Event History Analysis for Investigating the Likelihood and Timing of Changing Majors

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Students change their majors for various reasons, and academic advisors often assume the role of facilitating that change through institutional agreements or contracts. Therefore, advisors need to identify time periods during enrollment with the greatest likelihood that students will seek to change majors. They must also examine the student characteristics associated with changing majors so that advisors can identify students to avoid delays to graduation. The relationship between student characteristics and the likelihood of changing majors over time was studied through event history analysis techniques applied to enrollment data for a cohort of first-time first-year students.

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Many college students do not persist in their first declared major and opt to change their field of study (Foster, 2017; Kramer, Higley, & Olsen, 1994). Studies have placed the percentage of students who change majors at least once between 50 and 85% (Kramer et al., 1994; Steele, Kennedy, & Gordon, 1993; Venit, 2016). According to calculations from the U.S. National Center for Educational Statistics data (Wine, Janson, & Wheeless, 2011), approximately 46% of all first-time full-time students entering 4-year institutions in 2003 switched majors at least once within the following 6 years (Sklar, 2014). Various factors may contribute to a student's need to switch to a new major. Some students become uninterested in the course work of their declared major or discover a preference for courses taken in other programs (Steele et al., 1993), while others perform poorly in or find themselves otherwise unsuited for their current program of study (Malgwi, Howe, & Burnaby, 2005). The curriculum of science, technology, engineering, and mathematics (STEM) majors may prove too difficult for some students, explaining the reason that more students in STEM majors who received lower-than-average grades in the math and physical sciences courses were more likely to switch majors than students in non-STEM majors with similar grades (King, 2005). Other students may discover better career and employment opportunities from majors that prepare them for a different field (Foster, 2017; Malgwi et al., 2005). In the ideal case, switching to a different major provides students with a means to increase their satisfaction with studies and a more enjoyable college experience (King, 2015); however, some major-changing students may face a delay in graduation and incur additional expenses (Allen & Robbins, 2008).

Regardless of the student's reasons for switching programs of study, academic advisors are involved with the change-of-major process at some level. At the institution where this study was conducted, California Polytechnic State University (hereafter, *Cal Poly*), students are encouraged to consult with academic advisors in both their current and target majors before initiating a change-of-major request. Students may seek information and discuss reasons to switch with advisors in their current major, and then meet with advisors in the target major to learn about the requirements for changing into that program of study. In addition, advisors in the target major take responsibility for discussing the course curriculum, conducting workshops to inform students about the change-of-major procedures and policies, and processing change-of-major documents.

Current research focusing specifically on students who change majors and the impact of this switch on college outcomes, such as drop out or graduation, remains somewhat limited. Foster (2017) examined the association between various personality traits and major-changing behavior and found that more optimistic students and those with a clear sense of career direction sought to change majors than did those with less optimism or direction. Malgwi et al. (2005) examined factors influencing business students' decisions to change majors and found interest in a new subject as the primary reason for switching. They also concluded that females were more inclined to switch majors than males because of the level of difficulty they attribute to a business major. Shaw and Barbuti (2010) informally compared characteristics

between students who changed their initial choice of major by the end of their second college year and students who persisted in the originally intended major. They found slightly higher high school, first-year college, and cumulative college grade-point averages (GPAs) among students who persisted in original majors than those who switched from their first intended major (Shaw & Barbuti, 2010). In addition, they found that the percent of students who switched from majors pursued immediately after high school varied by academic field, gender, parental income, first-generation status, and ethnicity (Shaw & Barbuti, 2010). These researchers and others also examined and compared measures of self-efficacy between students who switch majors (or who switch frequently) and those who do not change majors (or change majors infrequently) (Cunningham & Smothers, 2010; Shaw & Barbuti, 2010). Major changers, defined as those who change majors three or more times, were associated with lower levels of self-efficacy than students who change majors fewer than three times (Cunningham & Smothers, 2010). Science self-efficacy scores were also found to be lower, on average, for students who switched from an intended STEM major than they were for those who persisted in a STEM major (Shaw & Barbuti, 2010).

