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.

Always going-out-of-business sale

Reasons for Markdowns

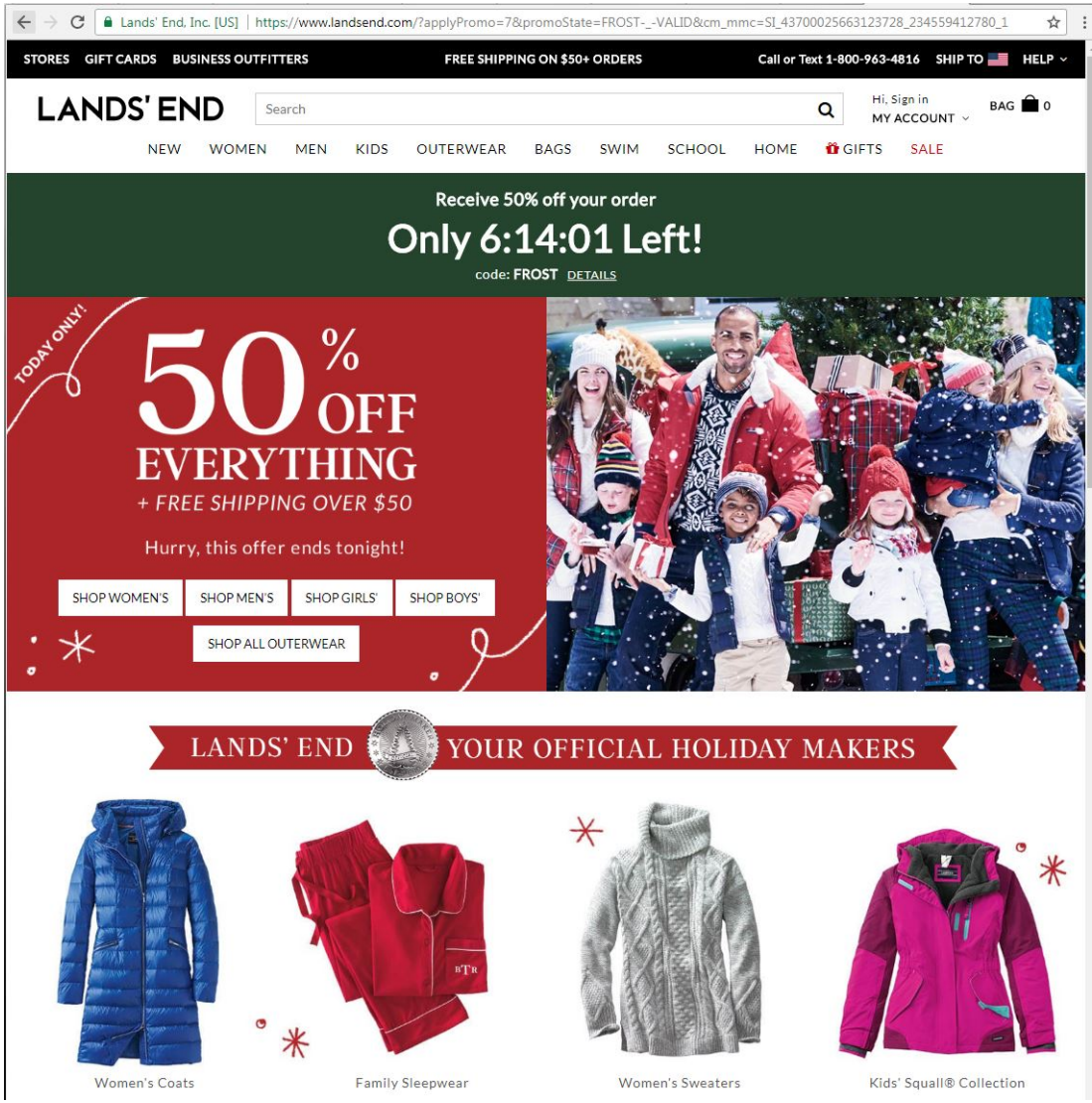
- Fixed inventory (capacity) must be sold by a certain date
  - Halloween costumes should be sold either before Halloween or immediately after
    - Small markdown before Halloween
    - Huge markdown after Halloween
  - Broadway tickets must be sold before the show
    - Sell half-priced tickets for 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:
    - Shawls for Winter 2006; Scarves for Winter 2007; Purple colored blouses for Winter 2008; Ankle high ladies boots for Winter 2009; Peaked (paded) shoulders Winter 2010; Masculine-looking cloths for Winter 2011; …; Faux fur for Winter 2015; Puffer coats for Winter 2016; Sterling silver outfits for Winter 2017.
    - 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.

