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

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Humanitarian Crises

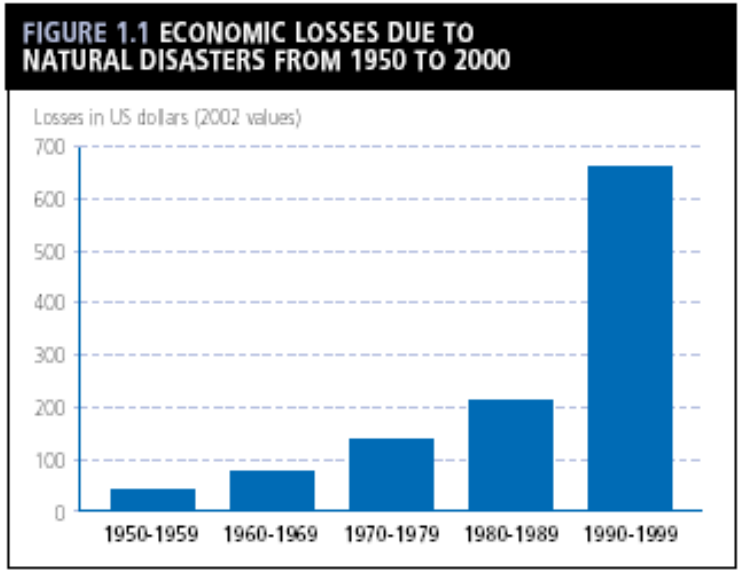
- Natural and manmade disasters
  - Hurricane, tsunami, etc.
- Ongoing problems about health, nutrition, etc.
  - AIDS pandemic, immunization for preventable diseases, etc.





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

Challenging logistics/SCM problems

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

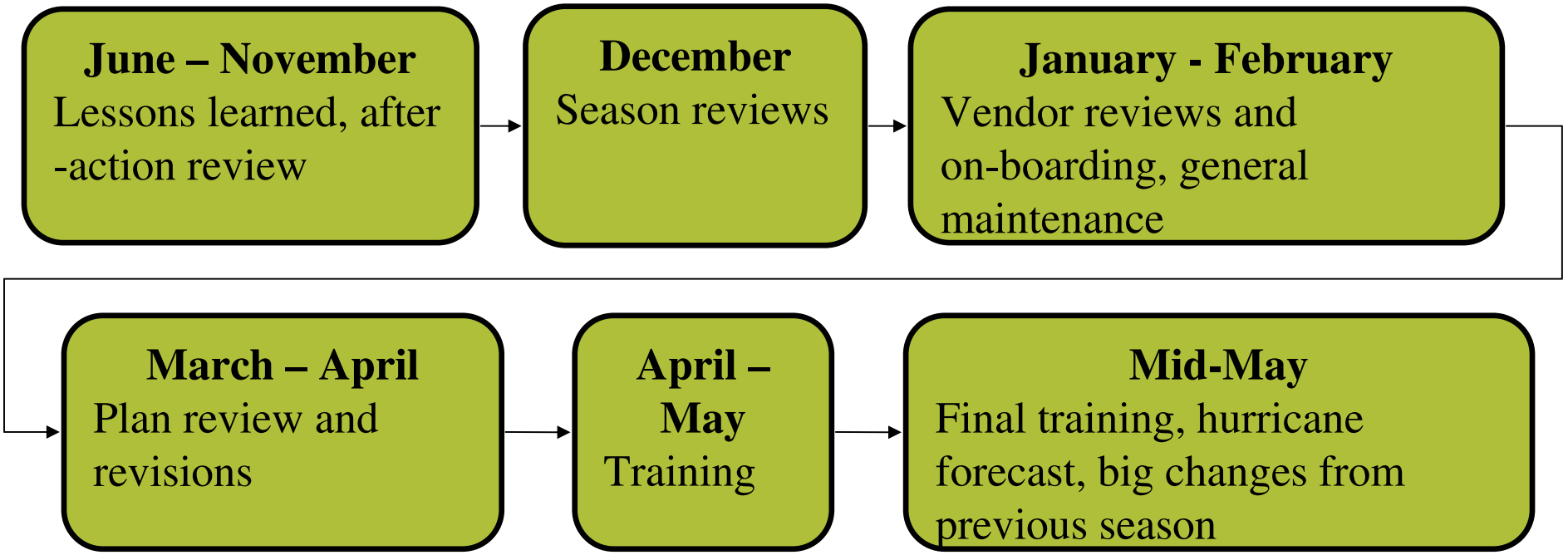
- Timeline:
  - Pre-storm season planning
  - Impending storm preparation
  - Post-storm recovery