Additional research has focused on factors associated with the selection of or persistence in a college major (Allen & Robbins, 2008, 2010; Pike, 2006; Porter and Umbach, 2006) using components from Holland's theory of careers (Feldman, Smart, & Ethington, 1999; Holland, 1997). The general findings revealed that students who have selected majors more congruent with their interests and who have earned a high first-year GPA are more likely to persist in the initial major than those with interests less compatible with their major and who earned lower grades (Allen & Robbins, 2008, 2010).

Regarding the impact of changing majors on college outcomes, various studies have shown that, if the transition is made early in the student's academic career, switching majors may improve graduation rates or exert little negative influence on time to graduation. Micceri (2001) reported that students at Cal Poly who had changed their major at least once graduated at higher overall rates than those students who had not changed majors. In another single-institution study, Foraker (2012) found that changing majors after the second college year was associated with lower graduation rates and longer time to graduation. In a national-level study, students who switched early in college did not experience significant addition of time to graduation (Sklar, 2014).

With a relatively large percentage of college students changing majors or planning to change majors, the characteristics of students who change into a different program need to be understood as does the timing of such changes. To identify the timing for switching majors and characteristics of major changers, advisors and administrators can access available institutional data. By applying event history analysis techniques (Singer & Willett, 2003; Yamaguchi, 1991) to enrollment data for a cohort of first-time freshman students from Cal Poly, I sought to address the following research question: "Are student characteristics, including gender, ethnicity, pre-college academic performance measures, and classification of first major, associated with the probability of changing majors over time?" In addition, I sought to answer the following question: "During which specific quarter(s) are students most likely to change majors?" Information gained from this study may prove valuable to academic advisors and administrators responsible for developing and implementing campus change-of-major policies.

Understanding attributes associated with changing majors helps advisors identify students most likely to make a switch and anticipate and address specific academic needs or concerns of students in their current major. For example, advisors may guide students struggling with course work to consider an alternate major with a more attainable degree. In addition, by knowing when to expect students to inquire about changing majors, advisors can proactively plan workshops that cover change-of-major policies and assistance for students choosing a new major. Ultimately, advisors must provide appropriate resources and advice in the current major or facilitate the change-of-major process so students can continue in the most satisfying field of study and graduate in a timely manner.

University Characteristics and Sample Cohort

Enrollment data on the entire cohort of 3,488 first-year students who began undergraduate degree programs at the beginning (summer or fall) of the 2008 academic year were obtained through the Office of Institutional Research at Cal Poly. The data included information on student's pre-college academic characteristics, including high school GPA, SAT scores, first college (in which the student first declares a major), and demographic

characteristics: gender, ethnicity, and mother's and father's highest level of education. Longitudinal data, including quarterly college GPA and current major, were also included for the period from Summer 2008 through Winter 2015. The longitudinal information proved especially relevant when examining the time (quarter) when a student changed majors.

Colleges

One of 23 campuses within the California State University system, Cal Poly features quarterly academic terms. Institutions within this system primarily serve undergraduate students and graduate students pursuing master's degrees. Total enrollment at Cal Poly (as of Fall 2016) was approximately 21,000 undergraduate and graduate students. Cal Poly offers more than 60 undergraduate majors in six colleges. The colleges and the major programs within each college are described as follows:

- College of Agriculture, Food and Environmental Sciences (CAFES) offers undergraduate degrees in agribusiness, animal science, and food science and nutrition;
- College of Architecture and Environmental Design (CAED) offers undergraduate degrees in architecture, architectural engineering, and construction management;
- College of Engineering (CENG) offers undergraduate degrees in computer science and a variety of engineering disciplines, including aeronautical, electrical, and mechanical engineering;
- College of Liberal Arts (CLA) offers undergraduate degrees in the humanities and social sciences, including English, history, and psychology;
- College of Science and Mathematics (CSM) offers undergraduate degrees in the STEM fields including mathematics, biology, statistics, and chemistry; and
- Orfalea College of Business (COB) offers undergraduate degrees in business administration (with various concentrations) and economics.

