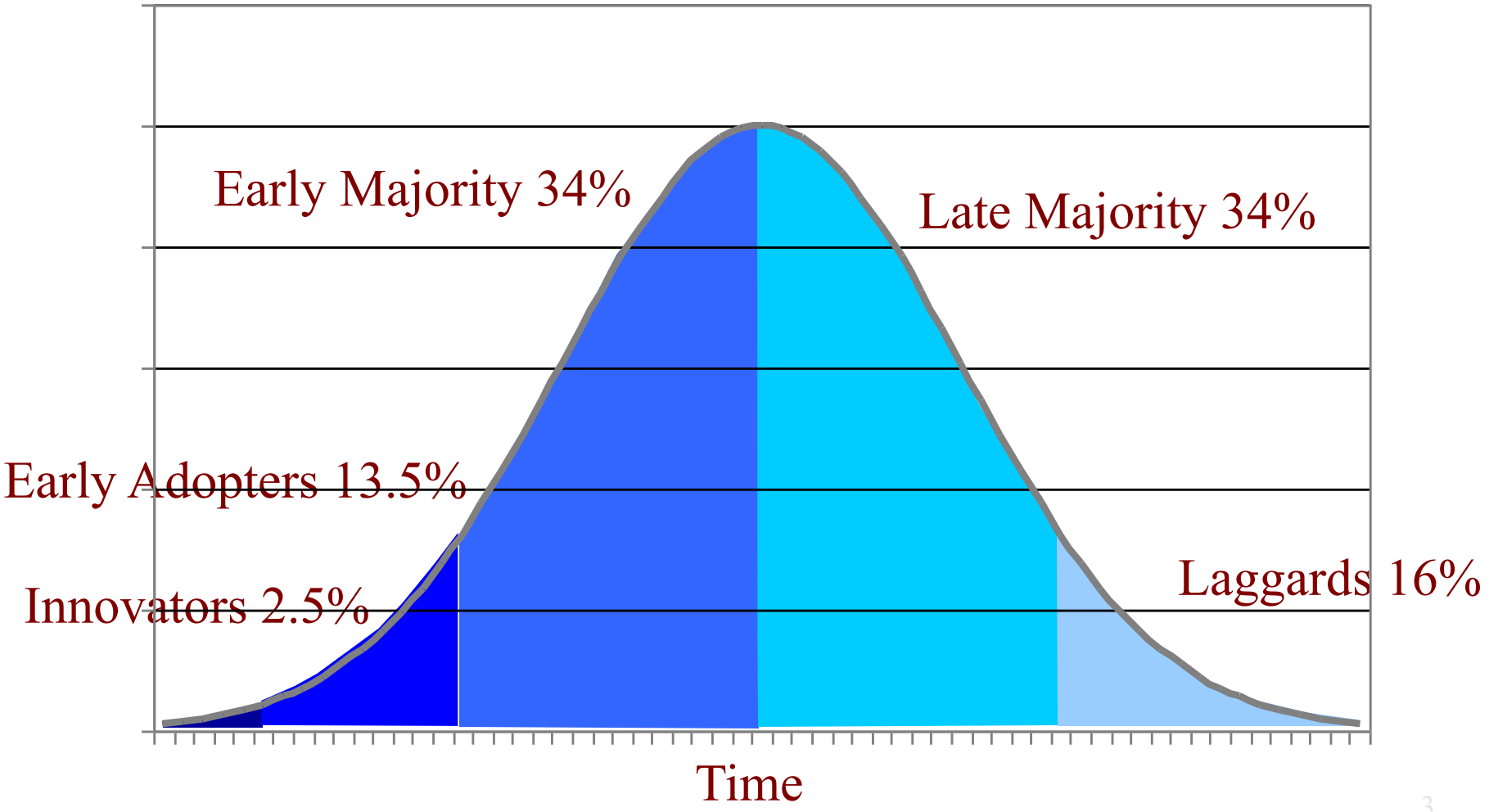
# ISE 599
# Special Topics Applied Predictive Analytics

# Some questions from last time: why is growth S-shaped?

- Stylized story 1: “Everett Rogers”
  - Consumers have different time preferences, e.g., different willingness to pay to have something now.
  - These differences can be captured by a uni-modal distribution
- Stylized story 2: “Frank Bass”
  - Not all consumers are informed about the product.
  - Information flows to potential adopters in proportion to how many already adopted