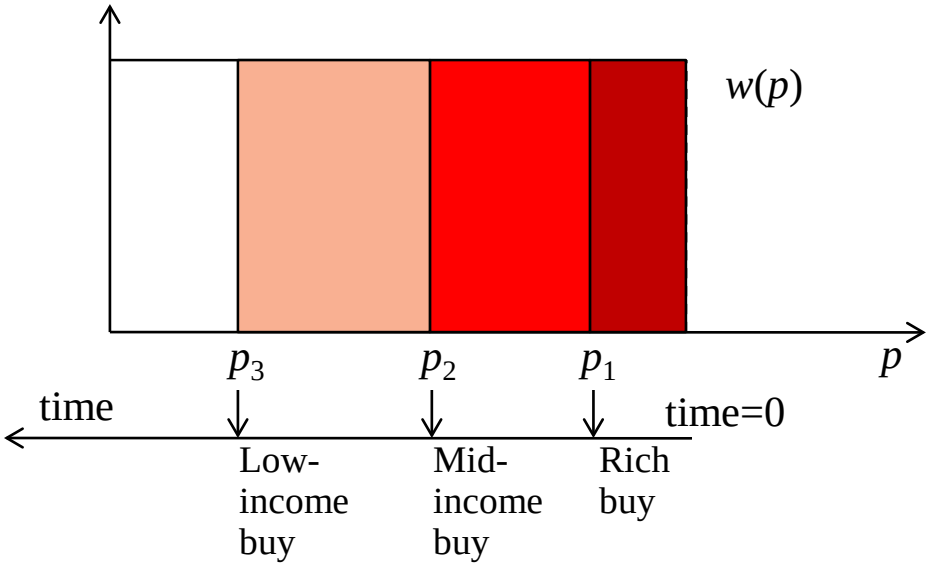
Even More Markdowns/Promotions Recently

- 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

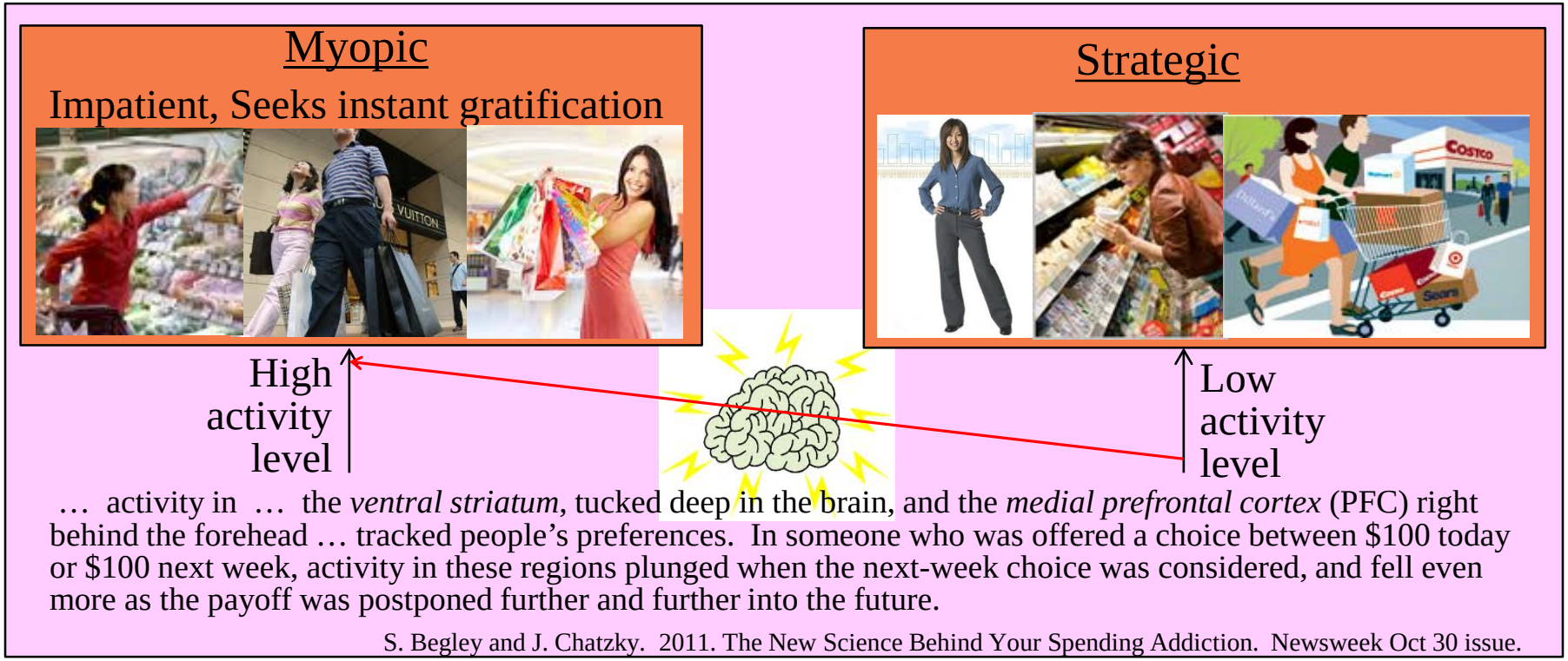
- One of the difficulties with market segmentation is cannibalization
  - Customers with high willingness to pay may discover the low cost alternative and purchase that alternative.
  - Markdown is a tactic to segment customers
    - High price first and lower prices afterwards for products
    - People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