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…

You can do it. We can help.™

Response Planning Schedule

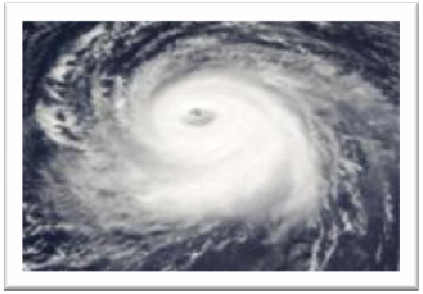


Functional Areas

- 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

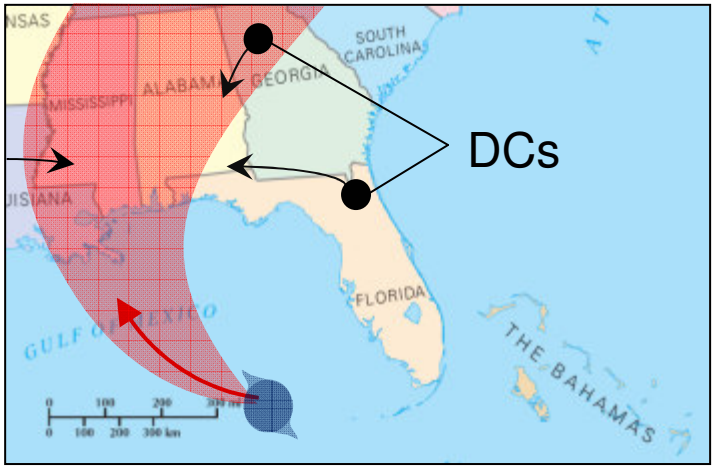


Merchandising

- 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

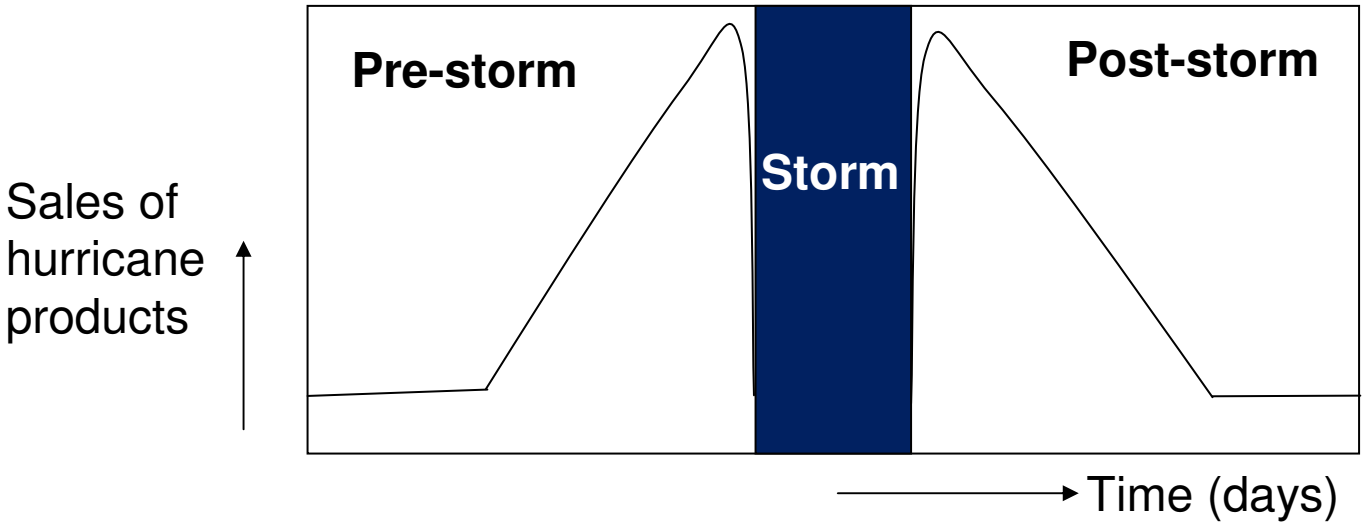
- Pre-season preparation
  - Train associates
  - Ensure store hardiness
- Impending storm preparation
  - Closes stores 6 hrs prior to tropical storm force winds
- Post-storm action
  - Ensure store readiness and associate availability to re-open stores
  - Communicate specific storm damage
  - Send 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 (<=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

