Statistical and Econometric Methods for Transportation Data Analysis

Chapter 16 – Random Parameter Models

Example 16.1
Mixed Logit Analysis

You are given accident, evirnomental, traffic, and roadway geometric data from 275 segments of highway in Washington State. The data are from 1990. The injury data consist of three possible outcomes: no injury, possible injury, injury. Your task is to estimate a mixed logit model of these three possible discrete outcomes.

The mixed logit model allows for parameter variations across roadway segments (i.e. variations in $\boldsymbol{\beta}$), a mixing distribution is introduced giving injury-severity proportions (see Train 2003),

$$P_{in} = \int \frac{EXP\left[\boldsymbol{\beta}_i X_{in}\right]}{\sum_I EXP\left[\boldsymbol{\beta}_i X_{In}\right]} f\left(\boldsymbol{\beta} \mid \varphi\right) d\boldsymbol{\beta}$$

where $f(\boldsymbol{\beta} \mid \boldsymbol{\varphi})$ is the density function of $\boldsymbol{\beta}$ with $\boldsymbol{\varphi}$ referring to a vector of parameters of the density function (mean and variance), and all other terms are as previously defined. Equation 3 is the formulation for the mixed logit model. For model estimation, $\boldsymbol{\beta}$ can now account for segment-specific variations of the effect of $\boldsymbol{X}$ on injury-severity proportions, with the density function $f(\boldsymbol{\beta} \mid \boldsymbol{\varphi})$ used to determine $\boldsymbol{\beta}$. Mixed logit proportions are then a weighted average for different values of $\boldsymbol{\beta}$ across roadway segments where some elements of the vector $\boldsymbol{\beta}$ may be fixed and some may randomly distributed. If the parameters are random, the mixed logit weights are determined by the density function $f(\boldsymbol{\beta} \mid \boldsymbol{\varphi})$. Most studies have used a continuous form of this density function in model estimation (such as a normal distribution) and this is what you are to use.

In your specification, consider random variable possibilities including constant or fixed (C), normally distributed (N) and log-normally distributed (L).

1. The results of your best model specification.

2. A discussion of the logical process that led you to the selection of your final specification (the theory behind the inclusion of your selected variables). Include *t*-statistics and justify the signs of your variables.

Variables available for your specification are (in file Ex16-1.txt):

Variable Number	**Explanation**
ID	Segment ID number
FREQ	Number of accidents
ROUTE	Route Number
LENGTH	Segment length in miles
INCLANES	Number of lanes in increasing milepost direction
DECLANES	Number of lanes in decreasing milepost direction
WIDTH	Total combined width of all lanes
MIMEDSH	Minimum median shoulder in feet
MXMEDSH	Maximum median shoulder in feet
SPEED	Speed limit (mi/h)
URB	Indicates urban area (1=yes, 0=no)
FC	Functional class (1=local, 2=collector, 3=arterial, 4=principal arterial, 5=interstate)
AADT	Average Annual Daily Traffic
SINGLE	Daily percentage of single unit trucks
DOUBLE	Daily percentage of tractor and trailer trucks
TRAIN	Daily percentage of tractor and two-trailer trucks
PEAKHR	Percent of daily traffic in the peak hour
GRADEBR	Number of grade breaks in the segment
MIGRADE	Minimum grade in the segment
MXGRADE	Maximum grade in the segment
MXGRDIFF	Maximum grade difference in the segment
TANGENT	Tangent length in the segment
CURVES	Number of cureves in the segment

