Counting Out Time:
Utilizing Zero Modified Count Regression
to Model Time-to-Degree Attainment

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John Kellogg
Motivation to study time to degree

• External
  – Department of Education
  – Higher Education Act reauthorization
  – AAU Institutional Data Committee

• Internal
  – Transforming the U
  – Provost’s Task Force on Financial Aid, Retention, Graduation and Student Success
Transforming the U: Framework

**Vision:** Improve the Human Condition Through the Advancement of Knowledge

**Mission:** Extraordinary Education • Breakthrough Research • Dynamic Public Engagement

**Goal:** Become one of the Top Three Public Research Universities in the World

**Exceptional Students**
Recruit, educate, challenge, and graduate outstanding students who become highly motivated lifelong learners, leaders, and global citizens.

**Exceptional Faculty and Staff**
Recruit, mentor, reward, and retain world-class faculty and staff who are innovative, energetic, and dedicated to the highest standards of excellence.

**Exceptional Organization**
Be responsible stewards of resources, focused on service, driven by performance, and known as the best among our peers.

**Exceptional Innovation**
Inspire exploration of new ideas and breakthrough discoveries that address the critical problems and needs of the University, state, nation, and world.

**Foundation for Success:**
- Foster Culture of Excellence • Cultivate International Learning
- Advance Interdisciplinary Frontiers • Build Diverse Community • Generate Critical Resources • Account for Results

University of Minnesota
Critical metrics/measures

- Retention/graduation rates/time to degree
- Satisfaction levels
  - Advising and career support
  - Quality of instruction
  - Sense of community and support within the UMNTC environment
- Participation in “deep” learning experiences
  - Study abroad, internships, service learning, student government/leadership
- Learning and development outcomes—assessment issues
- Inclination to recommend UMNTC to others
- Alumni success factors
Project Background

- Building on our previous research on duration of enrollment for drop-outs
- Continued refinement of our institutional model of probability of graduation
- Elaborating the paths students take on their journey through higher education
Research Questions

• How many semesters does it take to earn a bachelors degree from the University of Minnesota?
• What are the factors that increase or decrease a student’s time-to-degree?
• Do these factors differ from those that relate to non-degree attainment?
TTD: Let me count the ways

• Elapsed time
  – From HS graduation or time of matriculation to degree?

• Enrolled time
  – Number of semesters (summers or not)
  – Credit hours earned (native & transfer)
  – Calendar time (years, months)
Measuring Time-to-Degree: The Semester Count Method

• Semester count is a natural measurement of time as it reflects a student’s experience.
• Semester count is relatively immune to stopout behavior that complicates elapsed time measurements.
• Semester count better captures the pace of enrollment than credit hour counts as most programs require similar total credit hours.
Independent Variables

• **Academic Background**: ACT Score, First Generation College, First Choice College, AP Credits, and Remedial Course.

• **First Semester Performance**: Course Completion Ratio, C Count, D Count, and W Count

• **Demographic Characteristics**: Female, Asian, Underrepresented Minority, Nonresident/International, and Athlete

• **Geographic Origin**: Out-of-state, Reciprocity
Independent Variables (cont.)

- **Social Integration**: On-campus Housing, Living Learning Community (LLC), Federal Work Study, and On-campus employment.
- **Financial Aid**: Need Aid Award, Loan Award, Merit Aid Award, and Remaining Unmet Need.
- **Post Matriculation Enrollment Patterns**: Inter-Program Transfer, Transfer Credits, Study Abroad, Number of Summer Sessions, Number of Semesters Under 13 Credits
Methodology

• Adopt a multivariate approach to modeling time-to-degree.

• Because our dependent variable takes a non-negative, interval value, OLS is not appropriate
  • What’s wrong with a little OLS? Long (1997) tells us that application of OLS for count data leads to “inefficient, inconsistent, and biased estimates.”
Modeling Count Data

- While count models appear to be infrequently applied to higher education literature, they are used in many of other fields.
- Examples include models of:
  - Beverage consumptions (Mullahy, 1986)
  - Consumer loan default (Greene, 1994)
  - Publications by doctoral student (Long, 1997)
Methodological Issues

• Poisson is rarely appropriate model specification for data
• Two problems with Poisson:
  – Overdispersion
  – Excess Zeros
• Negative Binomial is common solution to overdispersion, it is unable to solve our problem with excess zeros
Count Models

• The Poisson model is the starting place for models of count data.