For purposes of this study, *first college* refers to one of the six colleges that was chosen according to the student's declared major at the time of admission. Although liberal studies majors are officially within the CSM, for the purpose of this study, they were grouped within the CLA because the course work does not fully align with that of a CSM program.

In a policy unique to Cal Poly, a student must declare a major when applying for admission due to ''the impaction of the campus and its programs'' (California Polytechnic State University, 2017, p. 55). Although students select a first- and second-choice major when applying for admission, students are admitted to the alternative choice only in the rare case that their first choice cannot be accommodated. Students cannot enter Cal Poly undeclared, and no pre-majors or exploratory offerings are made available. Therefore, all students begin their college careers in the chosen major within one of the six colleges described.

Major-Changing Process

Students considering a major change are encouraged to research the requirements in the target major and speak to representatives from the new department of interest before initiating the formal process. They also must complete at least one academic quarter before initiating an *Individualized Change-of-Major Agreement* (ICMA). Each department establishes a unique set of criteria for the ICMA, but those criteria fall within the scope of the university change-of-major policies. Students cannot be required to take courses not listed in the ICMA, and the ICMA cannot require students to take more than 3 specified courses or 12 units, as a condition for switching, in the target major. Furthermore, students must complete the courses and units specified in the agreement in one or two quarters. The GPA requirements set forth by the department of the major department may include a minimum GPA in courses specified in the ICMA or a term GPA; however, the GPA expectations must be attainable.

Change of Major Rates

Table 1 lists the overall percentages of the original 2008 first-year cohort of students who had changed majors at least once by Winter 2015 and the change-of-major rates by gender, ethnicity, mother's and father's highest level of education, and first college. The proportion of students from the entire 2008 cohort who changed majors was much smaller than the 46% computed from the 2003 national level data. The percentage of the 2008 first-year cohort who changed majors at

Table 1. Percentages of the 2008 freshman cohort who changed major at least once by Winter Quarter 2015 by background characteristics

Characteristic	*n*	%
All	3,488	21.1
Gender		
Male	1,915	20.6
Female	1,573	21.7
Ethnicity		
White	2,324	21.3
Asian/Pacific Islander	383	19.8
Hispanic/Latino	383	19.3
Other non-White	203	21.2
Unknown/decline	195	24.6
Mother's education		
High school or less	532	21.8
Less than 4-year degree	809	21.0
4-Year degree	1,304	20.1
Postgraduate	707	22.6
Unknown/decline	136	20.6
Father's education		
High school or less	538	18.2
Less than 4-year degree	608	21.6
4-Year degree	1,237	21.3
Postgraduate	946	22.1
Unknown/decline	159	22.0
First College		
CAED	363	18.7
CAFES	715	19.2
CENG	1,096	27.2
CLA	537	19.9
CSM	324	28.4
COB	453	7.5

Note. CAED = College of Architecture and Environmental Design; CAFES = College of Agriculture, Food and Environmental Sciences; CENG = College of Engineering; CLA = College of Liberal Arts; CSM = College of Science and Mathematics; COB = Orfalea College of Business

least once by Winter 2015 was slightly more than 21%.

The change-of-major rates did not vary considerably by student background characteristics, with the exception for students in the CAED. The change-of-major rates for the CSM and the CENG were notably higher (28.4 and 27.2%) than those of the four other colleges. The COB had the lowest change-of-major rate with 7.5% of incoming students from the 2008 cohort changing programs. A slightly higher percentage of female students switched majors compared to male students (21.7 and 20.6%, respectively).

Changes Within and Outside the Major

The academic pathways of the 736 students from the 2008 first-year cohort who switched majors at least once during the study period were also examined to determine whether the first major change was to another major within the same college or to a major in another college. Table 2 presents the counts of students by their first college and gender and those who changed to a major within and outside their original college. Approximately 61% of those who switched selected another major within the same college, meaning that roughly 39% selected a new major in a college other than the one they entered upon matriculation.