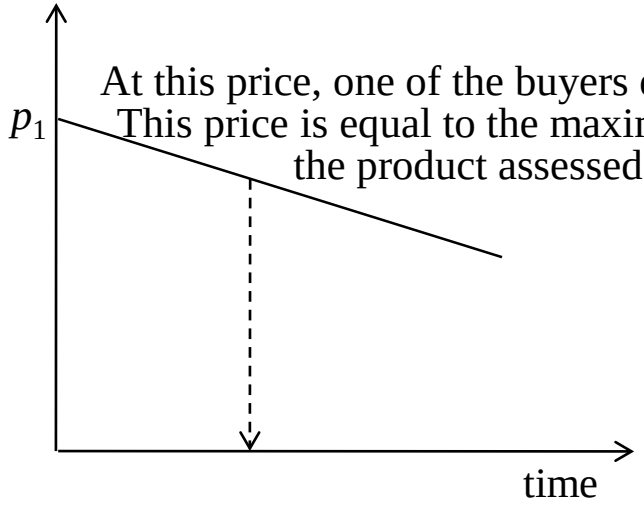


… activity in … the *ventral striatum*, tucked deep in the brain, and the *medial prefrontal cortex* (PFC) right behind the forehead … tracked people's preferences. In someone who was offered a choice between $100 today or $100 next week, activity in these regions plunged when the next-week choice was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

S. Begley and J. Chatzky. 2011. The New Science Behind Your Spending Addiction. Newsweek Oct 30 issue.

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



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 : $p_1 \geq p_2 \geq p_3 \ldots \geq p_{T-1} \geq p_T \geq r$

$$\underset{p_1,p_2,\ldots,p_T}{\text{Maximize}} \sum_{i=1}^{T} p_i d_i(p_i) + ry$$

Subject to

$$\sum_{i=1}^{T} d_i(p_i) \leq x_1$$

$$y = x_1 - \sum_{i=1}^{T} d_i(p_i)$$

$$p_i \geq p_{i+1} \quad \text{for } i = 1,\ldots,T-1$$

$$p_T \geq r$$

Simplifying

By inserting y in to the objective

$$rx_1 + \underset{p_1,p_2,\ldots,p_T}{\text{Maximize}} \sum_{i=1}^{T} (p_i - r) d_i(p_i)$$

Subject to

$$\sum_{i=1}^{T} d_i(p_i) \leq x_1$$

$$p_i \geq p_{i+1} \quad \text{for } i = 1,\ldots,T-1$$

$$p_T \geq r$$

<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?

$$\underset{p_1,p_2,\ldots,p_T}{\text{Maximize}} \sum_{i=1}^{T}(p_i - r)d(p_i)$$

Subject to

$$\sum_{i=1}^{T} d(p_i) \le x_1$$

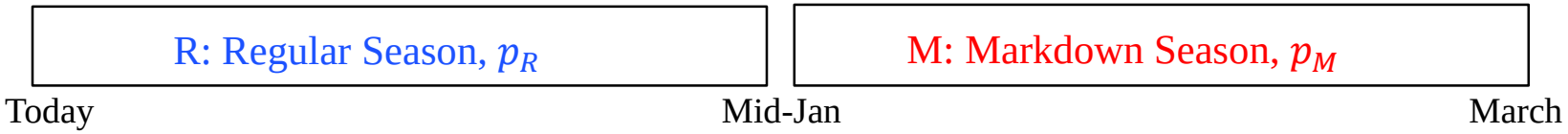
$$p_i \le p_{i-1} \quad \text{for } i = 2,\ldots,T$$