	Score	Differences
Greedy pre-storm	850	Minor changes—more water, more gas cans, more tarps
THD pre-storm	862	
Model pre-storm	952	
Model pre-storm (different loads)	**1034**	

Results -Post-storm Loads

	Score	Differences
Greedy post-storm	620	Minor changes—fewer brooms and mops, more batteries and tarps
THD post-storm	693	
Model post-storm	693	
Model post-storm (different loads)	**789**	

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

WAFFLE HOUSE®

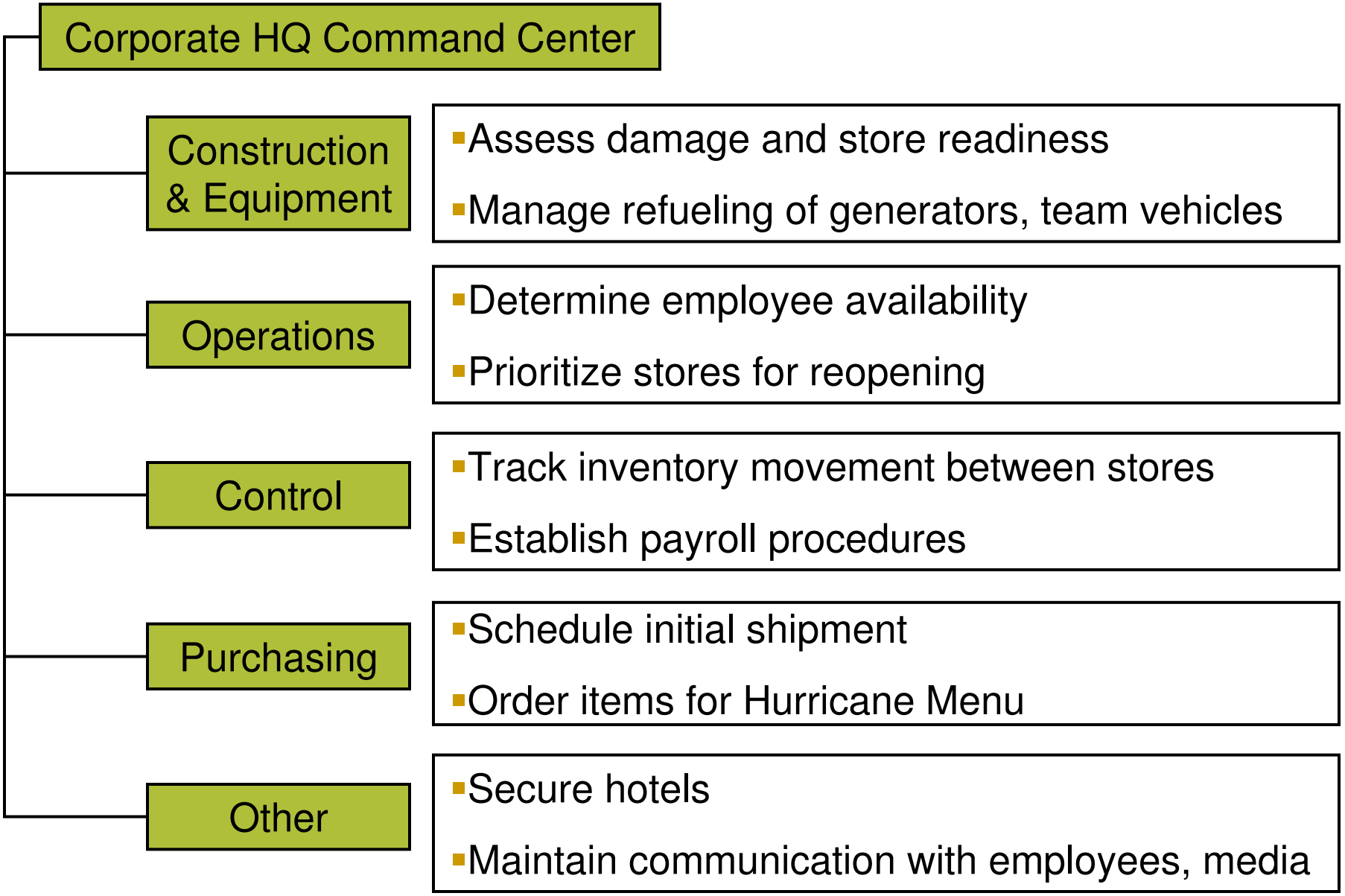
Pre-season Preparation

- 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



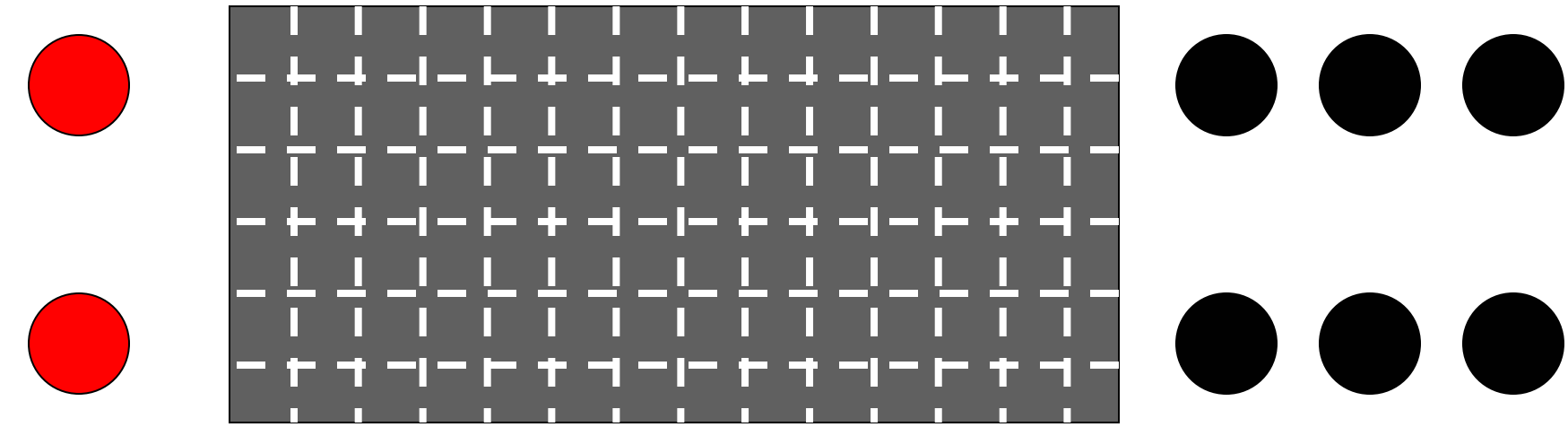
Key Response Decisions

- 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

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

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

Hurricane Menu Example Data

Item-maximizing Menu

Item	Customer Utility	Cooking Time (min)	Resource
Waffle	1	3	waffle iron
Egg	1	3	1/3 pan on burner
Sausage	1	2	1 grill unit
Ham	1	1.5	1 grill unit
Bacon	1	3	2 grill units
Omelet	1	7	1 burner
Hashbrowns	1	3	1 grill unit
Plain Grits	1	--	kept in steam table
Grits with Toppings	1	--	kept in steam 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 = overage cost; price of generator
  - c_u = underage cost; lost profit if generator shortage
  - Q = quantity purchased
  - D = actual demand, a random variable with cumulative distribution function F 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

