A Latent Markov Model for the Analysis of Longitudinal Data collected in Continuous Time: States, Durations, and Transitions

Ulf Böckenholt
McGill University

Supplemental Material for Psychological Methods

Website

SAS Proc IML Program for CT-LM Model

The following Proc IML code (SAS Institute, 2004) defines the log–likelihood function for the CT–LM model presented in Application I. The log–likelihood function can be maximized with any non–linear SAS optimization routines. For example, "NLPQN"–subroutine is well–suited for estimating the parameters of the CT–LM model.

```
start LM(x); dt= {1 1 1 1 487,
 1 1 1 2  35,
 1 1 2 1  27,
 1 1 2 2   6,
 1 2 1 1  39,
 1 2 1 2  11,
 1 2 2 1   9,
 1 2 2 2   7,
```

```
 2 1 1 1  50,
 2 1 1 2  11,
 2 1 2 1   9,
 2 1 2 2   9,
 2 2 1 1  16,
 2 2 1 2   9,
 2 2 2 1   8,
 2 2 2 2  19};
 sb=dt[,1:4];              /* data matrix */
 nt=ncol(sb); rn=nrow(sb); /* number of columns and rows of data matrix */
 nn=dt[,5];                /* frequency vector of binary observations*/
 d={1,1,1,1};              /* time differences between observation; here
                              the observations are spaced equally in time*/
 pnn=J(rn,1,0);            /* initialize probability vector*/
 cl=2;                     /* number of states*/

/* response probabilities of states */ ps=exp(J(cl,1,0)||x[{1
2}]); ps=ps/(ps[,+] # J(cl,cl,1));

/* intial state-specific probabilities */ w=exp(0//x[5]);
w=w/w[+];

/* transition rate matrix */ y=exp(x[{3 4}]);
q=(-y[1]||y[1])//(y[2]||-y[2]);

/*eigenvalue and eigenvector decomposition */ call eigen(ea,ev,q);

/* compute probability of observations under the CT-LM model*/ DO
j=1 to rn; ss=ps[,sb[j,1]] # I(cl); DO i=2 TO nt; eea=exp(ea #
d[i-1]) # I(cl); p = ev * eea * inv(ev); ss = ss * p *
(ps[,sb[j,i]] # I(cl)); end; pnn[j,1]=w‘ * ss * J(cl,1,1); end;

/* log-likelihood function to be maximized */ f=nn # log(pnn);
f=f[+]; return(f); finish LM;
```