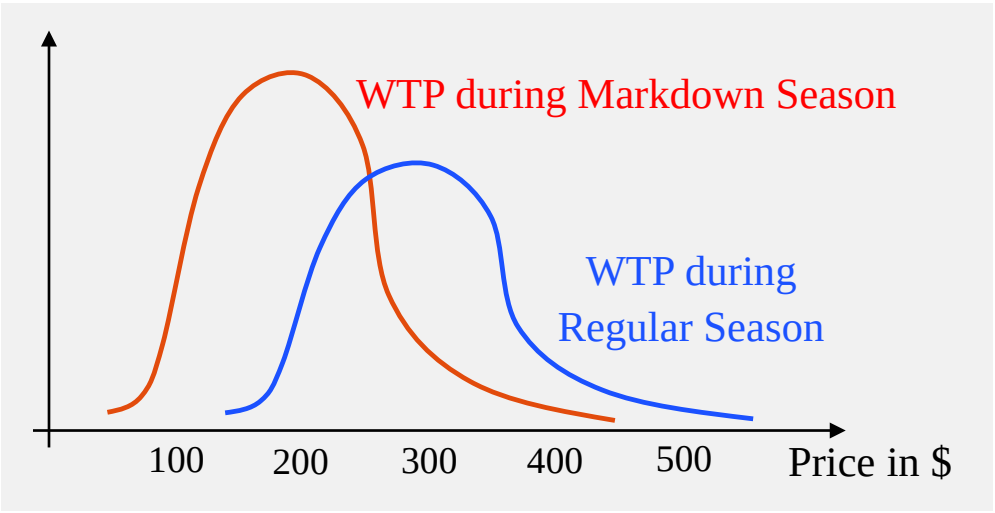
$$p_T \ge r$$

- 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:
    - $d_i(p) \ge d_j(p)$ for every period j that comes after period i

Deterministic Demands in Regular and Markdown Seasons

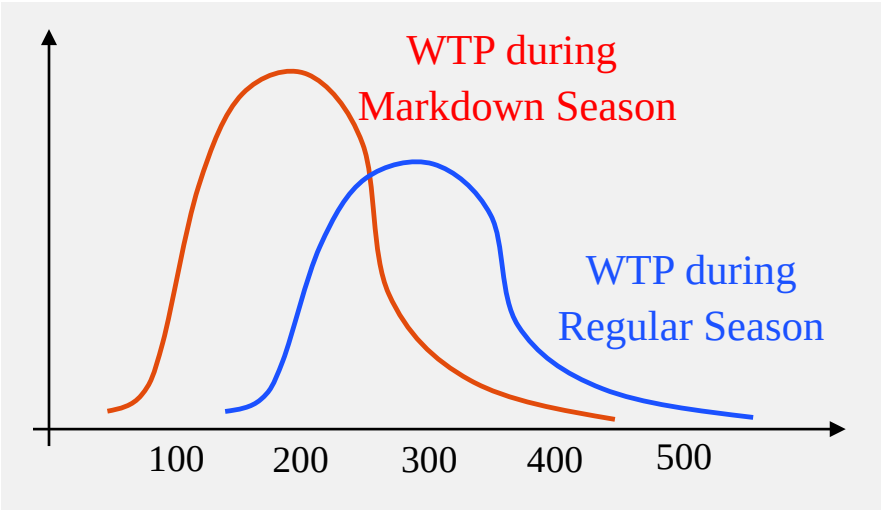
- This will happen when wtp decreases over time
- Think of your wtp for a winter coat which experiences markdown in mid January.

