

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.

2 DAYS ONLY!
30% OFF
ALL BEAUTY PRODUCTS

Discount taken at checkout.

BATH & BODY HOME SCENTS SKINCARE COLOR

This advertisement features a light blue background with various beauty products. A black oval highlights the text "2 DAYS ONLY!". The main offer is "30% OFF ALL BEAUTY PRODUCTS". A note states "Discount taken at checkout." Below the main text, there are categories: "BATH & BODY", "HOME SCENTS", "SKINCARE", and "COLOR".

the **Sale**

An Additional
30% OFF
All Sale Merchandise

south moon under
DISCOUNT TAKEN AT REGISTER

USE CODE 'EXTRA30' FOR ONLINE PURCHASES

This advertisement has a red background. The word "Sale" is written in a large, white, stylized font. Below it, the text reads "An Additional 30% OFF All Sale Merchandise". At the bottom, it says "south moon under DISCOUNT TAKEN AT REGISTER" and "USE CODE 'EXTRA30' FOR ONLINE PURCHASES".

FOR A LIMITED-TIME ONLY
ONLINE AND IN STORE

**BG DESIGNER
SHOE SALE**

TAKE **30% OFF***
SELECT STYLES

SHOP NOW ▶

This advertisement features a white background with a pair of black high-heeled shoes. A black oval highlights the text "FOR A LIMITED-TIME ONLY ONLINE AND IN STORE". The main offer is "BG DESIGNER SHOE SALE TAKE 30% OFF* SELECT STYLES". A "SHOP NOW" button with a right-pointing arrow is at the bottom.

30%
savings storewide

THREE
days only as

Sweet Shoppe
D-E-S-I-G-N-S.COM
turns 3!

offer excludes custom font & blog services
and the sweet shoppe quarterly assortment

This advertisement has a light blue background with a pattern of small white dots. It features a large "30% savings storewide" in a dotted font. Below that, "THREE days only as" is written in a decorative font. The Sweet Shoppe logo and website are also present, along with a note about the offer's exclusions.

save 30-50%
biggest rug sale

Save on a huge selection
of our best rug styles.

This advertisement shows several rolls of different styles of rugs. The text "save 30-50% biggest rug sale" is prominently displayed at the top. Below it, it says "Save on a huge selection of our best rug styles."

SAVE
IN-STORE

30% off*
Hardcover Books

50% off†
ALL Calendars

50% off†
ALL Seasonal Gifts

LAST WEEK TO SAVE!
FIND A STORE NEAR YOU →

This advertisement has a red background. It features a "SAVE IN-STORE" banner in the top left corner. The main offer is "30% off* Hardcover Books". Below this, there are two columns: "50% off† ALL Calendars" and "50% off† ALL Seasonal Gifts". A black oval highlights the text "LAST WEEK TO SAVE! FIND A STORE NEAR YOU →" at the bottom.

Reasons for Markdowns

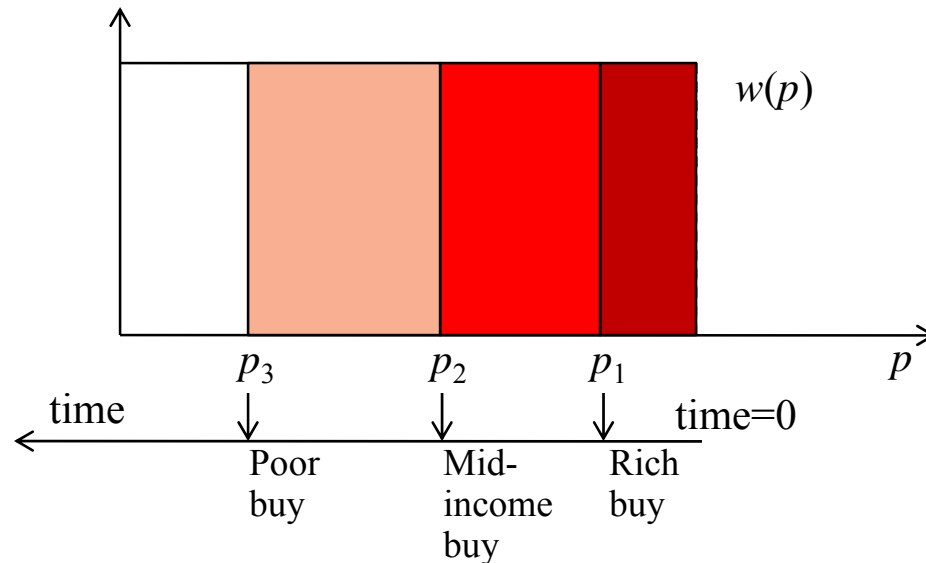
- ◆ Fixed inventory (capacity) must be sold by a certain date
 - ◆ Halloween costumes should be sold either before Halloween or immediately after
 - ◆ Small markdown before Halloween
 - ◆ Huge markdown after Halloween
 - ◆ December Tour of Machu Picchu (4 days/3 nights)
 - ◆ Reduce price before departure
 - ◆ 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
- ◆ 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
 - ◆ 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 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
- ◆ **Vicious circle:** More markdowns increase the expectation for even more markdowns
 - ◆ Economic recession is forcing 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.