• The model is represented by the equation

\[ Pr(Y = y | \mu) = \frac{e^{-\mu} \mu^y}{y!}, \quad y = 0, 1, 2, ... \]
Count Models

- Observed
- Poisson (Predicted)
- NegBi (Predicted)
Zero Modified Count Regression

- Zero inflated count models
- Hurdle models

- Zero inflated models “change the mean structure to allow zeros to be generated by two distinct processes, compared with one process generating zeros in the hurdle model” (Long & Freese, 2003, p. 394)
Hurdle Models

• Our data is represented by **two distinct** data generating processes (graduation and time to degree)
• When this is the case hurdle models are preferred to zero inflated models (although the results for the two models have been demonstrated to be similar).
Hurdle Model

- Part 1 models the binary outcome and indicates if the hurdle is crossed:

\[
\Pr(y_i = 0|x_i) = \frac{\exp (x_i \gamma)}{1 + \exp (x_i \gamma)} = \pi_i
\]

- Part 2 models the truncated count:

\[
\Pr(y_i|x_i) = (1 - \pi_i) \Pr(y_i|y_i > 0, x_i) \text{ for } y > 0
\]
Hurdle Model
Results

• The following table presents the regression coefficients and standard errors.
• Recall that applications of regression analysis assume that observations are independent of one another.
• Because we are worried about independence within different colleges, we provide cluster robust standard errors.
• Robust standard errors protect against type 1 errors when evaluating t statistics.
## Results: Academic Background

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hurdle Model</th>
<th>Truncated Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Rob. SE</td>
</tr>
<tr>
<td>Composite ACT Score</td>
<td>0.001</td>
<td>0.012</td>
</tr>
<tr>
<td>First Generation Student</td>
<td>0.245</td>
<td>0.097*</td>
</tr>
<tr>
<td>First Choice College</td>
<td>-0.125</td>
<td>0.032***</td>
</tr>
<tr>
<td>Advance Placement Credits</td>
<td>-0.034</td>
<td>0.006***</td>
</tr>
<tr>
<td>Remedial Course</td>
<td>0.805</td>
<td>0.170***</td>
</tr>
</tbody>
</table>
## Results: First Semester Performance

<table>
<thead>
<tr>
<th></th>
<th>Hurdle Model</th>
<th>Truncated Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Rob. SE</td>
</tr>
<tr>
<td>Course Completion Ratio</td>
<td>-0.032</td>
<td>0.002***</td>
</tr>
<tr>
<td>C Count</td>
<td>0.310</td>
<td>0.022***</td>
</tr>
<tr>
<td>D Count</td>
<td>0.600</td>
<td>0.088***</td>
</tr>
<tr>
<td>W Count</td>
<td>0.799</td>
<td>0.047***</td>
</tr>
</tbody>
</table>
### Results: Demographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Hurdle Model</th>
<th>Truncated Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Rob. SE</td>
</tr>
<tr>
<td>Female</td>
<td>-0.044</td>
<td>0.109</td>
</tr>
<tr>
<td>Asian</td>
<td>-0.014</td>
<td>0.086</td>
</tr>
<tr>
<td>Underrepresented Minority</td>
<td><strong>0.300</strong></td>
<td><strong>0.145</strong></td>
</tr>
<tr>
<td>Nonresident/International Athlete</td>
<td>-0.433</td>
<td>0.481</td>
</tr>
<tr>
<td>Athlete</td>
<td>-0.586</td>
<td>0.178**</td>
</tr>
</tbody>
</table>
## Results: Geographical Origin

### Hurdle Model

<table>
<thead>
<tr>
<th>Location</th>
<th>Coef.</th>
<th>Rob. SE</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-of-State</td>
<td>0.350</td>
<td>0.132</td>
<td>***</td>
</tr>
<tr>
<td>Reciprocity State</td>
<td>0.155</td>
<td>0.137</td>
<td></td>
</tr>
</tbody>
</table>