The percentage of first-time switches to another major within the same college varied by gender and by college. Approximately 68 and 50% of first-time switches by males and females, respectively, involved a major within the same first college. CENG students showed the highest overall within-college change-of-major rate, at approximately 78% of first-time switchers; however, the percentage of female students who had initially enrolled in the CENG and switched for the first time to another major within the CENG was less than that of male students (69 and 80%, respectively), an observation consistent with similar findings of females switching out of engineering fields at higher rates than males (Chen, 2013). Only female first-time switchers in the CLA had a higher within-college change-of-major rate than that of males (65.2 and 55.6% for females and males, respectively). Female switchers who matriculated into the CAED had the lowest within-college change-of-major rate; approximately 12.5% of CAED females changed for the first time to another major within that college.

Methods: Model-Based Analysis of Time Until First Major Change

Although they provide a snapshot of switching patterns by select demographic characteristics and by first college, descriptive statistics cannot be used to determine when students are more likely to change majors. To examine the variation in change-of-major likelihood over time and by student characteristics an appropriate statistical framework is required. Because this study was focused on the longitudinal process of persistence in a major,

Table 2. Counts and percentages of students who changed for the first time to another major within and outside their first college by gender

		Within First College		Outside First College	
	Gender	***n***	**%**	***n***	**%**
All		446	60.6	290	39.4
Total by Gender					
	Male	269	68.1	126	31.9
	Female	177	51.9	164	48.1
First College					
CAED	Male	17	47.2	19	52.8
	Female	4	12.5	28	87.5
CAFES	Male	37	61.7	23	38.3
	Female	42	54.6	35	45.4
CENG	Male	184	80.0	46	20.0
	Female	47	69.1	21	30.9
CLA	Male	10	55.6	8	44.4
	Female	58	65.2	31	34.8
CSM	Male	14	40.0	21	60.0
	Female	21	36.8	36	63.2
COB	Male	7	43.8	9	56.2
	Female	5	27.8	13	72.2

Note. CAED = College of Architecture and Environmental Design; CAFES = College of Agriculture, Food and Environmental Sciences; CENG = College of Engineering; CLA = College of Liberal Arts; CSM = College of Science and Mathematics; COB = Orfalea College of Business

event history analysis (also called *survival analysis*) techniques were implemented. Event history analysis methods incorporate *censoring,* a procedure common to time-to-event data (such as time until a new major is declared) that accounts for events that end before the observation of interest is completed. Censoring is appropriately applied to college enrollment data because students may leave college (drop out or transfer) before changing majors, persist in the same major through college, or change majors after the data collection period ends. Yamaguchi (1991) offered a useful introduction to event history analysis and the specific applications of it to the social sciences.

Data from students who changed their major (for the first time) by Winter Quarter 2015 (the last quarter for which enrollment data were collected) were determined to have complete event times such that the time until the change of major was known. Data from students who were still enrolled in their first major or who had dropped out, stopped out, transferred institutions without changing majors, or graduated by Winter 2015 in their first major were considered censored. The dependent variable was the time until the first change of major was completed, as measured by the number of consecutively enrolled academic quarters (fall, winter, and spring) until the new major was officially declared. A value from 1 to 20 for the time to change a major was used to represent the number of consecutive quarters between Fall 2008 and Winter 2015 that the student was enrolled until changing the major or until the time that the change of major was censored. Furthermore, because the time to change majors was measured in quarters, *discrete-time* event history analysis methods were appropriately used (Singer & Willett, 2003).

