ARE213 **Econometrics**

Spring 2006 UC Berkeley Department of Agricultural and Resource Economics

Discrete Response Models V:
McFadden's Conditional Logit Model for Gas/Electric Dryer Purchases

McFadden (1982) is interested in analyzing the choice by households to purchas an electric dryer, a gas dryer or no dryer at all. He uses a conditional logit model. The starting point is a indirect utility function that depends on the operating and capital cost of the device and interactions of the indicators for the choices with some individual characteristics.

The utility for the electric dryer for household i is

$$U_{i,elec} = \beta_{0,elec} + \beta_{1,elec} \cdot \text{own}_i + \beta_{2,elec} \cdot \text{persons}_i + \beta_{3,elec} \cdot \text{gasav}_i$$

$$+\beta_{oper} \cdot \text{elec} - \text{oper}_i + \beta_{cap} \cdot \text{elec} - \text{cap}_i + \varepsilon_{i,elec}.$$

The utility for the gas dryer for household i is

$$U_{i,gas} = \beta_{0,gas} + \beta_{1,gas} \cdot \text{own}_i + \beta_{2,gas} \cdot \text{persons}_i + \beta_{3,gas} \cdot \text{gasav}_i$$

$$+\beta_{oper} \cdot \text{gas} - \text{oper}_i + \beta_{cap} \cdot \text{gas} - \text{cap} + \varepsilon_{i,gas}.$$

The utility for no dryer for household i is

$$U_{i,no} = \beta_{0,no} + \beta_{1,no} \cdot \text{own}_i + \beta_{2,no} \cdot \text{persons}_i + \beta_{3,no} \cdot \text{gasav}_i + \varepsilon_{i,no}.$$

(The operating and capital cost of no dryer are assumed to be zero by McFadden. He probably has not done much handwashing.) McFadden assumes that the three disturbances are independent, and identically distributed with extreme value distribution with cdf

$$F(\varepsilon) = \exp(-\exp(-\varepsilon)).$$

Household i chooses the electric dryer if

$$U_{i,elec} = \max(U_{i,elec}, U_{i,gas}, U_{i,no}),$$

and similarly for the other options.

Define

$$U^*_{i,elec} = \beta_{0,elec} + \beta_{1,elec} \cdot \text{own} + \beta_{2,elec} \cdot \text{persons} + \beta_{3,elec} \cdot \text{gasav}$$

$$+\beta_{oper} \cdot \text{elec}_\text{o}\text{per} + \beta_{cap} \cdot \text{elec}_\text{c}\text{ap},$$

and similarly $U^*_{i,gas}$ and $U^*_{i,no}$. The implication of the model is that the probability of buying an electric dryer is

$$\Pr(elec) = \frac{\exp(U^*_{i,elec})}{\exp(U^*_{i,elec}) + \exp(U^*_{i,gas}) + \exp(U^*_{i,no})},$$

and similarly

$$\Pr(gas) = \frac{\exp(U^*_{i,gas})}{\exp(U^*_{i,elec}) + \exp(U^*_{i,gas}) + \exp(U^*_{i,no})},$$

$$\Pr(no) = \frac{\exp(U^*_{i,no})}{\exp(U^*_{i,elec}) + \exp(U^*_{i,gas}) + \exp(U^*_{i,no})}.$$

From data on the operating and capital cost, and the individual characteristics we cannot identify all parameters. Suppose we subtract an individual specific, choice-invariant c_i from $U_{i,elec}$, $U_{i,gas}$, and $U_{i,no}$. That would not change the ranking, so we cannot tell that apart from the original model. So, choose

$$c_i = -\beta_{0,gas} - \beta_{1,gas} \cdot \text{own} - \beta_{2,gas} \cdot \text{persons} - \beta_{3,gas} \cdot \text{gasav}.$$

That would amount to fixing in the original model $\beta_{0,gas} = \beta_{1,gas} = \beta_{2,gas} = \beta_{3,gas} = 0$.

Table 1: Conditional Logit Estimates (McFadden, 2982)

variable	variable name in paper	coeff
choic specific covariates		
Operating cost for dryer	CDOPCOST	-0.0144
Capital cost for dryer	CDCPCOST	-0.0160
Individual specific (choice-invariant) covariates		
Gas available electric	GASAV1	-1.27
House owner, electric	OWN1	-0.60
Number of people in household, electric	PERSONS1	0.075
Intercept, electric	C1	2.10
Gas available, no dryer	GASAV3	-1.56
House owner, no dryer	OWN3	-1.59
Number of people in household, no dryer,	PERSONS3	-0.40
Intercept, no dryer,	C3	0.02

McFadden's estimates are given in Table 1.

Even more than in the binary logit and probit models these coefficients are difficult to interpret. So instead McFadden reports some elasticities. For example consider the elasticity of the probability of buying an electric dryer with respect to the operating cost of an electric dryer:

$$\epsilon_{elec,elec-oper} = \frac{\partial \Pr(elec)}{\partial \text{elec} - \text{oper}} \cdot \frac{\text{elec} - \text{oper}}{\Pr(elec)}.$$

This elasticity will depend on the values of the covariates. We will evaluate the elasticities at the means of the variables, given in Table 2.

The derivative of the probability of buying an electric dryer with respecti to the operating

Table 2: MEANS

variable	electric	gas	no
CHOICE	0.447	0.235	0.318
CDOPCOST	31.17	7.56	0
CDCPCOST	233.20	258.80	0
GASAV	0.719		
OWN	0.873		
PERSONS	3.31		

cost of an electric dryer is

$$\frac{\partial \Pr(elec)}{\partial \text{elec} - \text{oper}} = \beta_{oper-cost} \cdot \frac{\exp(U^*_{i,elec})}{\exp(U^*_{i,elec}) + \exp(U^*_{i,gas}) + \exp(U^*_{i,no})}$$

$$-\beta_{oper-cost} \cdot \left(\frac{\exp(U^*_{i,elec})}{\exp(U^*_{i,elec}) + \exp(U^*_{i,gas}) + \exp(U^*_{i,no})} \right)^2 .$$

Evaluate this at the parameter estimates in Tabel 1, and at the means of the covariates given in Tabel 2 and you get -0.0036. So, the derivative of the probability of buying an electric dryer with respect to the operating cost of an electric dryer, at the means of the covariates is equal to -0.0036. The probability of buying an electric dryer at the covariate means is 0.5116. The average operating cost for an electric dryer is 31.17. Thus, the elasticity is

$$\epsilon_{elec,elec-oper} = \frac{\partial \Pr(elec)}{\partial \text{elec} - \text{oper}} \cdot \frac{\text{elec} - \text{oper}}{\Pr(elec)} = -0.0036 \cdot \frac{31.17}{0.5516} = -0.22.$$

The elasticitiy for the probability of buying a gas dryer with respect to the operating cost of an electric dryer is 0.23. The elasticitiy for the probability of buying nor with respect to the operating cost of an electric dryer is 0.23. This is identical to the elasticity for the gas dryer by the IIA property of the conditional logit model.

Note that we could have considered the average elastiticies, by averaging the elasticity evaluated at each set of values of the covariates. However, that information is not available

from the paper, and it is likely to be very similar to the elasticities evaluated at the average values for the covariates.

References

McFadden, D., (1982), "Qualitative Response Models," in Hildenbrand (ed.), *Advances in Econometrics*, Econometric Society Monographs, Cambridge University Press.