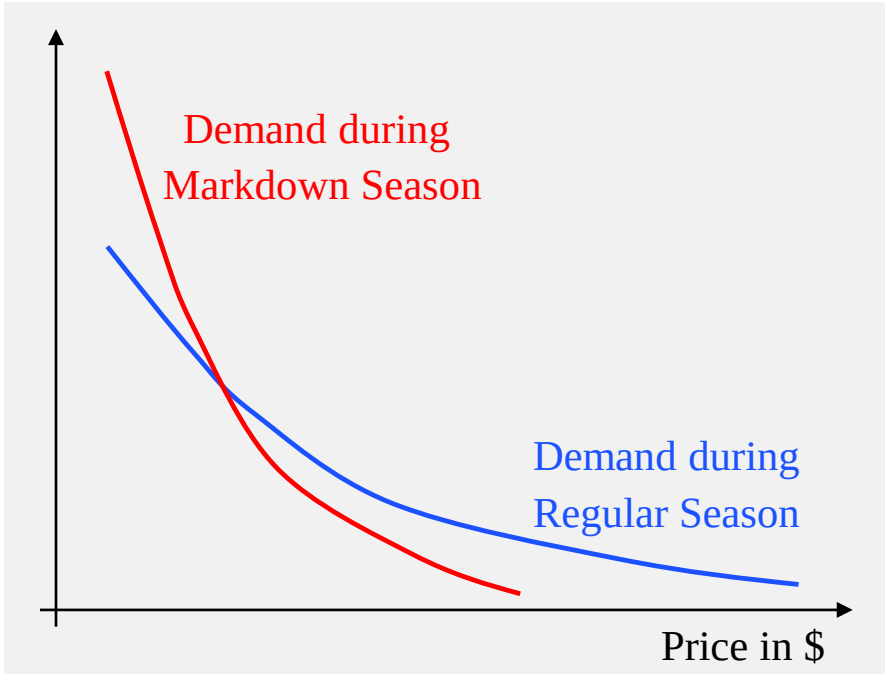




- Ex: WTP_R during regular season ranges over (200,400) whereas WTP_M during markdown season ranges over (100,300)
- Why does the WTP drop as we move to markdown season?
  - Not a hot fashion item anymore, presumably many people already bought this coat
  - Less time left in winter to utilize the coat
  - 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*.

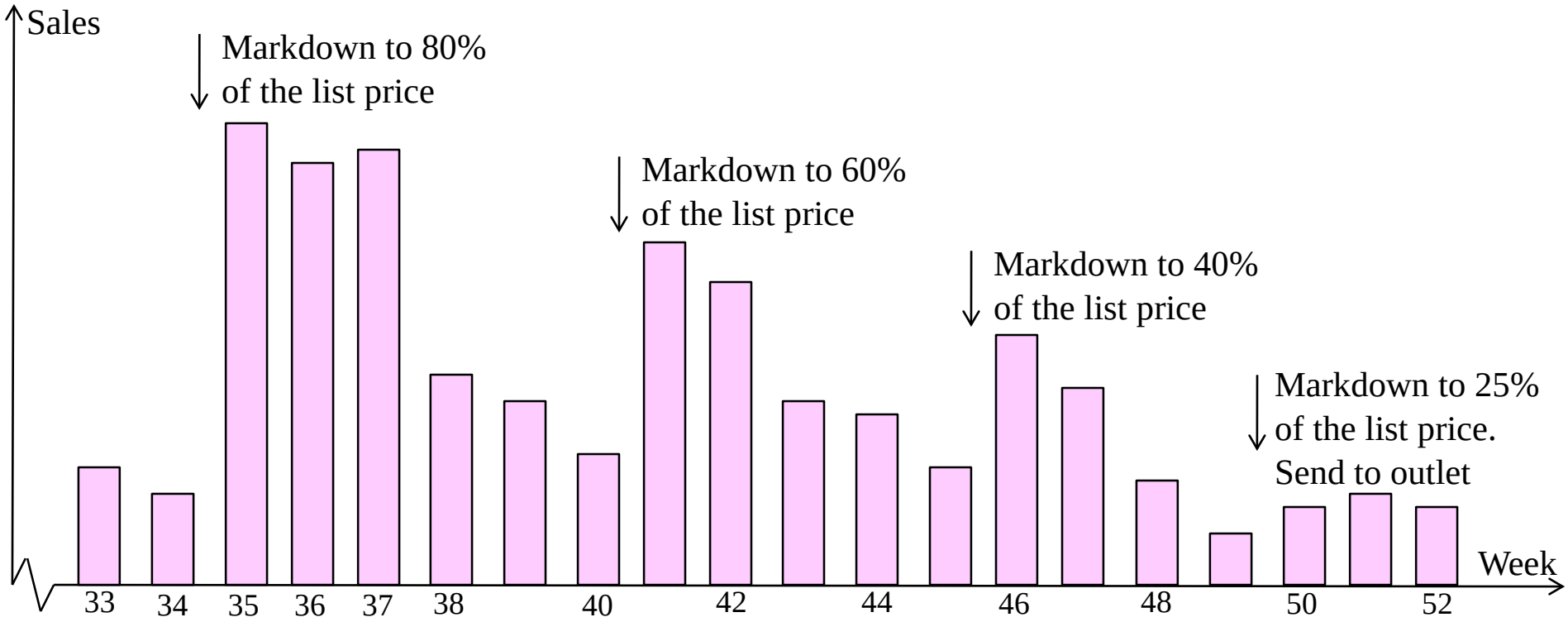
$$\underset{p}{\text{Maximize}}\ \ \mathrm{E}[TR(p)] = p\mathrm{E}[\min\{\hat{D}_t(p), x\}] + (x - \mathrm{E}[\min\{\hat{D}_t(p), x\}])r$$

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

So the relevant problem is $\underset{p}{\text{Maximize}}\ (p-r)\underbrace{\mathrm{E}[\min\{\hat{D}_t(p), x\}]}_{\text{sales}(p)}$

