Panel Data and Multilevel Models for Categorical Outcomes: Discrete Time Methods for the Analysis of Event histories

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Often, we are interested not only in whether an event occurs, but how quickly it happens (if at all). What factors speed up or delay death? Why do some friendships last longer than others? What causes some conflicts to be resolved quickly, while others drag on for years or even decades? Why do some individuals get tenure sooner than do others? Why do some people marry at young ages while others wait until they are much older?

Stata has a whole manual and suite of commands devoted to Survival Time Analysis. As Allison (1982, 1984; 2014; see exact citations later) points out, however, in some situations basic logistic regression techniques can be used. He refers to such approaches as *Discrete Time Methods for the Analysis of Event Histories*. To use such methods, you have to have Panel Data, e.g. repeated measures on the same individuals collected at multiple points in time on a regular basis, such as annually. At each time point, the dependent variable of interest is either coded 0 (the event has not happened yet) or 1 (the event occurred during the current interval, although you may not know exactly when). *After the event occurs no additional records are included for that case*. The coefficients for the logistic regression then tell you what factors speed up or slow down the pace at which the event in question occurs.

Allison explains how his procedure addresses problems that would be difficult to deal with via conventional regression techniques. First, the event may not occur (if it occurs at all) until after the data collection has ended; that is, the data may be *right censored*. (Somewhat more problematic is *left-censoring*, e.g. you don't know when exposure to risk began. For example, you might not know when a friendship or marriage started or when a person began an academic career. Still, Allison offers some ideas on what to do.) Second, his method allows the use of *time-varying covariates*, i.e. independent variables whose values change across time. For example, if somebody suddenly starts publishing more papers, that could speed up the rate at which they get tenure; or if they start smoking they might die more quickly. I will give two examples that illustrate the strategy.

Example 1. Allison (1999) analyzes a data set of 301 male and 177 female biochemists. The units of analysis are person-years rather than persons. Each person has one record for each year they were an assistant professor, for up to ten years; once a person achieves tenure no further records are added. This results in 1,741 person-years for men and 1,056 person-years for women. The dependent variable in his analysis, tenure, is promotion to associate professor, coded 1 if the person was promoted in that year, 0 otherwise. For the independent variables, year is the number of years since the beginning of the assistant professorship, yearsq is years squared, select is a measure of the selectivity of the colleges where scientists received their bachelor's degrees, articles is the cumulative number of articles published by the end of each person-year, and prestige is a measure of prestige of the department in which scientists were employed. The primary substantive interest of the analysis is whether the determinants of tenure differ for men (group 0) and women (group 1). Here is how we can conduct an EHA with these data.

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. use https://www3.nd.edu/~rwilliam/statafiles/xtenure, clear
(Gender differences in receipt of tenure (Scott Long 06Jul2006))
. quietly logit tenure i.female year c.year#c.year select articles prestige
. est store baseline
. quietly logit tenure i.female year c.year#c.year select articles prestige
i.female#c.articles
. est store interaction
. est tab baseline interaction, b(%7.4f) star

----------------------------------------
    Variable |  baseline    interact~n
-------------+--------------------------
      female |
      Female | -0.3538**     0.0100
             |
        year |  1.7232***    1.7201***
             |
      c.year#|
      c.year | -0.1253***   -0.1253***
             |
      select |  0.1544***    0.1521***
    articles |  0.0548***    0.0722***
    prestige | -0.4136***   -0.3935***
             |
      female#|
  c.articles |
      Female |              -0.0375*
             |
       _cons | -6.8127***   -7.0004***
----------------------------------------
legend: * p<0.05; ** p<0.01; *** p<0.001
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Several things stand out. The baseline model shows that women receive tenure more slowly than do men. The longer you have been an assistant professor, the more likely you are to receive tenure soon. Those at more prestigious universities receive tenure more slowly, while those who went to a more selective undergraduate institution get tenure faster. Not surprisingly, the more articles someone publishes, the more quickly they get tenure.

Perhaps the most concerning result from the baseline model is that women get tenure more slowly than men. This concern gets amplified in the 2nd model, when we add an interaction for female * articles. The coefficients suggest that each article published helps women only half as much as it did men. Does this reflect discrimination against women? Do we need additional measures, such as indicators of paper quality? Do women face obstacles not measured here, such as family-unfriendly workplaces? Those questions are not answered here, but the results do suggest the need for more study.