### Truncated Count

<table>
<thead>
<tr>
<th>Location</th>
<th>Coef.</th>
<th>Rob. SE</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.007</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.017</td>
<td>0.007*</td>
<td></td>
</tr>
</tbody>
</table>
## Results: Social Integration

<table>
<thead>
<tr>
<th></th>
<th>Hurdle Model</th>
<th>Truncated Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coeff.</strong></td>
<td><strong>Rob. SE</strong></td>
<td><strong>Sig.</strong></td>
</tr>
<tr>
<td>Living On Campus</td>
<td>-0.310</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>0.076 ***</td>
<td>0.008</td>
</tr>
<tr>
<td>Living Learning</td>
<td>-0.347</td>
<td>0.023</td>
</tr>
<tr>
<td>Community</td>
<td>0.076 ***</td>
<td>0.007 ***</td>
</tr>
<tr>
<td>Federal Work Study</td>
<td>0.056</td>
<td>-0.035</td>
</tr>
<tr>
<td></td>
<td>0.134</td>
<td>0.008 ***</td>
</tr>
<tr>
<td>On-Campus Job</td>
<td>0.037</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td>0.037</td>
<td>0.005 *</td>
</tr>
</tbody>
</table>
## Results: Financial Aid

<table>
<thead>
<tr>
<th>Hurdle Model</th>
<th>Coef.</th>
<th>Rob. SE</th>
<th>Sig.</th>
<th>Truncated Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmet Need Amount (in $100)</td>
<td>0.003</td>
<td>0.001</td>
<td>***</td>
<td>0.000</td>
</tr>
<tr>
<td>Need Aid Award</td>
<td>-0.079</td>
<td>0.082</td>
<td></td>
<td>0.004</td>
</tr>
<tr>
<td>Loan Award</td>
<td>0.292</td>
<td>0.091</td>
<td>**</td>
<td>0.002</td>
</tr>
<tr>
<td>Merit Award Award</td>
<td>-0.813</td>
<td>0.192</td>
<td>***</td>
<td>-0.010</td>
</tr>
</tbody>
</table>

*Note: Rob. SE refers to robust standard error, and Sig. indicates statistical significance: *** p < 0.001, ** p < 0.01, * p < 0.05.*
## Results: Post Matriculation Enrollment Patterns

<table>
<thead>
<tr>
<th></th>
<th>Hurdle Model</th>
<th></th>
<th></th>
<th>Truncated Count</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Rob. SE</td>
<td>Sig.</td>
<td>Coef.</td>
<td>Rob. SE</td>
<td>Sig.</td>
</tr>
<tr>
<td>Within College Transfer</td>
<td>0.016</td>
<td>0.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credits Transferred In</td>
<td>-0.004</td>
<td>0.000***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study Abroad</td>
<td>0.026</td>
<td>0.008**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Summer Semesters Enrolled</td>
<td>0.013</td>
<td>0.003***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Semester with &lt; 13 Credits</td>
<td>0.047</td>
<td>0.002***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** Significant at the 0.001 level
** Significant at the 0.01 level
* Significant at the 0.05 level
Overview of findings

• Less is known about time-to-degree than probability of graduation
• Rigor of previous curricula can give students a head start or force them to play catch-up
• On-campus work speeds time-to-degree
• Merit aid associated with increased likelihood of graduation, loans with decreased likelihood.
• Study abroad, summer enrollment, and part-time attendance associated with slower graduation
How have we responded?

• Instituted a 13-credit minimum and flat-rate tuition for full-time students
  – Credit loads have increased
  – Summer enrollment has decreased
• Founders Free Tuition Program
  – Aims to reduce reliance on loans for needy students
  – Now instituting a middle-class scholarship program
Current and future actions

• Focus on improving student engagement
• Increasing expectations for entering students to be prepared for college-level work
• Improving responsiveness of advising to keep students on track
• Curricular audit to identify and remove obstacles to program completion
Future research

• Expand specification of model with additional post-matriculation student experiences
• Compare results using alternative measures of time to degree (elapsed time or credits completed)
• Apply methodology to faculty career progression and time in rank
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