Data-Driven Pricing

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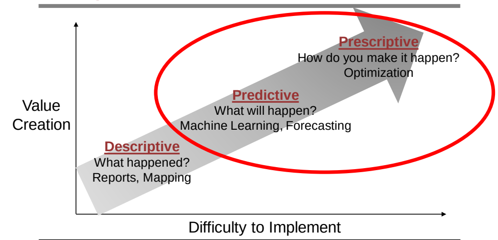
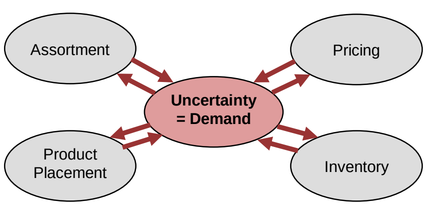
Analytics Overview



Tactical Decisions in Retail



*Time-dependent Decisions

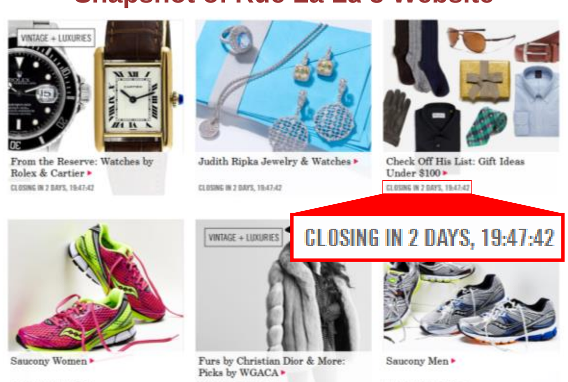
Challenge

How can we combine *predictive analytics* to predict demand with *prescriptive analytics* to make tactical decisions?

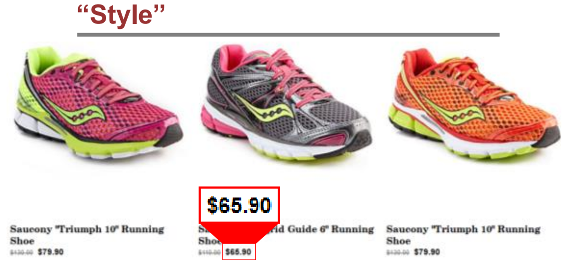
Data-Driven Approach

Internal Data Sources	External Data Sources
Historical Sales	Competitor's Pricing
Other ERP Data	Social Media
Clickstream / Page Views	Google Trends
…	…

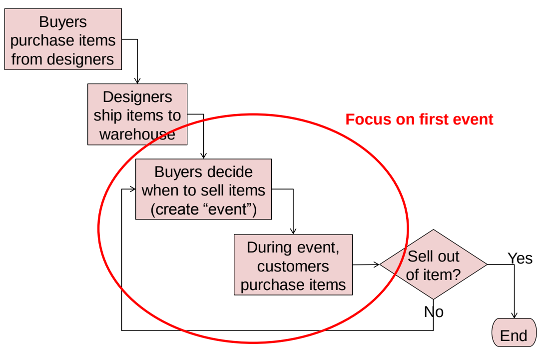
Snapshot of Rue La La's Website



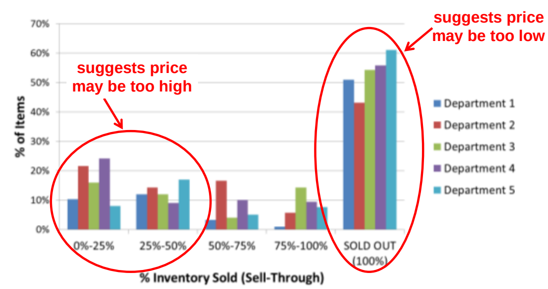
"Style"



Rue La La's Operations



Sell-Through Distribution of New Products



Approach

Goal: Maximize expected revenue of new styles

Demand Forecasting

Main Challenge:
- Predicting demand for styles that have never been sold before

Solution Techniques:
- Predictive analytics (machine learning – regression & clustering)

Price Optimization

Main Challenge:
- Demand of each style depends on price of similar styles

Solution Technique:
- Prescriptive analytics (optimization)

Features Included in Regression

Products	Combination	Events
Department	Price	Year
Class	% Discount = (1 – Price / MSRP)	Month
Color Popularity	# Concurrent Events in Department	Week Day / Time
Size Popularity	# Similar Styles in Event	Event Type
Brand Type A/B	Relative Price of Similar Styles	Event Length
Brand Popularity	# Branded Events in Previous 12 Months	