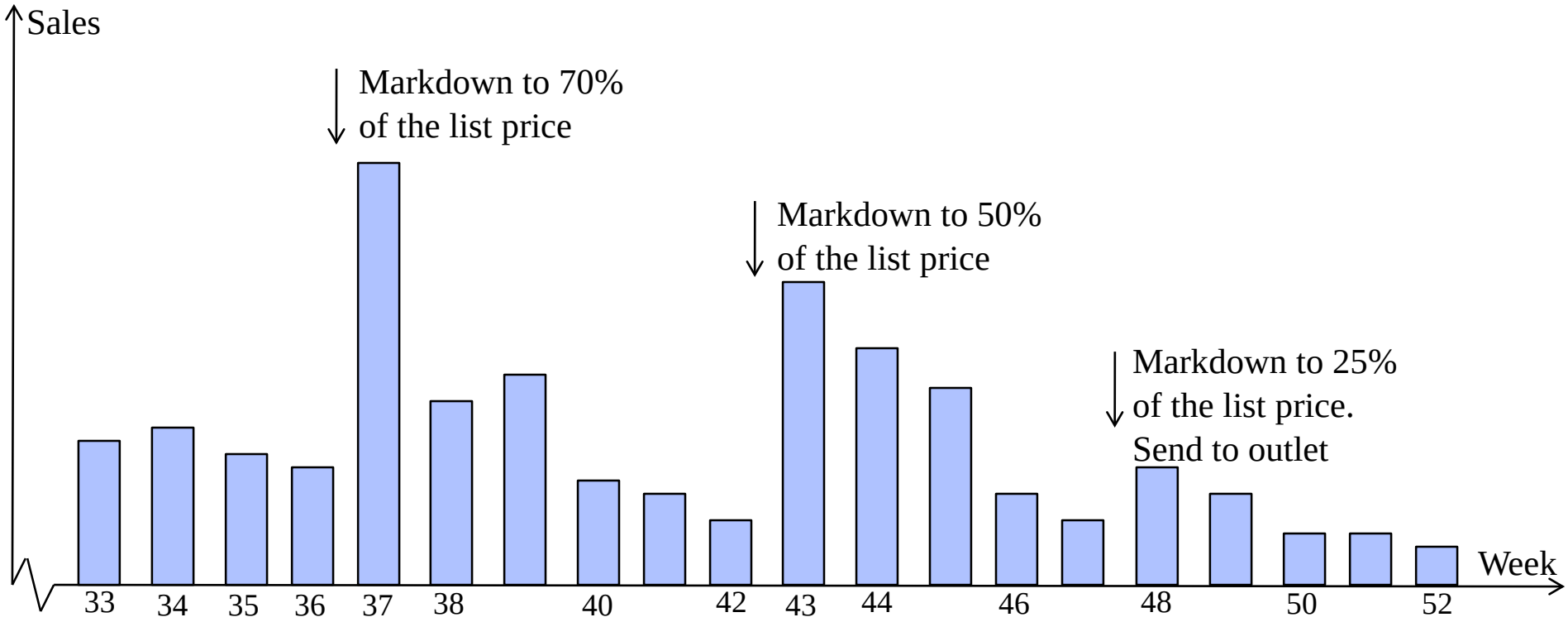
- Finding the price by maximizing the (*p*-*r*)*sales(*p*) is intuitive but not very easy.
- The challenge is obtaining sales(*p*).
  - This can be done for certain demand distributions.
  - Simulation is always a viable but a tedious approach.

Estimating Markdown Sensitivity
Historical data: Markdowns versus Sales in Year -1