MINRAD	Minimum radius in feet
ACCESS	Segment access control (0=none, 1=partial, 3=full)
MEDWIDTH	Median width (1=less than 30ft; 2=30 to 40ft; 3=40 to 50ft; 4=50 to 60ft to 5=high)
FRICTION	Friction value (0 to 100 with 100 being high)
ADTLANE	Average daily travel per lane
SLOPE	Segment slope (0=flat, 1=slight, 2=medium, 3=high)
INTECHAG	Indicates number of interganges in the segment
AVEPRE	Average precipitation per month in inches
AVESNOW	Average snowfall per month in inches

```
--> read;nvar=32;nobs=825;names=
    ID,INJFREQ,ROUTE,LENGTH,INCLANES,DECLANES,WIDTH,MIMEDSH,
    MXMEDSH,SPEED,URB,FC,AADT,
    SINGLE,DOUBLE,TRAIN,PEAKHR,GRADEBR,MIGRADE,MXGRADE,MXGRDIFF,
    TANGENT,CURVES,MINRAD,ACCESS,MEDWIDTH,
    FRICTION,ADTLANE,SLOPE,
    INTECHAG,AVEPRE,AVESNOW;
    FILE=D:Ex16-1.txt$
--> create;laneadt=aadt/(inclanes+declanes)$
--> create;lnlanadt=log(laneadt)$
--> create;lnaadt=log(aadt)$
--> create;density=laneadt/length$
--> create;if(friction<=30)lowfri=1$
--> create;if(friction>30&friction<50)medfri=1$
--> create;if(friction>=50)hifri=1$
--> create;curvmile=curves/length$
--> create;if(curvmile<=0.5)lowcvmil=1;(else)lowcvmil=0$
--> create;if(curvmile>0.5&curvmile<=2.5)medcvmil=1;(else)medcvmil=0$
--> create;if(curvmile>2.5)hicvmil =1;(else)hicvmil=0$
--> create;truck=single+double+train$
--> create;pcttruck=truck/aadt$
--> create;if(medwidth=1)med030=1$
--> create;if(medwidth=2)med3040=1$
--> create;if(medwidth=3)med4050=1$
--> create;if(medwidth=4)med5060=1$
--> create;if(medwidth=5)med60=1$
--> create;if(speed<=50)speed1=1$
--> create;if(speed<=55)speed2=1$
--> create;if(speed>55)speed3=1$
--> create;if(speed>=55)speed4=1$
--> create;if(fc=1)local=1$
--> create;if(fc=5)intstate=1$
--> create;if(access=0)none   =1$
--> create;if(access=1)partial=1$
--> create;if(access=2)full   =1$
--> create;if(slope=0)flat=1$
--> create;if(slope=1)slight=1$
--> create;if(slope=2)medium=1$
--> create;if(slope=0 |slope= 1)slpflat=1;(else)slpflat=0$
--> create;if(slope=2)slpmed=1;(else)slpmed=0$
--> create;if(avepre<=1.5)lowpre=1;(else)lowpre=0$
--> create;if(avepre>1.5&avepre<=2.5)medpre=1;(else)medpre=0$
--> create;if(avepre>2.5)hipre=1;(else)hipre=0$
--> create;if(avesnow<=1)norsnow=1$
--> create;if(avesnow>1)hisnow=1$
--> create;lanewid=(inclanes+declanes)/width$
--> dstat;rhs=lanewid$
Descriptive Statistics
All results based on nonmissing observations.
================================================================================
Variable        Mean          Std.Dev.        Minimum         Maximum      Cases
================================================================================
--------------------------------------------------------------------------------
All observations in current sample
--------------------------------------------------------------------------------
LANEWID   .809060949E-01  .643688046E-02  .392156863E-01  .869565217E-01    825

--> create;if(lanewid<12)nlanwid=1;(else)nlanwid=0$
--> create;if(lanewid>12)wlanwid=1;(else)wlanwid=0$
--> create;intmi=intechag/length$
--> create;gbmile=gradebr/length$
```

```
--> nlogit;lhs=injfreq;
    choices=pdo,pinj,inj;
    model:
    U(pdo)=a0+a1*laneadt+a3*minrad/
    U(pinj)=b0+b2*truck/
    U(inj)=c3*friction+c2*intmi+c1*gbmile
    ;fcn=a0(c),a1(c),a3(N),
    b0(c),b2(N),c2(n),c3(c),c1(N);rpl;frequencies;parameter;pts=200,halton$
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Start values obtained using nonnested model |
| Maximum Likelihood Estimates                |
| Model estimated: Sep 14, 2010 at 11:06:53AM.|
| Dependent variable               Choice     |
| Weighting variable                 None     |
| Number of observations              258     |
