When Disaster Strikes: Lessons from Logistics at Home Depot and Waffle House

Ozlem Ergun
Pinar Keskinocak and Julie Swann
Center for Humanitarian Logistics

Co-authors:
Matt Drake, Jessica Heier, Paul Kerl
Humanitarian Crises

- Natural and manmade disasters
  - Hurricane, tsunami, etc.
- Ongoing problems about health, nutrition, etc.
  - AIDS pandemic, immunization for preventable diseases, etc.
Humanitarian Sector

- Economic losses from disasters are rapidly growing
- Relief is a “growth market”, with governmental aid doubling from 1990 to 2000
- From 1985 – 1999, 14% of world weather disasters hit US, causing 58% of the insurance losses
Humanitarian Response

- Needs Assessment
  - What, where, how much
- Resource Mobilization
  - Financial, staff, equipment, supplies
- Procurement
  - Local, regional, international
- Distribution
  - Warehouses, DCs, other delivery points
- Transportation
  - International, in-country, last-mile

Private industry, Government, Military, Non-Governmental Organizations (NGOs) …
Disaster Response at The Home Depot and Waffle House

- Focus on stresses that disasters place on:
  - Forecasting demand
  - Deciding how much of which products to hold in inventory
  - Allocating limited resources (workers, stores)
  - Transporting goods
Disaster Response at The Home Depot and Waffle House

Timeline:
- Pre-storm season planning
- Impending storm preparation
- Post-storm recovery
Disaster Relief at The Home Depot

- The Home Depot founded in 1978 in Atlanta
  - Leader in the repair supply market
  - Southeast US is the home region
  - “Doing the right thing”
- Encourage other businesses to respond
- Support the local community
- Provide services to disaster recovery teams
  - Red Cross, National Guard, law enforcement, etc…
Response Planning Schedule

- **June – November**: Lessons learned, after-action review
- **December**: Season reviews
- **January - February**: Vendor reviews and on-boarding, general maintenance
- **March – April**: Plan review and revisions
- **April – May**: Training
- **Mid-May**: Final training, hurricane forecast, big changes from previous season
Functional Areas

- Asset Protection
- Merchandising
- Logistics
- Regional Management
Asset Protection

- **Pre-season preparation**
  - Plan cohesiveness between functional areas
  - Obtain local permits for drivers and associates
  - Maintain merchant relationships
  - Track potential hurricane threats

- **Impending storm preparation**
  - Book hotel rooms
  - Ready repair teams for immediate roof repairs
  - Initiate Command Center for Cat 3 or greater storms

- **Post-storm action**
  - Bus in associates, facilitate communication
  - Send in repair teams and open stores
Merchandising

- **Pre-season preparation**
  - Predict inventory for a season
    - Previous years demand
    - Forecasted season strength
    - Lead times
  - Arrange consignment agreements with vendors
  - Prepare trucks prefilled with merchandise (canned loads)

- **Impending storm preparation**
  - Communicate with field to determine needs
  - Create purchase orders to fulfill needs

- **Post-storm action**
  - Constant continued needs assessment
  - Track orders
Logistics and Transportation

- **Pre-season preparation**
  - Contract with transportation companies
  - Pre-plan routes during a disaster/hurricane situation
  - Establish hurricane distribution centers (Florida, Texas, Georgia)
  - Work with merchandising to optimize space utilization

- **Impending storm preparation**
  - Track the storm
  - Preposition canned loads

- **Post-storm action**
  - Track trucks/orders
Regional Management

- **Pre-season preparation**
  - Train associates
  - Ensure store hardiness

- **Impending storm preparation**
  - Closes stores 6 hrs prior to tropical storm force winds

- **Post-storm action**
  - Ensure store readiness and associate availability to re-open stores
  - Communicate specific storm damage
  - Send merchandise needs to corporate
Key Response Decisions

- Plan seasonal hurricane inventory
- Prepare and pre-position canned loads
- Route trucks dynamically
  - Continuously changing storm trajectory and damage type
  - Road closures
  - Evacuation paths
Plan Inventory

- Forecast pre- and post-storm demand
  - Demand “spikes”

Three week time frame, separated into daily sales of hurricane-related products
Prepare Canned Trailer Loads