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
 - ◆ People with high wtp buy first the others buy later



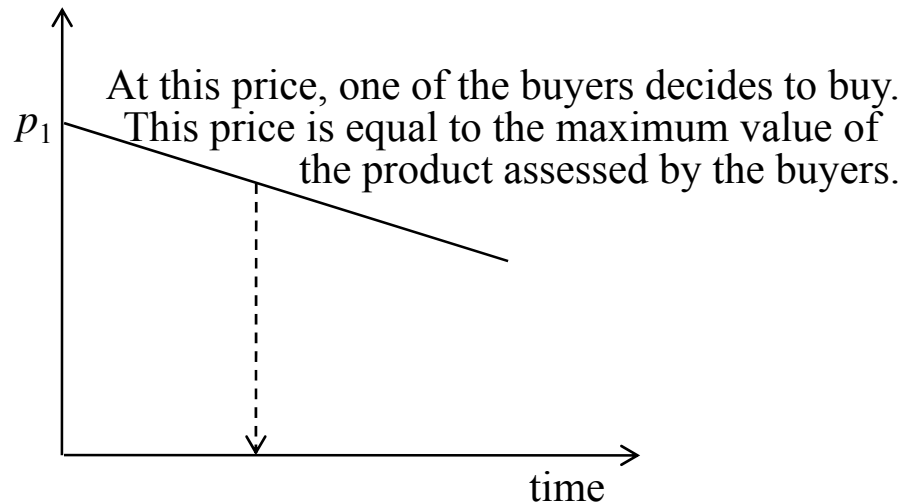
- ◆ Obsolescence, Fashionability, Deterioration, Time of Use decrease may wtp over time

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

- ◆ Start the sales horizon with inventory x_1 and price p_1
- ◆ Index periods (weeks or months) by $1, 2, \dots, T$, 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 : $p_1 \geq p_2 \geq p_3 \dots \geq p_{T-1} \geq p_T \geq r$

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

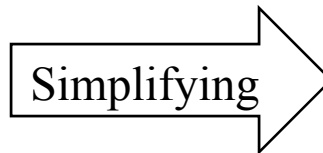
Subject to

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

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

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

$$p_T \geq r$$



$$\text{Maximize}_{p_1, p_2, \dots, p_T} \sum_{i=1}^T (p_i - r) d_i(p_i)$$

Subject to

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

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

$$p_T \geq r$$

<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 ?

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

Subject to

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

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

$$p_T \geq r$$

- ◆ All the periods are the same, so should the prices be: $p_1 = p_2 = p_3 = \dots = p_{T-1} = p_T$
- ◆ For different prices, we need different demands in different periods
 - ◆ For markdowns, we need dropping demands over time:
 - ◆ $d_i(p) \geq d_j(p)$ for every period j that comes after period i
 - ◆ This will happen when wtp decreases over time

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 .