| Iterations completed                  5     |
| Log likelihood function       -4485.876     |
| R2=1-LogL/LogL*  Log-L fncn  R-sqrd  RsqAdj |
| No coefficients  -5116.2374  .12321  .10233 |
| Constants only.  Must be computed directly. |
|                  Use NLOGIT ;...; RHS=ONE $ |
| Chi-squared[ 6]           =    111.53902     |
| Prob [ chi squared > value ] =   .00000     |
| Response data are given as frequencies.     |
| Number of obs.=   275, skipped  17 bad obs. |
+---------------------------------------------+
+---------+--------------+----------------+--------+---------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] |
+---------+--------------+----------------+--------+---------+
 A0            2.11216686      .38393093     5.501   .0000
 A1           .690742D-05    .479817D-05     1.440   .1500
 A3          -.125860D-04    .598640D-05    -2.102   .0355
 B0            1.73119412      .37948435     4.562   .0000
 B2            -.05631942      .00690283    -8.159   .0000
 C2            -.11618126      .07426145    -1.564   .1177
 C3             .02623092      .00746039     3.516   .0004
 C1            -.02657617      .02626467    -1.012   .3116


Normal exit from iterations. Exit status=0.
+---------------------------------------------+
| Random Parameters Logit Model               |
| Maximum Likelihood Estimates                |
| Model estimated: Sep 14, 2010 at 11:09:57AM.|
| Dependent variable              INJFREQ     |
| Weighting variable                 None     |
| Number of observations              825     |
| Iterations completed                 30     |
| Log likelihood function       -4440.983     |
| Restricted log likelihood     -5116.237     |
| Chi squared                    1350.508     |
| Degrees of freedom                   12     |
| Prob[ChiSqd > value] =         .0000000     |
| R2=1-LogL/LogL*  Log-L fncn  R-sqrd  RsqAdj |
| No coefficients  -5116.2374  .13198  .11132 |
| Constants only.  Must be computed directly. |
|                  Use NLOGIT ;...; RHS=ONE $ |
| At start values  -4485.8756  .01001 -.01356 |
| Response data are given as frequencies.     |
+---------------------------------------------+
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+--------------------------------------------+
| Random Parameters Logit Model              |
| Replications for simulated probs. = 200    |
| Number of obs.=   275, skipped  17 bad obs. |
+--------------------------------------------+
+---------+--------------+----------------+--------+---------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] |
+---------+--------------+----------------+--------+---------+
         Random parameters in utility functions
 A0           2.63055229      .57514058     4.574   .0000
 A1          .113482D-04    .724898D-05     1.565   .1175
 A3          .188581D-04    .276536D-04      .682   .4953
 B0           2.73068134      .64190615     4.254   .0000
 B2           -.13353509      .03899427    -3.424   .0006
 C2          -1.26570151      .34650281    -3.653   .0003
 C3            .04349874      .01148259     3.788   .0002
 C1           -.17878575      .08955385    -1.996   .0459
         Derived standard deviations of parameter distributions
 CsA0            .000000   .....(Fixed Parameter).....
 CsA1            .000000   .....(Fixed Parameter).....
 NsA3          .00044556      .00010979     4.058   .0000
 CsB0            .000000   .....(Fixed Parameter).....
 NsB2          .10031812      .03522847     2.848   .0044
 NsC2         2.27834370      .51217501     4.448   .0000
 CsC3            .000000   .....(Fixed Parameter).....
 NsC1          .31433085      .16756988     1.876   .0607
```