Introduction to Choice Models

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Outline

Modeling behavior

- Individual behavior (vs. aggregate behavior)
- Theory of behavior which is:
  - mostly descriptive and not too prescriptive: how people behave and not how they should;
  - general: not too specific;
  - operational: can be used in practice for forecasting.
- Type of behavior: discrete choice, i.e. what is observed is a discrete action

Motivations

Field :

- Marketing
- Transportation
- Politics
- Management
- New technologies
- Finance
- Health
- etc.

Type of behavior:

- Choice of a brand
- Choice of a transportation mode
- Choice of a representative
- Choice of a management policy
- Choice of investments
- Choice of portfolios of assets
- Choice of treatment

Importance

Daniel McFadden

- UC Berkeley 1963, MIT 1977, UC Berkeley 1991;
- Laureate of *The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 2000;*
- Owns a farm and vineyard in Napa Valley;
- "Farm work clears the mind, and the vineyard is a great place to prove theorems".

Simple example

Travel Information System (TIS):

- What is the market penetration?
- How will the penetration change in the future?
- Assumption: level of education is an important explanatory factor.

Data collection:

- Sample of 600 persons, randomly selected;
- Two questions:
  1. Do you subscribe to a travel information system? (yes/ no)
  2. How many years of education have you had? (low/ medium/ high)

Simple example (cont.)

- Contingency table

	Education			
TIS	Low	Medium	High	
Yes	10	100	120	230
No	140	200	30	370
	150	300	150	600

- Penetration in the sample: $230/600 = 38.3\%$
- Forecasting: need for a model

Example: A model

- Dependent variable:

$$y = \begin{cases} 1 & \text{if subscriber} \\ 2 & \text{if not subscriber} \end{cases}$$

Discrete dependent variable

- Independent or explanatory variable

$$x = \begin{cases} 1 & \text{if level of education is low} \\ 2 & \text{if level of education is medium} \\ 3 & \text{if level of education is high} \end{cases}$$

Example: Probabilities

Marginal probability

- frequency of subscribing in the population
- $\hat{p}(y=1) = 10/600 + 100/600 + 120/600 = 0.383$
- Market penetration in population: $p(y=1)$ inferred from sample market penetration $\hat{p}(y=1)$

Joint probability

- frequency of subscribing and medium level of education
- $\hat{p}(y=1, x=2) = 100/600 = 0.1667$

Conditional probabilities

- frequency of subscribing among people with medium level of education
- $\hat{p}(y=1|x=2) = \hat{p}(y=1, x=2)/\hat{p}(x=2) = 0.167/0.5 = 0.33$

Example: Probabilities (cont.)

Similarly, we obtain:

$$\begin{aligned} \hat{p}(y=1|x=1) &= 0.067 \\ \hat{p}(y=1|x=2) &= 0.333 \\ \hat{p}(y=1|x=3) &= 0.8 \end{aligned}$$

We assume a causal relationship.

Interpretation$\rightarrow$ level of education explains subscription propensity

- Behavioral model: $\hat{p}(y=i|x=j)$
- Forecasting assumption: stable over time

Example: Forecasting

- Model:

$$\begin{aligned} p(y=1|x=1) &= \pi_1 = 0.067 \\ p(y=1|x=2) &= \pi_2 = 0.333 \\ p(y=1|x=3) &= \pi_3 = 0.8 \end{aligned}$$

  where π_1, π_2, π_3 are estimated parameters.

- Assumption: future split of levels of education: 10%, 60%, 30%

Q: What is the future uptake of TIS ?

$$\begin{aligned} p(y=1) &= \sum_{j=1}^{3} p(y=1|x=j)p(x=j) \\ &= 0.1\pi_1 + 0.6\pi_2 + 0.3\pi_3 \\ &= 44.67\% \end{aligned}$$

Example: Forecasting (cont.)

- If the level of education increases
  - from 25%, 50%, 25% to 10%, 60%, 30%,
- The market penetration of TIS will increase
- From 38.33 % to 44.67%.

In summary:

- $p(x = j)$ can be easily obtained and forecasted;
- $p(y = i|x)$ is the behavioral model to be developed.

Model assessment

Informal checks

- Do these estimates make sense?
- Do they match our a priori expectations?
- Here: as years of education increases, there is a higher propensity to subscribe to a travel information system.

Quality of the estimates

- How is $\hat{\pi}$ different from π ?
- We have no access to π
- For each sample we would obtain a different $\hat{\pi}$

Bibliography

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