Markdowns

Outline

- Markdowns
- Markdown Price Optimization
- Estimating Price Sensitivity

Based on Phillips (2005) Chapter 10
Markdowns

- Markdown is a permanent reduction in price whereas promotions are temporary.
Reasons for Markdowns

- **Fixed inventory (capacity) must be sold by a certain date**
  - **Halloween costumes** should be sold either before Halloween or immediately after
    - Small markdown before Halloween
    - Huge markdown after Halloween
  - **Broadway tickets** must be sold before the show
    - Sell half-priced tickets for a Saturday night show at Times square after the noon of that Saturday
  - **December Tour of Machu Picchu (4 days/3 nights)**
    - Reduce price before departure

- **Additional reasons**
  - **Obsolescence:** Panasonic Lumix DMC-ZS3K Digital cameras
    - Markdown before the arrival of the next generation of Panasonic digital cameras
  - **Fashionability:**
    - **Accessories:** 1920s Hats and Oversized bags for Winter 2012
  - **Deterioration:** Bread/Bakery
    - 1-day old bread/bakery sold at half-price. Great for picnics.
  - **Time of Use:** Winter Coats
    - Markdown significantly in February
More Markdowns/Promotions Recently

- **Increased customer mobility:** Physical (driving) and Virtual (Internet)
- **Popularity of discount chains/outlets**
- **Markdown money/budget contract** where manufacturers reimburse the retailers for their losses from markdowns
  - Manufacturer initiated rebates
- **Ease and accuracy of updating prices** and informing customers about the updates
  - Dynamic (weekly) prices at retailers
  - Weekly coupons has become the reason for buying a newspaper
  - Growing online shopping
- **Vicious circle:** More markdowns increase the expectation for even more markdowns
  - Economic recession forced Nieman Marcus, Saks Fifth Avenue, Nordstrom to markdown heavily. They are concerned that such markdowns increase expectation for lower prices even after the recession ends: Dilution of brand value.
Even More Markdowns/Promotions Recently

- Cyber Monday: First Monday after Thanksgiving
  - Window-shopping on Black Friday to purchase on Cyber Monday
  - Missed Cyber Monday – No worries there is ____________ Tuesday!!
- On the right, Lands’ End promotion on Tuesday after Cyber Monday in 2017.
Markdown to Segment a Market

- One of the difficulties with market segmentation is cannibalization
  - Customers with high willingness to pay may discover the low cost alternative and purchase that alternative.
  - Markdown is a tactic to segment customers
    - High price first and lower prices afterwards for products
    - People with high wtp buy first the others buy later

- Obsolescence, Fashionability, Deterioration, Time of Use may decrease wtp over time
- What if customers with high wtp choose to wait for markdowns?
Strategic vs. Myopic Customers

- **Strategic customers:** Consideration of future option
  - Waiting for a cheaper/better product
    - Easier to monitor prices: web sites, iPhone, consumer groups
    - Abundant information and speculation on the internet/media

- **Myopic customers:** No consideration of future option

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**Myopic**

Impatient, Seeks instant gratification

- High activity level

**Strategic**

- Low activity level

... activity in ... the *ventral striatum*, tucked deep in the brain, and the *medial prefrontal cortex* (PFC) right behind the forehead ... tracked people’s preferences. In someone who was offered a choice between $100 today or $100 next week, activity in these regions plunged when the next-week choice was considered, and fell even more as the payoff was postponed further and further into the future.

Markdown as a Dutch Auction
To Reveal Customer’s Valuation

- If demand-price relationship is uncertain, let the customer name the price.
- Customer names the price by buying the product while the vendor constantly but slowly reduces the price.
- This is a **Dutch Auction** (Reverse Auction)
  - Each buyer knows the value of the product for himself/herself
  - This value is private information; nobody else knows it.
  - Used to sell flowers
- The vendor starts at a maximum price and reduces it down until a buyer decides to pay the current price to buy or until a minimum price

\[ p_1 \]

At this price, one of the buyers decides to buy. This price is equal to the maximum value of the product assessed by the buyers.
Markdown Optimization
Deterministic Demands

- $x_1$ inventory at the beginning of the season
- Index periods (weeks or months) by 1, 2, ..., $T$, end of horizon $T$ is known
  - Product is shipped to an outlet or sold to a jobber after $T$.
- Lowest allowed price at the end of horizon $r$, specified by company policy
- $d_i(p_i)$: Demand-price relationship in period $i$
- Since inventory is already paid for, we maximize the revenue.
- Markdown prices are decision variables: $p_1 \geq p_2 \geq p_3 \ldots \geq p_{T-1} \geq p_T \geq r$

Maximize $\sum_{i=1}^{T} p_i d_i(p_i) + ry$

Subject to

- $\sum_{i=1}^{T} d_i(p_i) \leq x_1$
- $y = x_1 - \sum_{i=1}^{T} d_i(p_i)$
- $p_i \geq p_{i+1}$ for $i = 1, \ldots, T - 1$
- $p_T \geq r$

Simplifying

By inserting $y$ in to the objective

$rx_1 + \text{Maximize} \sum_{i=1}^{T} (p_i - r)d_i(p_i)$

Subject to

- $\sum_{i=1}^{T} d_i(p_i) \leq x_1$
- $p_i \geq p_{i+1}$ for $i = 1, \ldots, T - 1$
- $p_T \geq r$

<See deterministic_markdown.xlsx>
Markdown Optimization
Deterministic Demands: Equal demands

What if the demand $d_i(p) = d_j(p)$ for every price $p$ in different periods $i$ and $j$?