Having said that, there has been a lot of controversy over whether the above models are valid. If interested, see https://www3.nd.edu/~rwilliam/oglm/index.html for an extended discussion.

Example 2. The rest of this handout actually consists of of references to the classic 1987 ASR paper, *The Stability of Students' Interracial Friendships*, by Maureen Hallinan and Richard Williams. Alas, I was apparently less well organized 30+ years ago, and I can't find any of the original materials or data sets. If I can ever find the data I will try to rework some of these analyses, but if not we'll just have to trust my much younger self.

Excerpts from “The Stability of Students’ Interracial Friendships”, by Maureen Hallinan and Richard Williams

In 1976-77, a large, longitudinal data set was obtained from 1,477 students in 48 classes in six public and four private schools in northern California. The sample contains 229 black students and 226 non-black students. The students were given a sociometric questionnaire six times during the school year at approximately six-week intervals. The students were given a list of their classmates and, next to each name, were the categories: "Best Friend”, "Friend", "Know", "Don't Know", and "My Name". They were asked to circle the appropriate category for each student and encouraged to name as many best friends and friends as they wished.

To examine the determinants of interracial friendship stability, a dyadic-level analysis is required. In each dyad, P is designated the chooser and O the student who can be chosen. We examine those dyads in which P chooses 0 as Best Friend at some time during the course of the school year. Our interest is the stability of that choice. The dependent variable for the descriptive analysis in Table 2 is the termination of P's choice of O (Dissol), coded as unity if the friendship dissolved and zero if the friendship continued. The dependent variable is the same for the inferential analyses reported in Tables 3, 4, and 5, except that coding is reversed (1 = continuation, 0 = dissolution) to facilitate interpretation of parameter estimates. The best friend choices are used instead of the weaker friend choices because the latter are likely to contain more response error.

To obtain the dyadic-level data file for the analysis, records were created for all possible dyadic combinations of students within each of the 16 classrooms. Each dyad is included in the sample twice; in the first case, one member of the dyad is designated as ***P,*** the chooser, and the other member as *0,* the person chosen. In the second case, the chooser and chosen designation is reversed. This redundancy is necessary because friendship choices need not be mutual. To prevent standard errors from being inflated, each dyad is weighted by one-half in the inferential analysis.

Analyzing the stability of dyadic friendship choices is not straightforward. It is tempting to do a conventional regression analysis in which the observed duration of the friendship is the dependent variable. However, Allison (1984) has outlined a number of reasons why such a strategy is inappropriate for individual-level data. The basic problems are the same for dyadic-level data.

First, the ultimate duration of a friendship choice is not known for choices that were still in existence at the end of the school year. These observations are said to be "right-censored." Simply using the observed duration clearly underestimates the true duration and can produce substantial biases. Further, it has been shown that excluding the censored observations is also highly problematic (Sorensen 1977; Tuma and Hannan 1978).

Second, even during the school year, it is not known exactly when the friendship choices began or ended. Only the status of the friendship at each of the six observational periods is known. Assumptions of methods that require precise interval-level measurement may be violated.

Third, the values of some explanatory variables of interest can change across time (e.g., whether or not both members of the dyad are in the same reading group, or whether or not friendship choices are reciprocated). Changes in the values of variables might affect the stability of the friendship choice. Conventional regression techniques do not provide any convenient means of incorporating time-varying explanatory variables in the analysis.

Finally, many of the dyads are not only right-censored, but left-censored as well. Over half of the friendship choices already existed by the first observational period. These choices were made either extremely early in the school year or before school begun, but it is impossible to tell exactly when. Thus, again, the true value of duration is not known. Further, it seems reasonable to suspect that friendship choices made prior to the school year may differ substantially from those formed during it.

Allison (1982, 1984) has proposed a technique for dealing with the first three of these problems. The strategy treats each discrete time unit for each dyad as a separate observation or unit of analysis. If the friendship choice ended after four time periods, four different observations would be created. On the first three observations, dissolution would be coded 0 while on the last observation it would be coded unity. Time periods in which the friendship choice did not yet exist, was just being reported for the first time, or after the friendship choice had already terminated, are excluded from the analysis because the friendship choice was not at risk of dissolving at those times. Explanatory variables for each of these new observations are assigned whatever values they had at that particular unit of time. The final step is to pool the observations and compute maximum likelihood estimates for the logistic regression model.