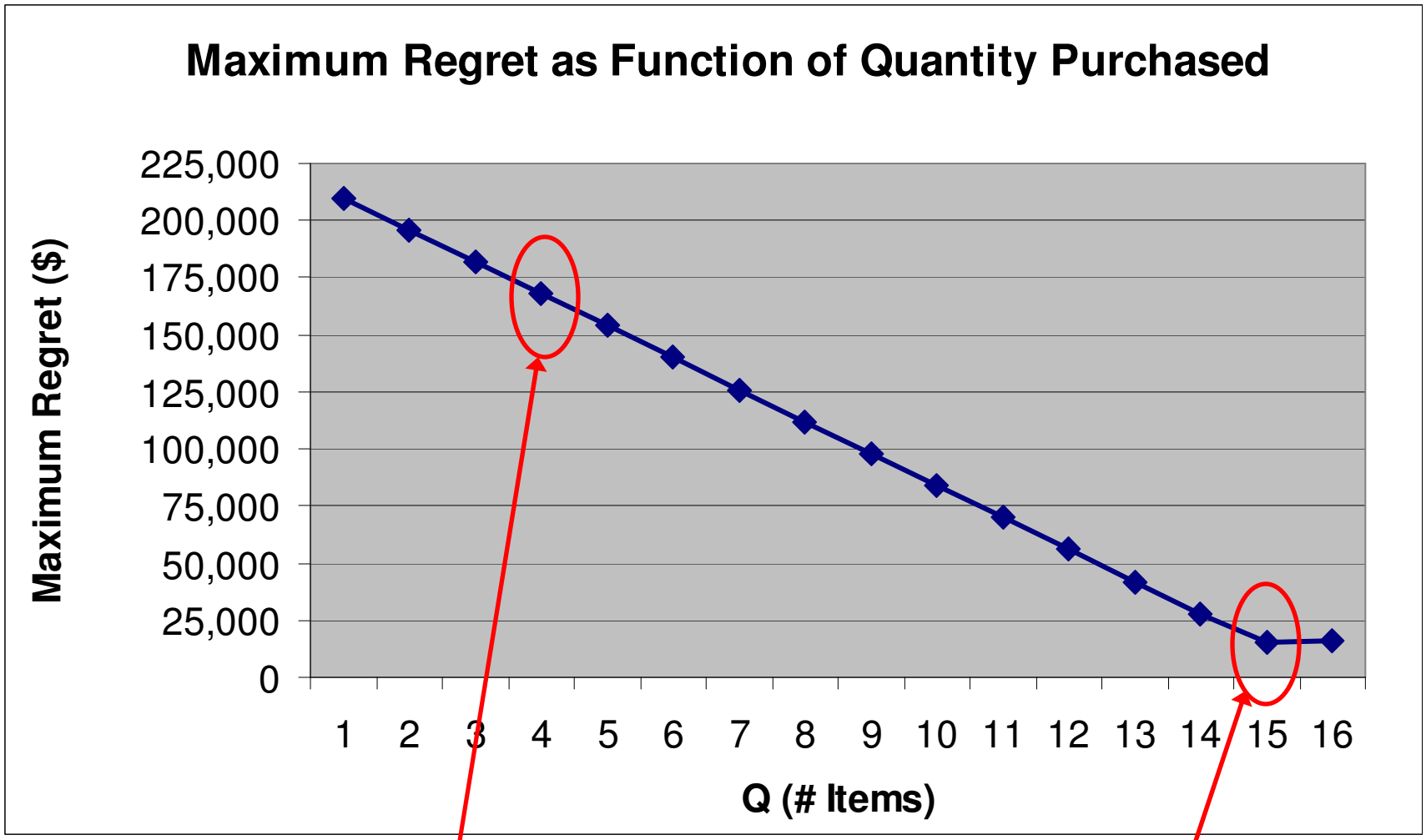
Distribution of Generator Demand+	
D	**Pr{d·D}**
16	1.00
12	0.98
8	0.96
4	0.94
0	0.52