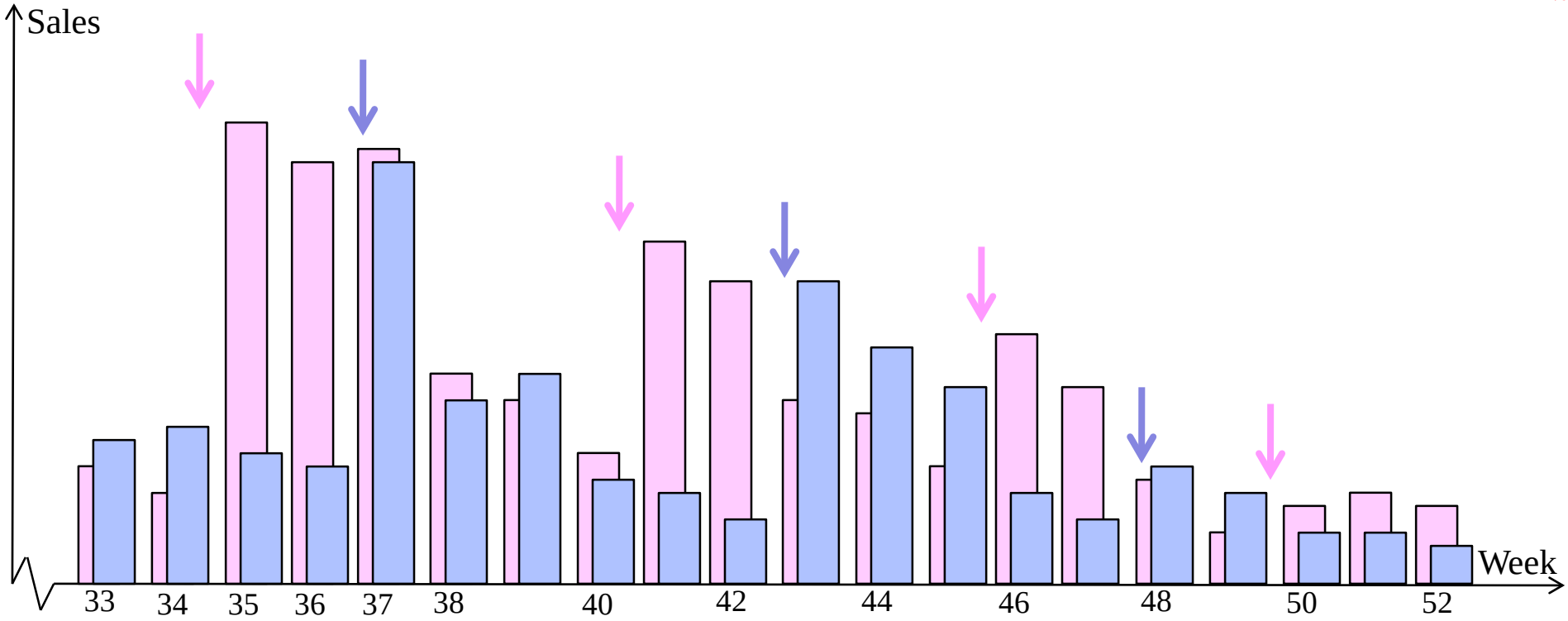
- We can obtain the sales during the last (-1) year
- For the first 34 weeks, there was no markdown
- Markdown happened in weeks 35, 41, 46 and eventually the product is sold at the outlet starting with the 50th week

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

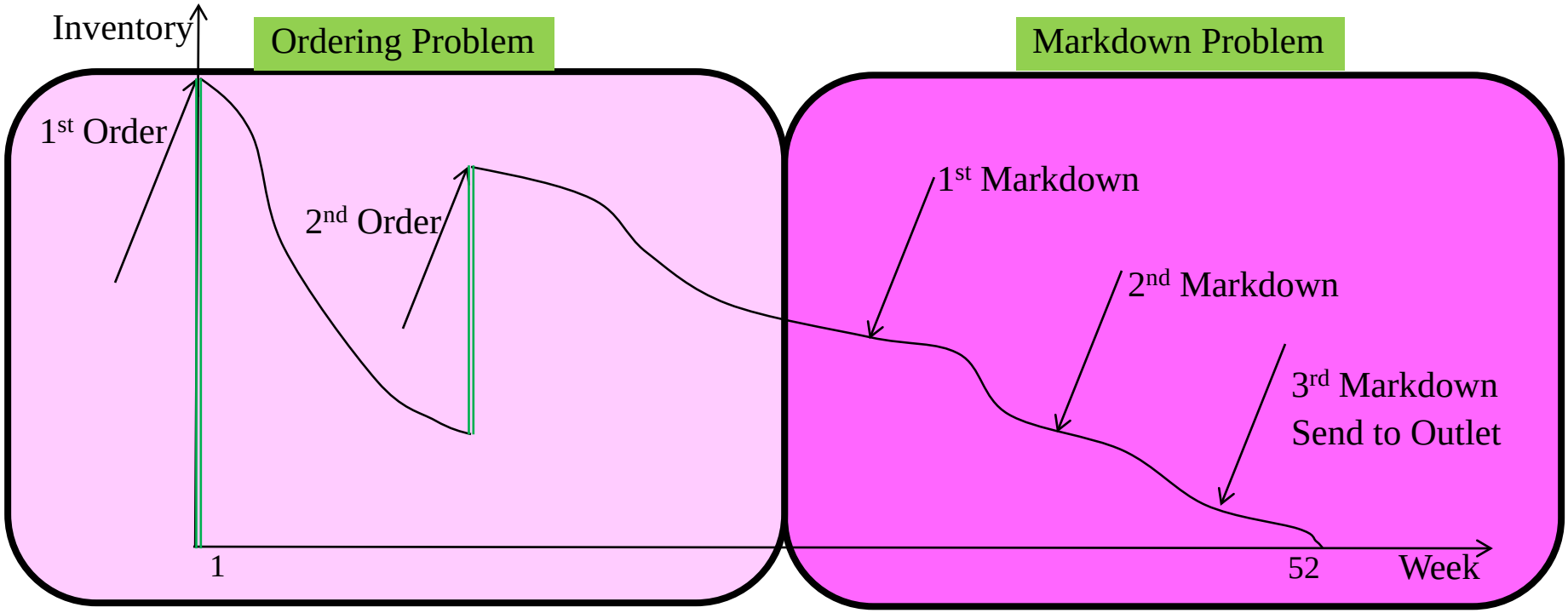
Estimating Markdown Sensitivity Looking at Two Years Together