Allison's technique addresses each of the first three concerns we presented. Dyads in which duration of a friendship choice is censored contribute exactly what is known about them – that the friendship choice did not end in any of the time periods in which they were observed. The method does not require that the duration be precisely measured; simply knowing the status of the friendship choice at each of the different observational periods is sufficient. Time-varying explanatory variables are easily incorporated into the analysis because each six-week interval the friendship choice is at risk is treated as a distinct observation.

The final problem of left-censoring is not so easily dealt with. One approach is to simply discard the initially censored intervals (Allison 1984). However, an examination of differences between friendship choices formed before the school year and those formed during it may be of interest. Therefore, we perform analyses on the total sample and separate analyses for the left-censored and non-left-censored observations.

Since there are only two possible outcomes for each friendship choice (continuation or dissolution), we analyze the data using a logistic regression model.

A positive beta coefficient implies that the friendship choice dyads that have a higher value on the independent variable X will tend to survive longer, while a negative coefficient implies that a higher value on the independent variable will lead to shorter friendship choices.

Table 3. Multivariate Logistic Regression of Friendship Stability on Organizational and Dyadic-Level Variables for Full Sample

Variable	Total ($N = 3,103$)	Bl–Wh ($N = 586$)	Wh–Bl ($N = 366$)	Bl–Bl ($N = 1,358$)	Wh–Wh ($N = 793$)
Intercept	1.34**	.04	4.15*	.71	.75
	(.50)	(1.23)	(1.75)	(.83)	(1.15)
Recip	1.01***	.72**	1.14***	.88***	1.44***
	(.10)	(.24)	(.31)	(.14)	(.21)
Sex-P	−.25**	.00	−.52	−.49***	−.13
	(.09)	(.20)	(.30)	(.13)	(.19)
Samesex	.80***	1.05***	.98**	.73**	.99***
	(.10)	(.24)	(.40)	(.14)	(.29)
Rankdiff	.01	.03**	.01	−.00	.01
	(.01)	(.01)	(.02)	(.01)	(.01)
Grade	.02	.21	−.36	.14	.06
	(.06)	(.15)	(.20)	(.13)	(.14)
Classize	−.02	−.01	−.07*	.00	−.02
	(.01)	(.02)	(.03)	(.02)	(.02)
Read Same	.07	−.01	.49	−.09	.21
	(.10)	(.24)	(.34)	(.15)	(.21)
Prop Black	.64***	−.27	1.89**	.05	1.80**
	(.19)	(.48)	(.65)	(.44)	(.70)
Climate	−.31***	−.53**	−.17	−.51**	−.19
	(.08)	(.18)	(.25)	(.18)	(.14)
Period 1	−1.02***	−.92***	−1.45***	−.84***	−1.14***
	(.09)	(.19)	(.28)	(.13)	(.18)

Note: Standard errors are in parentheses.
* Significant at the .05 level.
** Significant at the .01 level.
*** Significant at the .001 level.

DISCUSSION

One might think that because students' interracial friendships are fairly uncommon, they are also unstable. Our research shows that this is not the case. Interracial friendship choices in the desegregated classrooms in our sample were fairly stable. While they generally did not last the entire school year, they did continue for several weeks and often months. Indeed, students' interracial friendship choices were almost as stable as their same-race choices. This surprising result may be because interracial friendships are unlikely in the first place and are made only if there is a strong attraction between a black and white student that then sustains the relationship over time.

This research has several policy implications. Clearly, dyadic-level characteristics have the strongest impact on the stability of interracial friendship choices. However, it is also clear that schools are not powerless in this area. If school personnel wish to support interracial sociability in desegregated schools, they should try to provide a classroom environment that promotes stable interracial friendship choices. Our study shows that this can be done by paying attention to the racial composition of the class and to the class climate. The ratio of black to white students can afford opportunities for black and white students to interact with each other to foster positive sentiment between them. The classroom climate can decrease major status differences between black and white students by providing opportunities for all students to win the esteem of their peers. Thus, by manipulating the environmental and organizational factors that affect interpersonal attraction and the cohesiveness of relationships, school administrators and teachers can help sustain interracial friendship ties once they are made.