- Quickly fulfill the high-demand for essentials
  - Pre-storm: water, gas cans, flashlights, batteries, tarp
  - Post-storm: water, chainsaws, garbage cans, towels, wheelbarrows

- OR Problem:
  - What products should be placed in the loads?
  - What is an appropriate objective function?
Model – Parameters

- **Product weights**
  - E.g. water is more important than trash bags hence water should have a larger weight

- **Other parameters**
  - Stacking ability (double, triple and quadruple)
  - Forecasted demand pre-storm and post-storm
  - Size of each pallet
Model - Decision Variables

- Is an available trailer used?
- How many items are placed on level 1 of a given truck?
- How many additional items are placed on levels 2, 3 and 4?
Model

- Maximize total worth of items placed in trailers

  - Subject to
    - Maximum number of available trucks ($\leq 10$)
    - Constraints on the number of first level pallets
    - Constraints on stacking pallets
      - Up to four levels of stacking ability
      - Each level up is constrained by the level below it
    - Demand constraints
# Results - Pre-storm Loads

<table>
<thead>
<tr>
<th></th>
<th>Score</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greedy pre-storm</td>
<td>850</td>
<td></td>
</tr>
<tr>
<td>THD pre-storm</td>
<td>862</td>
<td>Minor changes—more water, more gas cans, more tarps</td>
</tr>
<tr>
<td>Model pre-storm</td>
<td>952</td>
<td></td>
</tr>
<tr>
<td>Model pre-storm (different loads)</td>
<td>1034</td>
<td></td>
</tr>
</tbody>
</table>
## Results - Post-storm Loads

<table>
<thead>
<tr>
<th></th>
<th>Score</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greedy post-storm</td>
<td>620</td>
<td></td>
</tr>
<tr>
<td>THD post-storm</td>
<td>693</td>
<td>Minor changes—fewer brooms and mops, more batteries and tarps</td>
</tr>
<tr>
<td>Model post-storm</td>
<td>693</td>
<td></td>
</tr>
<tr>
<td>Model post-storm (different loads)</td>
<td>789</td>
<td></td>
</tr>
</tbody>
</table>
Hurricane Response at Waffle House

- Founded near Atlanta in 1955
- 1600 stores in 25 states
  - Dense presence in Southeast
- Pro-active approach to hurricane planning and response
  - Direct involvement of senior management
  - Documentation of lessons learned
  - Engagement with suppliers, employees, community, and government
Pre-season Preparation

- Review previous season
- Secure needed equipment
  - Generators, vehicles, and communication devices
- Review response preparation with vendors
- Train associates
- Develop printed material
  - Hurricane Menu—a shorter menu used to simplify inventory, ordering, and organization during a disaster
  - Signs, phone lists
Impending Storm Preparation

- Monitor storm
- Ensure equipment readiness
- Encourage associate evacuation, as needed
- Coordinate store closings
- Place suppliers on alert
  - Inventory pre-positioning
  - Anticipated demand for Hurricane Menu items
- Assemble response team
Post-storm Action

Corporate HQ Command Center

Construction & Equipment
- Assess damage and store readiness
- Manage refueling of generators, team vehicles

Operations
- Determine employee availability
- Prioritize stores for reopening

Control
- Track inventory movement between stores
- Establish payroll procedures

Purchasing
- Schedule initial shipment
- Order items for Hurricane Menu

Other
- Secure hotels
- Maintain communication with employees, media
Key Response Decisions

- Hurricane Menu
- Purchase/lease agreements for recovery necessities
  - Generators
  - Portable toilets
- Food order quantities for transition period
- Stores prioritized for re-opening
Hurricane Menu

- Offer limited menu in days immediately following disaster
  - Enables quicker reopening with limited resources
  - Expedites service to customers
  - Simplifies purchasing, inventory

OR Problem

- What items should be included on the Hurricane Menu?
- What is an appropriate objective function?
Hurricane Menu

Resources for Cooking
- Burners: eggs and omelets
- Waffle Irons: waffles
- Grill: meats, hashbrowns, and sandwiches
## Hurricane Menu Example Data