+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



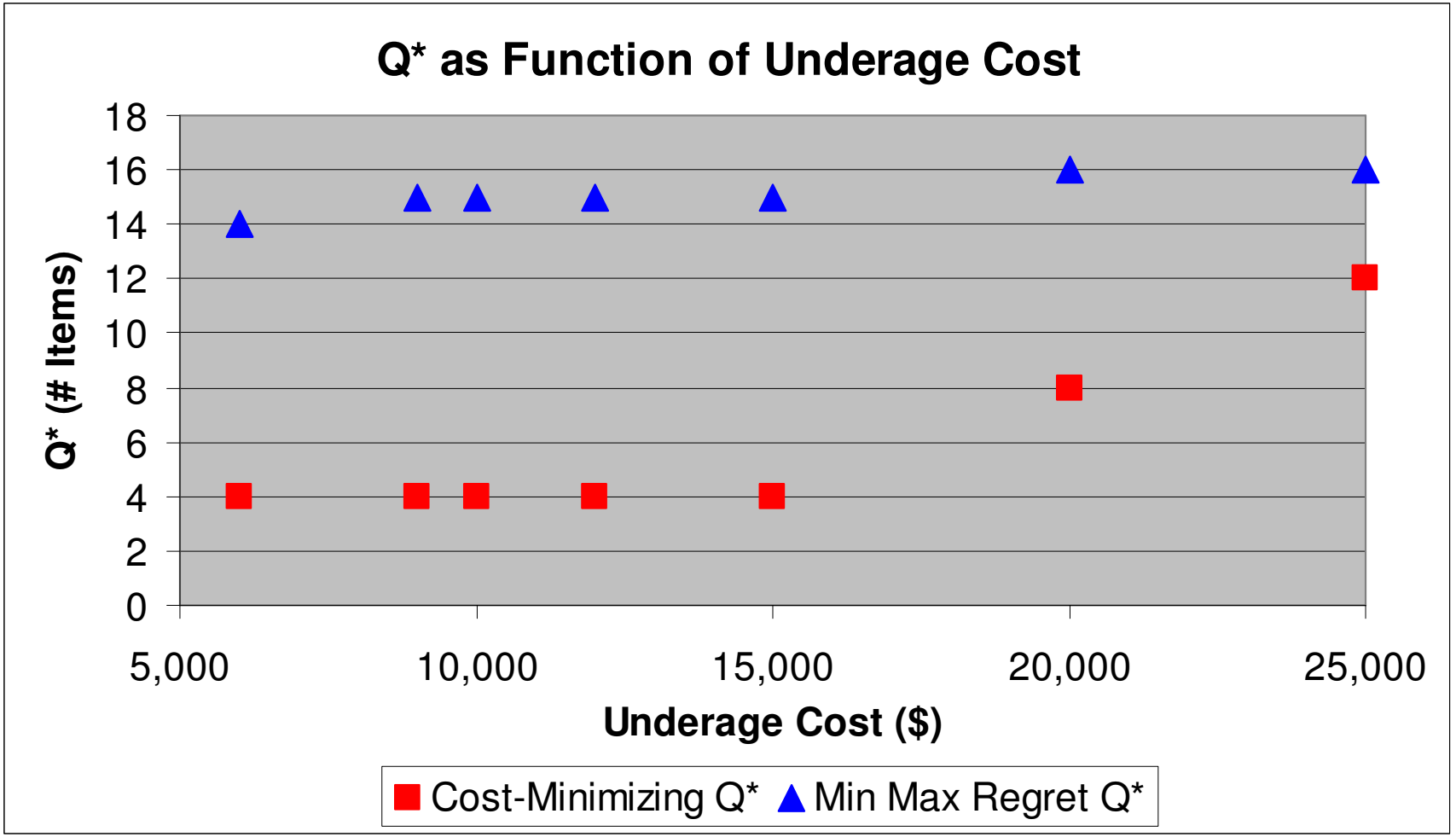
Min Cost: Q*= 4;

Max Regret = $168,000

Min Max Regret: Q*=15;