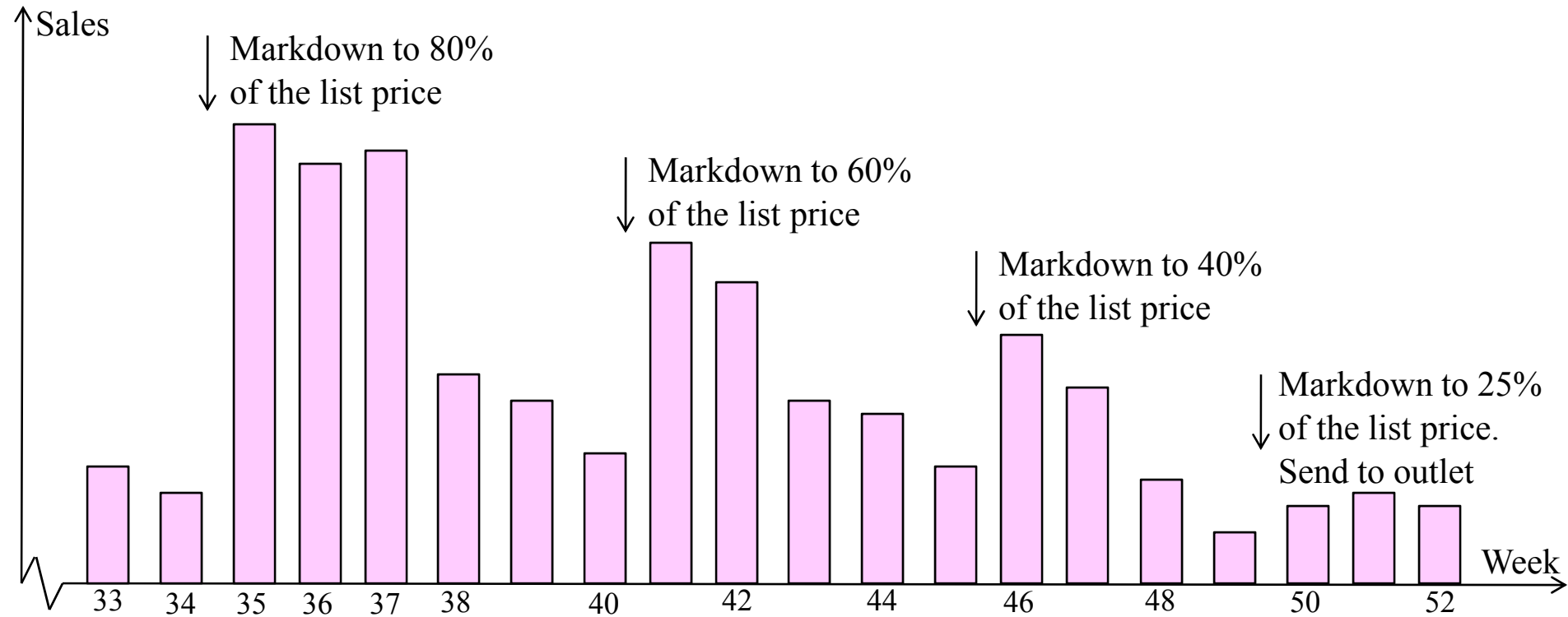
$$\begin{aligned} \text{Maximize}_p E[TR(p)] &= pE[\min\{\hat{D}_t(p), x\}] + (x - E[\min\{\hat{D}_t(p), x\}])r \\ &= (p - r)E[\min\{\hat{D}_t(p), x\}] + rx \end{aligned}$$