### Candidate Menu Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Customer Utility</th>
<th>Cooking Time (min)</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waffle</td>
<td>5</td>
<td>3</td>
<td>waffle iron</td>
</tr>
<tr>
<td>Egg</td>
<td>5</td>
<td>3</td>
<td>1/3 pan on on burner</td>
</tr>
<tr>
<td>Sausage</td>
<td>3</td>
<td>2</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Ham</td>
<td>2</td>
<td>1.5</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Bacon</td>
<td>5</td>
<td>3</td>
<td>2 grill units</td>
</tr>
<tr>
<td>Omelet</td>
<td>4</td>
<td>7</td>
<td>1 burner</td>
</tr>
<tr>
<td>Hashbrowns</td>
<td>2</td>
<td>3</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Plain Grits</td>
<td>3</td>
<td>--</td>
<td>kept in steam table</td>
</tr>
<tr>
<td>Grits with Toppings</td>
<td>5</td>
<td>--</td>
<td>kept in steam table</td>
</tr>
</tbody>
</table>
Hurricane Menu Model

Maximize

Total Utility: measures customers’ preference for items

s.t.

Resource Availability Constraints
Cooking Duration Constraints
Integrality Constraints

Weighted knapsack with space and time constraints
## Hurricane Menu Example

### Utility-maximizing Menu

<table>
<thead>
<tr>
<th>Item</th>
<th>Customer Utility</th>
<th>Cooking Time (min)</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waffle</td>
<td>5</td>
<td>3</td>
<td>waffle iron</td>
</tr>
<tr>
<td>Egg</td>
<td>5</td>
<td>3</td>
<td>1/3 pan on burner</td>
</tr>
<tr>
<td>Sausage</td>
<td>3</td>
<td>2</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Ham</td>
<td>2</td>
<td>1.5</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Bacon</td>
<td>5</td>
<td>3</td>
<td>2 grill units</td>
</tr>
<tr>
<td>Omelet</td>
<td>4</td>
<td>7</td>
<td>1 burner</td>
</tr>
<tr>
<td>Hashbrowns</td>
<td>2</td>
<td>3</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Plain Grits</td>
<td>3</td>
<td>--</td>
<td>kept in steam table</td>
</tr>
<tr>
<td>Grits with Toppings</td>
<td>5</td>
<td>--</td>
<td>kept in steam table</td>
</tr>
</tbody>
</table>
## Hurricane Menu Example Data

### Item-maximizing Menu

<table>
<thead>
<tr>
<th>Item</th>
<th>Customer Utility</th>
<th>Cooking Time (min)</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waffle</td>
<td>1</td>
<td>3</td>
<td>waffle iron</td>
</tr>
<tr>
<td>Egg</td>
<td>1</td>
<td>3</td>
<td>1/3 pan on burner</td>
</tr>
<tr>
<td>Sausage</td>
<td>1</td>
<td>2</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Ham</td>
<td>1</td>
<td>1.5</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Bacon</td>
<td>1</td>
<td>3</td>
<td>2 grill units</td>
</tr>
<tr>
<td>Omelet</td>
<td>1</td>
<td>7</td>
<td>1 burner</td>
</tr>
<tr>
<td>Hashbrowns</td>
<td>1</td>
<td>3</td>
<td>1 grill unit</td>
</tr>
<tr>
<td>Plain Grits</td>
<td>1</td>
<td>--</td>
<td>kept in steam table</td>
</tr>
<tr>
<td>Grits with Toppings</td>
<td>1</td>
<td>--</td>
<td>kept in steam table</td>
</tr>
</tbody>
</table>
2007 Hurricane Menu

Breakfast
- Waffle or Pecan Waffle
- Two Eggs, Toast, & Grits/Hashbrowns
- Ham & Egg Sandwich
- Hashbrowns, Single or Double
- Sausage
- Ham
- Cereal with Milk
- Pastries

Lunch and Dinner
- ¼ lb. Hamburger
- Double ¼ lb. Hamburger
- Chicken Sandwich
- Ham & Cheese Sandwich
- Turkey & Cheese Sandwich
- Grilled Cheese Sandwich
- Pie