Max Regret = $15,000

Advance Purchase – Uncertainty in Costs

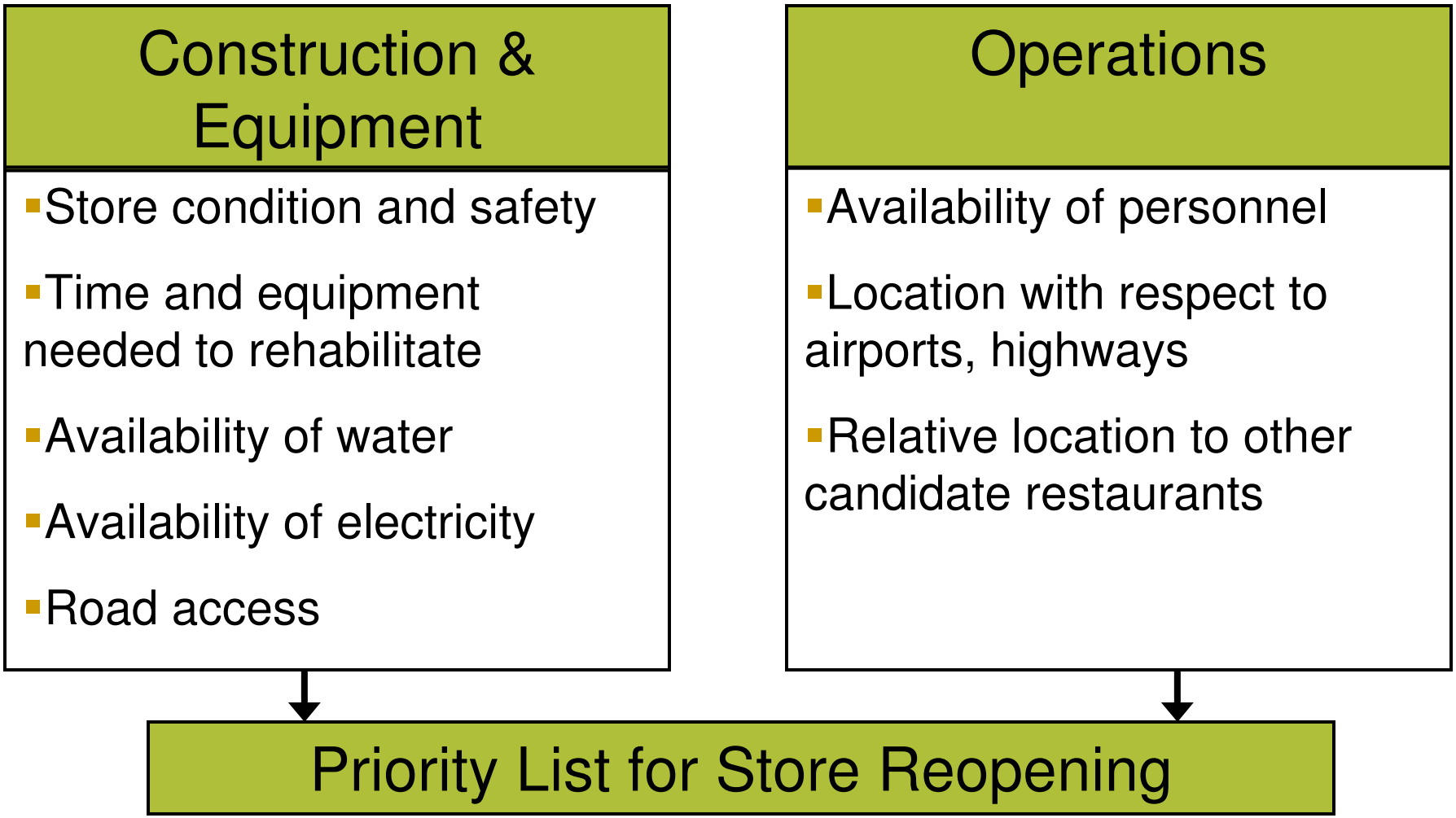


- Uncertainty in value of lost profits or days without electricity affects Q*
- Min Max Regret Q* has smaller range (14 to 16) than Min Cost Q* (4 to 12) over wide range of underage costs

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



"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?

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