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

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

Estimating Markdown Sensitivity

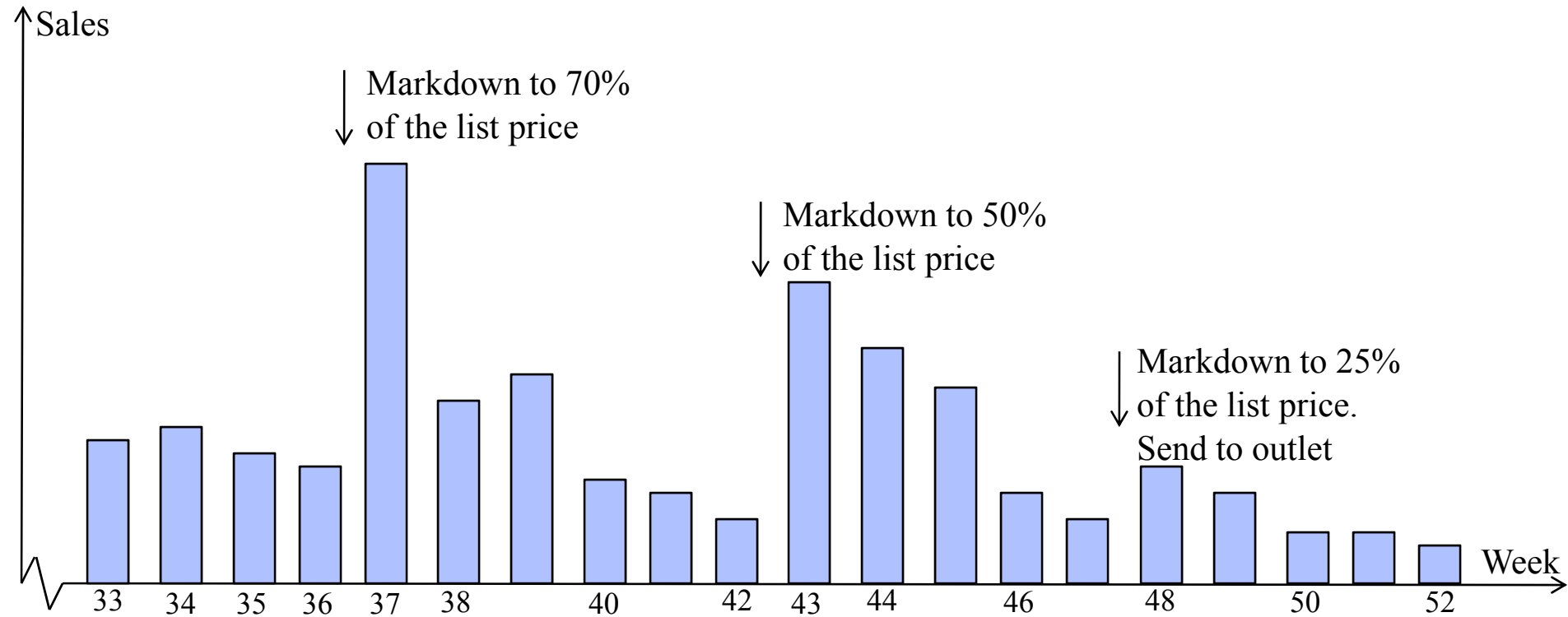
Historical data: Markdowns versus Sales in Year -1



- ◆ 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

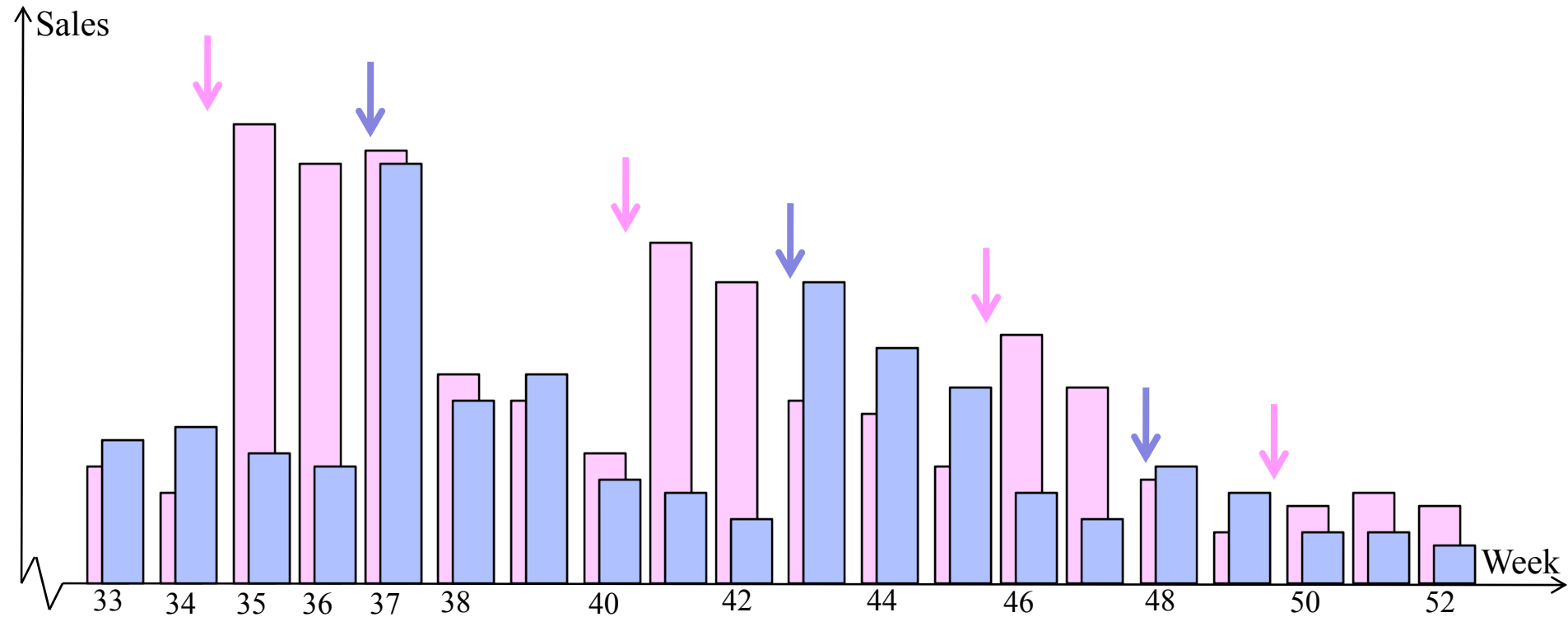
Historical data: Markdowns versus Sales in Year -2