- Tested several machine learning techniques
  - Regression trees performed best

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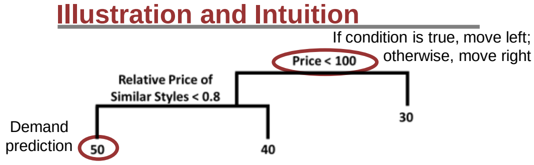
Regression Trees: Illustration and Intuition



Why regression trees?
- Use features to partition styles sold in past, and only use relevant styles to predict demand
- Allow for non-standard price/demand relationship

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Complexity

- Three of the features used to predict demand are associated with pricing
  - Price
  - % Discount = $\frac{1 - \text{Price}}{\text{MSRP}}$
  - Relative Price of Similar Styles = $\frac{\text{Price}}{\text{Avg. Price of Similar Styles}}$
- **Pricing must be optimized concurrently for all similar styles**

Naïve Approach

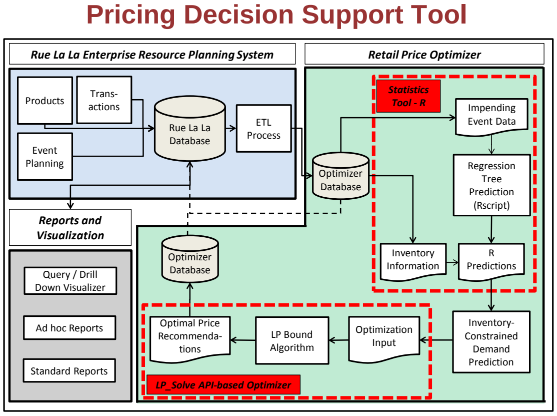
- Set of possible prices:
  - Prices must end in $4.90 or $9.90
  - Ex: {$24.90, $29.90, $34.90, $39.90}
- For each combination of possible prices assigned to each style, calculate expected revenue
  - Requires predicting demand for each style given each competing style's price
  - Computationally intractable…could take months to solve

Key Observation

- Demand depends only on the *average* price of competing styles in an event, as opposed to each style's individual price
- Reformulated multi-product price optimization model with far fewer variables using this key observation
- Developed efficient algorithm to solve on daily basis
  - Average run-time ~1 hour

IMPLEMENTATION & IMPACT

Pricing Decision Support Tool



Field Experiment

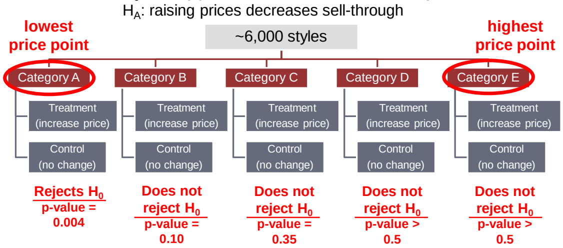
- Test questions:
  1. Would implementing model recommended price increases cause a decrease in sales?
  2. What would be the associated revenue impact?
- Set lower bound on price = legacy price (cost + markup)
  - Model only recommends price increases (or no change)
- Identified ~6,000 styles where tool recommended price increases
  - 5-month field experiment

Impact on Sell-Through

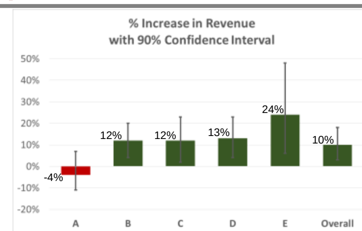
Rank Sum Test

H_0: raising prices has no effect on sell-through

H_A: raising prices decreases sell-through



Impact on Revenue



How can we do even better?

Dynamic Pricing

- You are a new online retailer who sells a fashionable purse during the Spring 2016 season
- How would you price this purse?
  - Prices that you're considering: {$150, $200}
- You don't know customer demand at each price
- You have unlimited inventory
- **Exploration vs. Exploitation Tradeoff**
  - "Explore" by offering a variety of prices to learn demand
  - "Exploit" this information to choose the best price (max $$)

Dynamic Pricing

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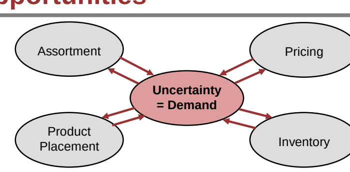
- You don't know customer demand at each price
- You have ~~unlimited inventory~~ *limited inventory*
- **Tradeoffs**
  - **Exploration vs. Exploitation**
  - **Explore at the cost of running out of inventory**

Opportunities



- Use data to develop innovative machine learning & optimization techniques to best address these challenges
  - Combination of predictive and prescriptive analytics