# Time preferences: “Adoption Time”



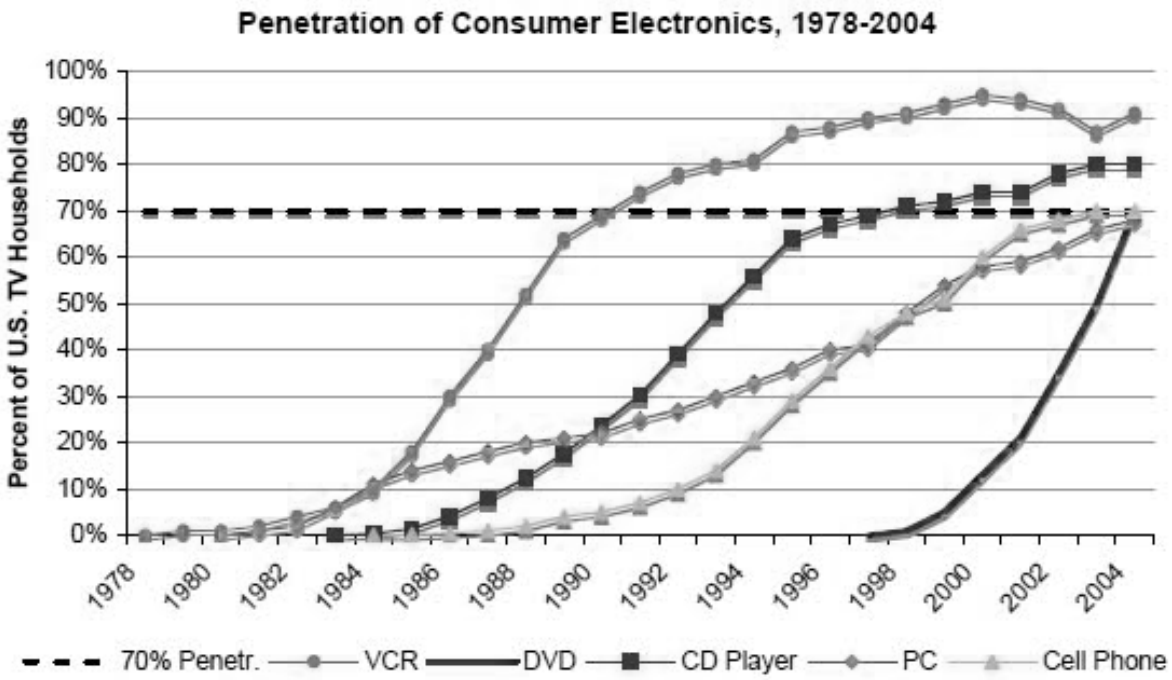
# Adopter Categories

- Innovativeness along the bell curve
  - Innovator - Venturesome (Not a change agent)
  - Early Adopter – Respectable (Not necessarily a good change agent)
  - Early Majority - Deliberate
  - Late Majority - Skeptical
  - Laggards – Traditional

# Attributes of Innovations and Their Rate of Adoption

- Relative Advantage: the degree to which an innovation is perceived as better than what it supersedes.
- Compatibility: the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs.
- Complexity: the degree to which an innovation is perceived as difficult to understand and use.
- Trialability: the degree to which an innovation may be experimented with on a limited basis.
- Observability: the degree to which the results of an innovation are visible to the receiver and others.

# Examples


Penetration of Consumer Electronics, 1978-2004
Percent of U.S. TV Households
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
70% Penetr.
VCR
DVD
CD Player
PC
Cell Phone

# Special interest case: Analyzing sales potential in new markets

- Sales of new innovative products
  - early stages driven by innovators
  - later stages driven by word-of-mouth

# Modeling Framework

- Potential adopters classified into 2 groups
  - innovators
  - imitators
- Key assumptions
  - innovators are not influenced by others in the timing of their initial product purchase
  - imitators are influenced by the number of previous buyers in the timing of their initial product purchase
- Implication
  - the importance of innovators to product sales will be high at first but will diminish with time

# A model specification

- The probability of adoption at time T is given by

$$P(t) = p + q \cdot \left( \frac{Y(t-1)}{m} \right)$$

where

$$p = coefficient\ of\ innovation$$

$$q = coefficient\ of\ imitation$$

$$Y(t-1) = cumulative\ number\ of\ adopters$$

$$m = total\ number\ of\ potential\ adopters$$

# How it works….

- New adoptions at time T equal the probability of adoption times the number of potential adopters who haven't done so already….

$$
\begin{aligned}
S(t) &= P(t)\cdot\left[m - Y(t-1)\right] \\
&= \left[p + q\left(\frac{Y(t-1)}{m}\right)\right]\cdot\left[m - Y(t-1)\right] \\
&= p\cdot\left[m - Y(t-1)\right] + q\left(\frac{Y(t-1)}{m}\right)\cdot\left[m - Y(t-1)\right] \\
&= \text{sales to "innovators "} + \text{sales to "imitators"}
\end{aligned}
$$