All Items Available 24 Hours
Advance Purchase of Key Response Items

- Necessary to reopen following a disaster (e.g. generators)
  - Limited availability at that time
  - Purchase or lease in advance of hurricane season

- OR Problem
  - How many units should be secured in advance?
  - What is the correct objective function for this problem?
Advance Purchase: Minimum Cost Objective

- **Objective:** Minimize Expected Cost
  - $c_o = \text{overage cost; price of generator}$
  - $c_u = \text{underage cost; lost profit if generator shortage}$
  - $Q = \text{quantity purchased}$
  - $D = \text{actual demand, a random variable with cumulative distribution function } F \text{ determined from past hurricane data}$

- **Standard Newsvendor Model**
  - Choose optimal quantity $Q^*$ based on critical ratio

\[
F(Q^*) = \frac{c_u}{c_u + c_o}
\]
Advance Purchase Example – Minimum Cost Model

Consider the following scenario

- $c_o = $1,000
- $c_u = $15,000
- 3 days without electricity, with lost profits of $5000/day
- $F(Q^*) = 0.938$

**Min Cost $Q^* = 4$ generators**

<table>
<thead>
<tr>
<th>Distribution of Generator Demand*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Pr{d·D}</td>
</tr>
<tr>
<td>16</td>
<td>1.00</td>
</tr>
<tr>
<td>12</td>
<td>0.98</td>
</tr>
<tr>
<td>8</td>
<td>0.96</td>
</tr>
<tr>
<td>4</td>
<td>0.94</td>
</tr>
<tr>
<td>0</td>
<td>0.52</td>
</tr>
</tbody>
</table>

+Demand data based on number of U.S. landfalling hurricanes, 1956-2005; Source: NOAA.
Advance Purchase –
Minimum Maximum Regret Objective

- Objective: Minimize Maximum Regret
  - Given the purchase decision, what is the maximum difference over all possible demand realizations between actual cost and optimal cost?
  - Actual Cost = 1000*Q + 15,000*max{0, D-Q}
  - Optimal Cost = 1000*D
  - Regret = max{14,000*(D-Q), 1,000*(Q-D)}

- Previous Data: Min Max Regret Q* = 15
Advance Purchase of Key Response Items

**Maximum Regret as Function of Quantity Purchased**

- **Min Cost**: $Q^* = 4$; Max Regret = $15,000$
- **Min Max Regret**: $Q^* = 15$; Max Regret = $168,000$

Graph shows a decreasing trend in maximum regret as the quantity purchased increases. The critical points are marked with red circles.
Advance Purchase – Uncertainty in Costs

- Uncertainty in value of lost profits or days without electricity affects Q*
- Min Max Regret Q* has smaller range (14 to 16) than Min Cost Q* (4 to 12) over wide range of underage costs
Food Order Quantities

- **Current Practice**
  - Truck #1
    - Standard shipment including disposable tableware, sanitation supplies, and other immediate needs
  - Order-up-to-Level
    - Checklist for store managers to generate food orders
    - Based on past hurricane experience
    - Prefer to over-estimate

- **OR Problem**
  - Develop forecasting model for transition period demand
Reopening Prioritization

**Construction & Equipment**
- Store condition and safety
- Time and equipment needed to rehabilitate
- Availability of water
- Availability of electricity
- Road access

**Operations**
- Availability of personnel
- Location with respect to airports, highways
- Relative location to other candidate restaurants

**Priority List for Store Reopening**

“Nothing good can come from a closed Waffle House after a hurricane.”

*Bert Thornton, President & COO*
The Home Depot and Waffle House are top responders because:

- Nature of the business
- Corporate culture
- Investment in pre-planning and preparedness
- High level management involvement in response

- Some of their significant challenges can be solved with the help of operations research techniques.
Questions?

humlog@isye.gatech.edu

http://www.scl.gatech.edu/research/humanitarian/

- Co-Directors of Humanitarian Logistics in ISyE
  - Ozlem Ergun
    - Ozlem.Ergun@isye.gatech.edu
    - (404) 894-2369
  - Pinar Keskinocak
    - Pinar.Keskinocak@isye.gatech.edu
    - (404) 894-2325
  - Julie Swann
    - Julie.Swann@isye.gatech.edu
    - (404) 385-3054