- ◆ 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

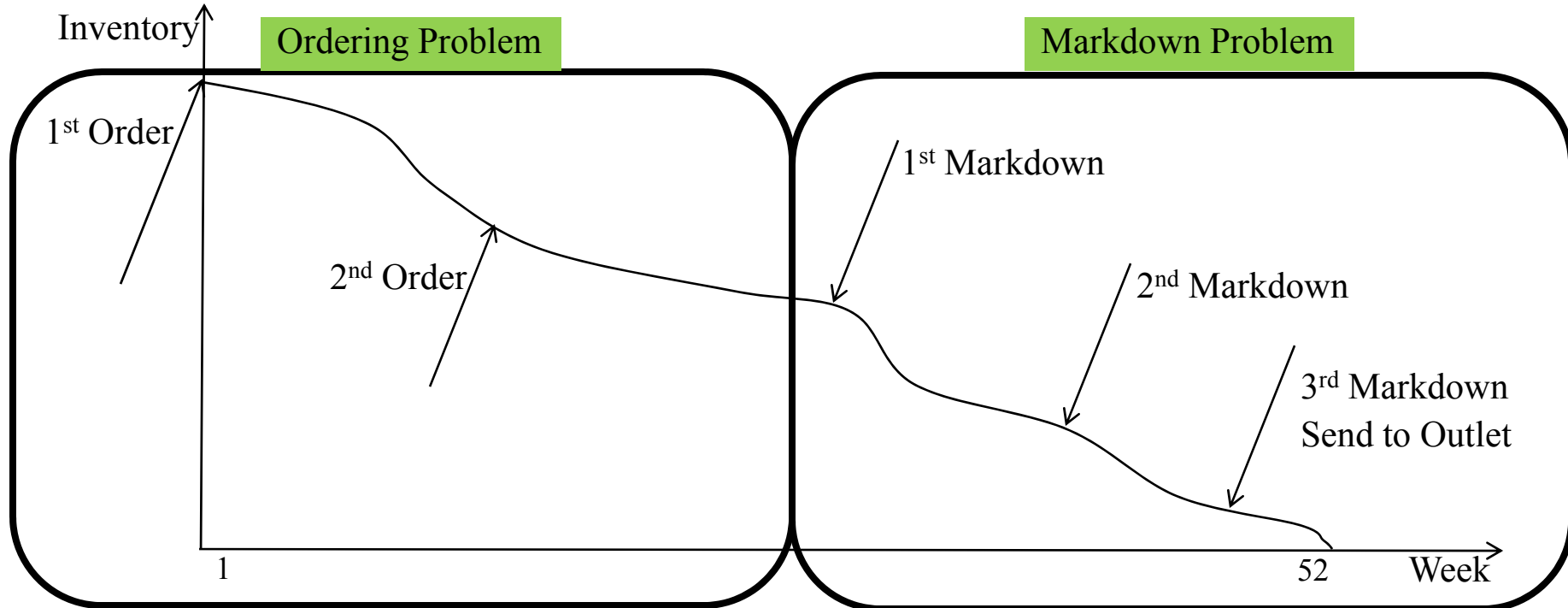
Looking at Two Years Together



- ◆ Crude estimation does not work
 - ◆ Sales in week 35 of two years are not from the same population!
- ◆ Demand depends on
 - ◆ amount of the last markdown
 - ◆ number of weeks since the last markdown

Take these into account when forecasting

Putting Pricing and Ordering Together at a Retailer



- ◆ Retailers (JcPenney, 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.

Summary

- ◆ **Markdowns**
- ◆ **Markdown Price Optimization**
- ◆ **Estimating Price Sensitivity**