# Estimating the model

- Simplify the model to

$$S(T) = a + bY(T-1) + cY^2(T-1)$$

- Run the above regression

$$a = pm$$
$$b = (q - p)$$
$$c = -q/m$$

# Estimating the model

- “Back out” the values of p and q

$$m = \frac{-b - \sqrt{b^2 - 4ac}}{2c}$$

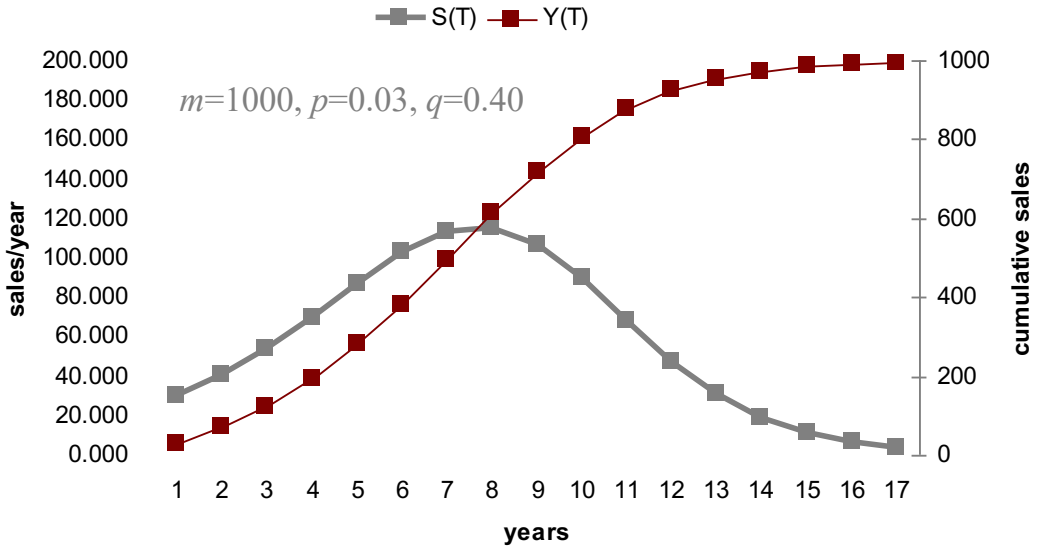
$$p = a/m$$

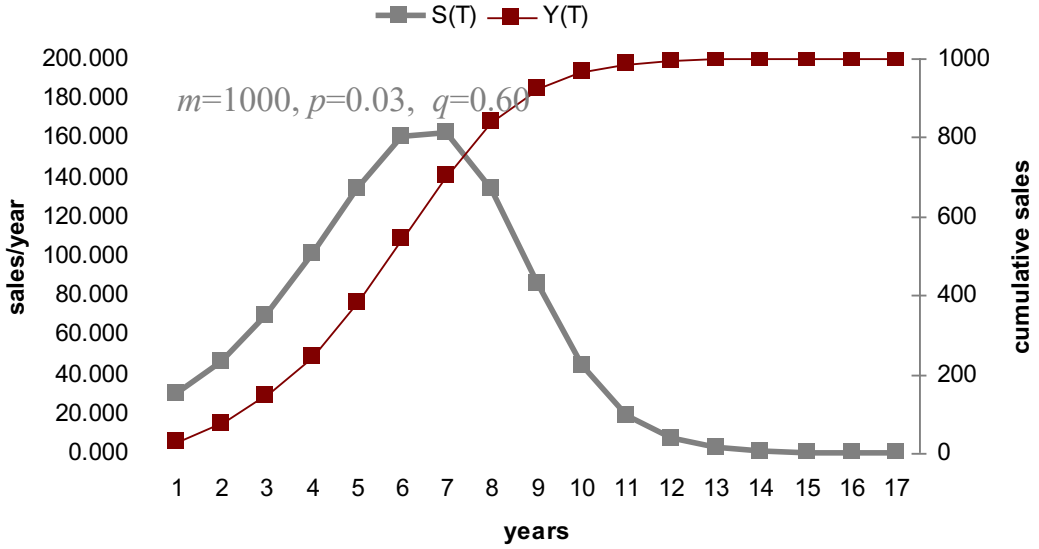
$$q = -mc$$

# Meaning of the p's and the q's

- p and q control the shape of the diffusion curve.
- The coefficient of innovation p
  - high p shifts the adoption curve left
  - low p shifts the adoption curve right
  - p ranges from very near zero to as high as 0.30
  - overall average for p from marketing studies is 0.030
  - industrial durables tend to have lower p's than consumer durables
- the coefficient of imitation, q
  - high q creates a more spiked curve
  - low q flattens the curve
  - q ranges from 0.3 to 0.9
  - overall average for q from marketing studies is 0.4
  - industrial durables tend to have higher q than consumer durables