- 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

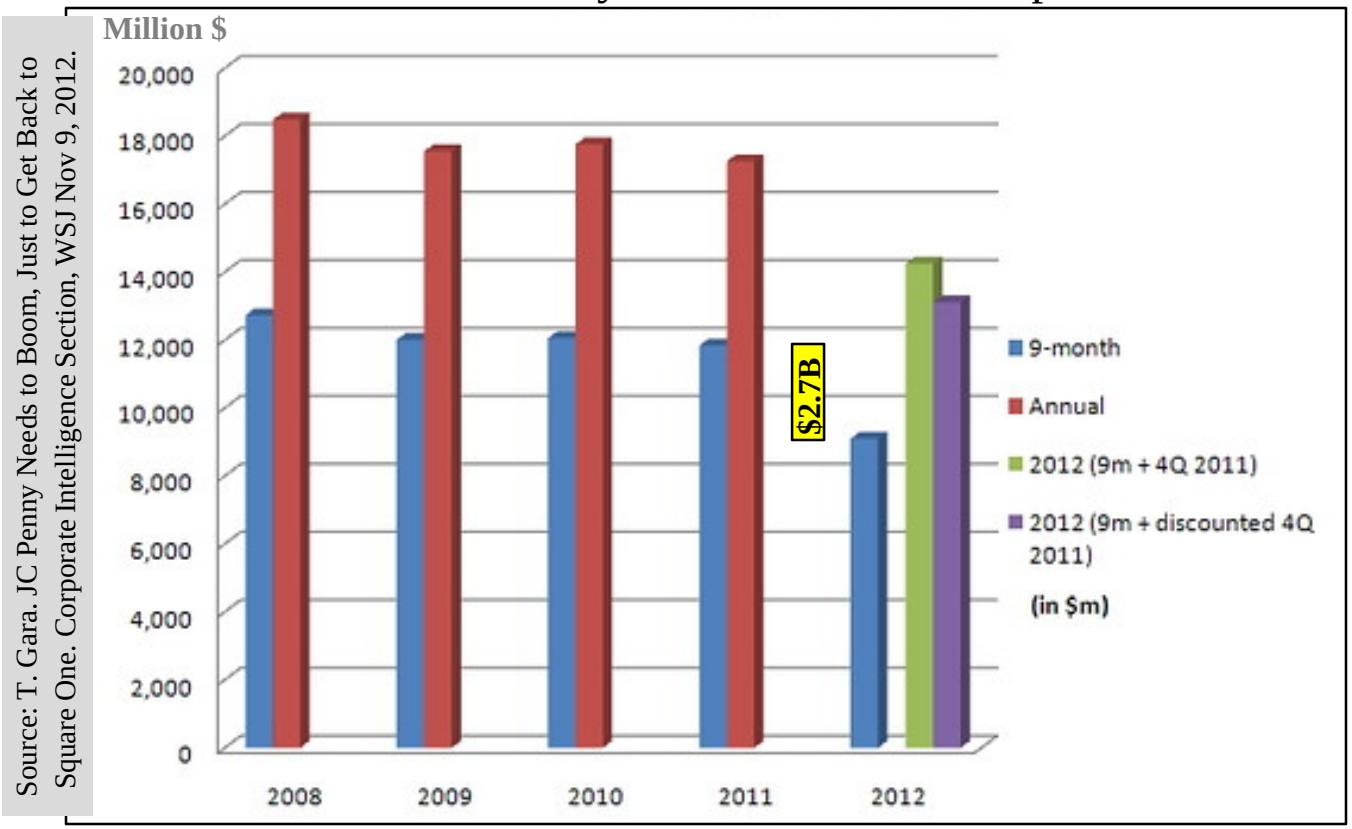
Putting Pricing and Ordering Together at a Retailer



- 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.



Source: T. Gara. JC Penny Needs to Boom, Just to Get Back to Square One. Corporate Intelligence Section, WSJ Nov 9, 2012.

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

Summary

- Markdowns
- Markdown Price Optimization
- Estimating Price Sensitivity