Discrete-Time Hazard Model

To model the likelihood of changing majors as a function of time and student-level predictors specifically, a discrete-time hazard model was utilized (Singer & Willett, 2003). In particular, the logit (log-odds) *hazard* or *risk* (terms are used interchangeably) of changing majors was modeled as a function of time plus the various student demographic and academic variables. The (discrete-time) hazard of changing majors was defined as the probability that a student is pursuing a new major in the current time period (quarter) given that the student had been in the original major, declared at enrollment, in the prior

quarter. The discrete-time hazard model takes the following form:

$$\ln\left(\frac{h_j}{1-h_j}\right) = \sum_{j=1}^{20} \alpha_j D_j + \sum_k \beta_k \text{Predictor}_k \quad (1)$$

where ln $[h_j / (1 - h_j)]$ is the logit hazard (or log-odds) of changing majors. The term h_j represents the probability of being officially enrolled in a new major in quarter j, given that the student was in the original declared major in quarter j–1, and is used to assess the (conditional) risk of changing majors in quarter j. The conditional hazard probability, h_j, is used to assess the risk of changing a major such that high values of h_j indicate a high risk of changing majors in quarter j. In addition, D_j represents a dummy variable indicating whether or not the student was enrolled in quarter j; α_j is a parameter indicating the amount by which the logit hazard of changing majors increases or decreases in quarter j; and β_k provides information on the change in the logit hazard associated with a unit increase in Predictor$_k$.

The term in the left-hand side of Equation 1 is interpreted as the log-odds of having switched to a new major in the current quarter; it is conditional on the student being in the original major in the previous quarter. The parameterization of the model was identical to that of a logistic regression model without an intercept term (Singer & Willett, 2003).

Predictor Variables

The set of predictor variables used in the discrete-time hazard model, shown in Equation 1, was selected according to previous studies on college major persistence (Allen & Robbins, 2008), persistence in a STEM major (Crisp, Nora, & Taggart, 2009; King, 2015; Leuwerke, Robbins, Sawyer, & Hovland, 2004), and choice of college major (Pike, 2006; Porter & Umbach, 2006). Variables used in the model were chosen on the basis of restricted information available from the Office of Institutional Research. The final set of predictors included demographic control variables and measures of pre-college and postsecondary academic success, including the following with variable labels provided in parentheses:

- Demographic characteristics—gender, ethnicity, mother's highest level of education (mother's education) ranging from high school graduation or less education to postgraduate school, and father's highest level of education (father's education) ranging from high school graduation or less education to postgraduate school.
- Pre-college academic measures—maximum SAT mathematics score (SAT math) ranging from 0 to 800, SAT reading score (SAT reading) ranging from 0 to 800, and cumulative high school GPA (HSGPA) ranging from 0.00 to 4.92.
- College academic measures—quarterly college GPA (QCGPA) ranging from 0.00 to 4.00 and college of first declared major (CAED, CAFES, CENG, CLA, CSM, or COB).

Quarterly college GPA, known as a *time-varying* predictor, can change each quarter for which the student is enrolled, but the other predictors in the model are called *time-invariant* because the values are fixed throughout the duration of the study period (Singer & Willet, 2003). To minimize any potential problems with collinearity, values of the quantitative variables (e.g., SAT scores, HSGPA, and QCGPA) were each centered at the respective mean. Kutner, Nachtsheim, and Neter (2004) presented a good discussion of collinearity and the strategies for detecting and addressing this concern.

Information on other potentially important background variables, such as family income and financial aid amounts, could not be obtained because of Cal Poly privacy policies. In addition, nonobjective student characteristics found to be associated with changing majors and major persistence, such as self-efficacy (Cunningham & Smothers, 2010), measures of occupational and vocational interest (Allen & Robbins, 2008; Porter & Umbach, 2006), and measures of personality traits (Foster, 2017) were unavailable.

The sample for the event history analysis was limited to the 2008 freshman cohort of students who first enrolled in Fall 2008 and remained continuously enrolled. Students who left the university for at least one quarter for any reason (e.g., medical issues, study abroad, employment) were excluded from the analysis. Students with missing values for predictors were also removed from the model. The final sample used for the discrete-time hazard model with the predictors described was thus reduced to 2,619 students.

