VIDEO 2
Innovation - Analytics
Pharmacy Overview

Kroger for Android
simplify your shopping...

Weekly Ad
See great deals at your preferred store

Coupons
Load coupons to your shopper's card

List
Never forget your list at home again

Rewards
Check balances and view your history

Rx Refills
Refill prescriptions on your mobile device

Enjoy the CONVENIENCE of
Auto Refill
It's a free and easy way to stay on top of important prescription refills.

Hundreds of generic prescriptions

$4 30-day $10

Save even more on a 90-day supply!
The Inventory Conundrum

- Regulatory Obligations
- High Service
- Volatile Demand

Decrease Working Capital
Increase In-Stock Position
Decrease Time to Manage Inventory
VIDEO 3
Project – Doug & Dr. Z
Project Overview

Dr. Xinhui Zhang
Associate Professor, Wright State University
Periodic Review Inventory System

**Ordering**
- Fixed delivery schedule
- 2-3 days per week
- Order point (s); Order-up-to level (S)

**Cost Structure**
- Carrying cost
- Complex out-of-stock structure
- Reorder cost
Challenges
Challenges

Graphs showing distribution of units with density on the y-axis and units on the x-axis. The graphs display different distributions across two categories.
"Everything should be made as simple as possible, but not simpler.”

- Albert Einstein
Simulation Models

Demand

Simulation
Benefits of Simulation Models

- Provides visual & interactive environment
- Allows deep dive into inventory conundrum

Optimization via Simulation

- Generate 440 days of realization of demand
- Utilizes optimization techniques (gradient based, perturbation) to find near optimal solutions
Define $Q = S - s$

If $Q$ is fixed then the cost function is convex

For various $Q$, the cost function is non-convex

Enumeration would be necessary for global optimum
Search Procedure

Starting Solution

Move 1: Increase or Decrease an equal amount of (s, S) under fixed Q

Move 2: Increase s while keeping S unchanged

Move 3: Decrease S while keeping s unchanged

Iterate between moves
An Example Demand

![Demand Chart]

- Days
- Quantity

Values:
- Days 0: 70
- Days 100: 120
- Days 200: 180
- Days 300: 120
- Days 400: 120
Move 2

Min: 170  Max: 240, OBJ: 12.31

Inventory

Days
## The Search Process

<table>
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<tr>
<th>Reorder Point</th>
<th>0.00</th>
<th>10.00</th>
<th>20.00</th>
<th>30.00</th>
<th>40.00</th>
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<th>60.00</th>
<th>70.00</th>
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<td>51.17</td>
<td>24.19</td>
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<td>18.04</td>
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<tr>
<td>160</td>
<td>104.23</td>
<td>90.82</td>
<td>43.72</td>
<td>50.66</td>
<td>50.37</td>
<td>24.67</td>
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<td>17.21</td>
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<td>17.54</td>
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</tr>
</tbody>
</table>
Search Features

- Simulation results used to narrow the search
- Heuristic is myopic yet intelligent
- Fast and intuitive
- Eliminates unnecessary steps and the use of bounds
Computational Results

Speed
- 8G RAM i7 Desktop
- 6 hours for ~4M Drug/Store
- Average ~10 millisecond per Drug/Store

Optimality
- Grid search for 1,621 NDCs for one store
- 92.9% NDC achieved the same best solutions obtained through grid search
Implementation and Results

Dennis Bird
Manager, Corporate Pharmacy
Business Acceptance

Simulation Based Inventory Approach

- Intuitive and easy to understand
- Transparent
- Test drive and purchase
- Business acceptance
- Accurately model demand patterns
- Fast and agile to change
Too little inventory
Enterprise Deployment

• Started in October, 2011
• Centrally managed
• 6 divisions every 2 weeks
• Fortuitous timing
Results

1.5 million annual OOS reduction
$120 million inventory reduction
$10 million annual labor savings
$80 million increase annual revenue
Inventory Extensions

• Extended approach to meat and seafood
• Addressed costs of higher perishability
• Implemented multiple linear regression forecast
• Sales shaped by freshness and inventory
Other Kroger departments
United States Pharmacy Industry
   - 3.8 billion prescriptions annually
   - $228 billion annually
Operations Research Impact

Manufacturing

Supply Chain

Merchandising

Inventory

Store Operations

“Nice... faster checkout and a smile!”

“We promise you’ll spend less time in line.”

“Who likes standing in line?”

Faster Checkout

Faster Checkout at Kroger.
VIDEO 4
Innovation - Future