# Some examples



# Using the model to forecast

- Select analogous products for which a fairly complete diffusion history is available (past the inflection point on the S-curve)
- Obtain the diffusion model parameters p and q for these products
  - previous analyses in marketing (mostly consumer products)
  - regression analysis
- Estimate market potential m for the new innovation
  - management judgement
  - survey research
- conduct scenario analysis
  - for each analogous product plug p, q, and m into the model to obtain an adoption forecast
  - explore sensitivity of forecasts to changes in the three model parameters
  - if there is no best analogous product use an average

# Some products

| *product* | *years* | *p* | *q* | *initial price in real $* |
|---|---|---|---|---|
| B&W TV | 1946-1957 | 0.0159 | 0.4 | 1283 |
| Blender | 1958-1971 | 0.001 | 0.55 | 87 |
| Calculator | 1974-1986 | 0.0294 | 0.12 | 107 |
| Can Opener | 1958-1971 | 0.0135 | 0.3 | 55 |
| Cass.Tape Deck | 1974-1990 | 0.0179 | 0.18 | 377 |
| Color TV | 1954-1970 | 0.0001 | 0.66 | 1734 |
| Curling Iron | 1974-1982 | 0.0399 | 0.3 | 31 |
| Deep Fryer | 1950-1961 | 0.0337 | 0.74 | 79 |
| Digital Watch | 1974-1982 | 0.0204 | 0.41 | 173 |
| Electric Blanket | 1946-1966 | 0.0029 | 0.26 | 148 |
| Elec. Clothes Dryer | 1947-1960 | 0.008 | 0.4 | 669 |
| Electric Toothbrush | 1963-1971 | 0.0826 | 0.13 | 33 |
| Fire Extinguisher | 1975-1982 | 0.0694 | 0.16 | 10 |
| Food Processor | 1978-1984 | 0.0271 | 0.51 | 79 |
| Hair Setter | 1968-1977 | 0.1305 | 0.35 | 50 |
| Heating Pad | 1922-1931 | 0.0274 | 0.26 | 64 |
| Knife Sharpener | 1957-1969 | 0.0655 | 0.5 | 45 |
| Lawn Mower | 1946-1961 | 0.0056 | 0.3 | 403 |
| Microwave Oven | 1970-1989 | 0.0101 | 0.37 | 884 |
| Refrigerator | 1922-1931 | 0.0047 | 0.42 | 2785 |
| Room A/C | 1946-1960 | 0.0031 | 0.43 | 1280 |
| Slow Cooker | 1973-1982 | 0.0654 | 0.32 | 45 |
| Styling Dryer | 1974-1984 | 0.0891 | 0.18 | 32 |
| Trash Compactor | 1972-1982 | 0.0866 | 0.19 | 401 |
| Turntable | 1974-1990 | 0.0577 | 0.21 | 185 |
| VCR | 1976-1990 | 0.0012 | 0.53 | 1808 |
| Waffle Iron | 1922-1931 | 0.0128 | 0.43 | 82 |

# Some products

| Cluster | *product* | *p* | *q* | *initial price in real $* |
|---|---|---|---|---|
| 1 | Electric Toothbrush | 0.083 | 0.22 | 108 |
| | Fire Extinguisher | | | |
| | Hair Setter | | | |
| | Slow Cooker | | | |
| | Styling Dryer | | | |
| | Trash Compactor | | | |
| | Turntable | | | |
| | | | | |
| 2 | Calculator | 0.0249 | 0.27 | 140 |
| | Digital Watch | | | |
| | | | | |
| 3 | Can Opener | 0.0232 | 0.32 | 151 |
| | Cass.Tape Deck | | | |
| | Curling Iron | | | |
| | Electric Blanket | | | |
| | Heating Pad | | | |
| | Knife Sharpener | | | |
| | Lawn Mower | | | |
| | Waffle Iron | | | |
| | | | | |
| 4 | B&W TV | 0.0141 | 0.48 | 623 |
| | Blender | | | |
| | Deep Fryer | | | |
| | Elec. Clothes Dryer | | | |
| | Food Processor | | | |
| | Microwave Oven | | | |
| | Room A/C | | | |
| | | | | |
| 5 | Color TV | 0.002 | 0.54 | 2109 |
| | Refrigerator | | | |
| | VCR | | | |

# Summary

- Theory of diffusion
- Application to new product adoption
- A forecasting approach based on prediction adoption