Maximize $\sum_{i=1}^{T} (p_i - r) d(p_i)$
Subject to
$\sum_{i=1}^{T} d(p_i) \leq x_1$
$p_i \leq p_{i-1}$ for $i = 2, \ldots, T$
$p_T \geq r$

All the periods are the same, so should the prices be: $p_1 = p_2 = p_3 = \cdots = p_{T-1} = p_T$

For different prices, we need different demands in different periods

Demands over different periods may affect each other.

For markdowns, we need dropping demands over time:

$d_i(p) \geq d_j(p)$ for every period $j$ that comes after period $i$
Deterministic Demands in Regular and Markdown Seasons

- This will happen when WTP decreases over time
- Think of your WTP for a winter coat which experiences markdown in mid January.

<table>
<thead>
<tr>
<th>R: Regular Season, $p_R$</th>
<th>M: Markdown Season, $p_M$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Today</td>
<td>Mid-Jan</td>
</tr>
</tbody>
</table>

- Ex: $WTP_R$ during regular season ranges over (200,400) whereas $WTP_M$ during markdown season ranges over (100,300)

- Why does the WTP drop as we move to markdown season?
  - Not a hot fashion item anymore, presumably many people already bought this coat
  - Less time left in winter to utilize the coat
  - People affording regular price already bought and left the market: $[WTP_M] = [WTP_R | WTP_R \leq p_R]$
Deterministic Demands in Regular and Markdown Seasons

- Ex: Formulation of dropping demand
  - For continuous time $t$, $d(t, p) = (a - bp)e^{-\alpha t}$ where $\alpha \geq 0$ is an age factor, see Talluri & Van Ryzin 2004.
  - For discrete time, $d_R(p) = (a - bp)$ and $d_M(p) = (a - bp)e^{-\alpha} = (a - bp)\alpha'$ where $\alpha' \geq 0$ is a factor for scaling down for markdown demand
  - You can also try $d_R(p) = (a - bp)$ and $d_M(p) = a - \alpha''bp$
  - Other formulations are also possible
Markdown Optimization
Random Demands – A demand aggregation approach

- When demands are random, we can aggregate remaining demands while we are deciding on the price for period $t$.

$$\hat{D}_t(p) = \sum_{i=t}^{T} D_i(p)$$

- Let $x$ be the current inventory level.
- Then solve single-period revenue maximization problem to find the price of period $t$.

Maximize $E[TR(p)] = pE[\min\{\hat{D}_t(p), x\}] + (x - E[\min\{\hat{D}_t(p), x\}])r$

$$= (p - r)E[\min\{\hat{D}_t(p), x\}] + rx$$

So the relevant problem is

Maximize $(p - r)E[\min\{\hat{D}_t(p), x\}]$

Finding the price by maximizing the $(p-r)\cdot sales(p)$ is intuitive but not very easy.
- The challenge is obtaining $sales(p)$.
  - This can be done for certain demand distributions.
  - Simulation is always a viable but a tedious approach.
Estimating Markdown Sensitivity
Historical data: Markdowns versus Sales in Year -1

- We can obtain the sales during the last (-1) year
- For the first 34 weeks, there was no markdown
- Markdown happened in weeks 35, 41, 46 and eventually the product is sold at the outlet starting with the 50th week
Estimating Markdown Sensitivity

**Historical data: Markdowns versus Sales in Year -2**

- We can obtain the sales during the year (-2) before the last year.
- For the first 36 weeks, there was no markdown.
- Markdowns happened in weeks 37 and 43 and eventually the product is sold at the outlet starting with the 48th week.
Estimating Markdown Sensitivity
Looking at Two Years Together

- Crude estimation does not work
  - Sales in week 35 of two years are not from the same population!
  - Case in point: Black Friday has become Thursday in 2011. Stores opened in the late evening.

- Demand depends on
  - amount of the last markdown
  - number of weeks since the last markdown
  - competitor prices

Take these into account when forecasting
Retailers (WalMart, Nordstrom) all have these ordering and pricing problems.

- There is a lot of uncertainty while ordering products so orders are higher than average demand to avoid product shortages.

- Then markdowns are used to clear the extra inventory.
Revenues of the Past and Future

- JCPenney is attempting a constant price strategy in 2012.
- In the third quarter of 2012 sales are down by 27% with respect to 2011.
- First nine month sales are down by $2.7 billion with respect to 2011.

![Graph showing sales from 2008 to 2012]($2.7B)

- Realistic estimate for 2012 revenue: 9 months of 2011 + scaled down 3 months of 2012.

Summary

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- Estimating Price Sensitivity