Table 3. Final discrete-time hazard model results

Predictor	Coefficient	*SE*
HSGPA	−0.308***	.1376
CGPA	0.325*	.0771
HSGPA × QCGPA	−0.472***	.1962
Gender		
Male	(Reference group)	
Female	0.643***	.2861
SAT reading	0.000	.0007
SAT math	−0.001	.0008
Ethnicity		
Other non-White	(Reference group)	
White	−0.143	.1826
Asian/Pacific Islander	−0.291	.2259
Hispanic/Latino	−0.269	.2276
Mother's education		
High school or less	(Reference group)	
Less than 4-year degree	−0.151	.1595
4-Year degree	−0.319†	.1590
Postgraduate	−0.205	.1747
Father's Education		
High school or less	(Reference group)	
Less than 4-year degree	0.199	.1747
4-Year degree	0.219	.1679
Postgraduate	0.278	.1768
First college		
Architecture (CAED)	(Reference group)	
Agriculture (CAFES)	0.407†	.2463
Engineering (CENG)	0.659**	.2106
Liberal Arts (CLA)	−0.281	.3419
Science and Math (CSM)	0.729**	.2733
Business (COB)	−1.136**	.3865
First College × Gender		
CAED × Female	(Reference group)	
CAFES × Female	−1.005**	.3490
CENG × Female	−0.163	.3290
CLA × Female	−0.221	.4201
CSM × Female	−0.748***	.3813
COB × Female	−0.182	.5150

Note. *$p < .001$. **$p < .01$. ***$p < .05$. †$p < .1$.

Person–Period Data Set

Before the discrete-time hazard models were fit to the data, the original *person–level* data set, for which each row of data corresponded to a single student, was converted to a person–period format such that each student was associated with multiple rows of data equal to the number of quarters during which the student was continuously enrolled. The number of rows of data for each student varied by the number of quarters enrolled at the university. Singer and Willett (2003) provided complete details about the person–period data format.

Results

The discrete-time hazard model (Equation 1) using the predictors described was fit to the person–period data. To determine whether they were statistically significant in association with the risk of changing majors, all predictor variables were simultaneously included in the model along with the time-indicator variables. Interaction terms between the pairs of predictors were individually introduced into the model and tested after the initial model (Equation 1) was fit. The only interactions found to be statistically significant were between HSGPA and QCGPA and between first college and gender. To test whether the categorical variables (e.g., mother's education) or interactions that contributed more than one term (e.g., First College × Gender) were significant in the model, likelihood ratio tests were performed (see, e.g., Kutner et al. [2004] for details).

Table 3 displays the results of the final discrete-time hazard model including the estimated coefficients, standard errors, and indicators regarding significance in the model. Although not shown for the sake of brevity, the time indicator variables $D_1,\ldots,D_{20}$ were determined as statistically significant and were collectively associated with the log-odds of changing majors ($\chi^2 = 368$; $df = 19$; $p < .001$). Thus, after adjusting for the values of the remaining predictors in the model, the log-odds (and, hence, the risk) of changing majors was found to vary in a statistically significant manner over time.

The interaction between QCGPA and HSGPA was statistically significant ($p < .05$). For students with a very high HSGPA, a higher QCGPA was associated with a small chance of changing majors. For students with a low HSGPA, a higher QCGPA was associated with a greater chance of changing majors. The interaction between first college and gender was also statistically significant ($\chi^2 = 15$; $df = 6$; $p < .05$). Individually, the predictors of SAT reading, SAT math, ethnicity, mother's education, and father's education were not statistically significantly associated with a risk of changing majors after adjusting for all other terms in the model.

Odds and Odds Ratios

To compare the risk of changing majors between various groups of students, predicted odds ratios and confidence intervals (CI) for true odds ratios were computed (per Kutner et al.,

Table 4. Confidence intervals of 95% for true ratio of odds of changing majors comparing females to males by first college

CAED	CAFES	CENG	CLA	CSM	COB
(1.09, 3.33)*	(0.47, 1.04)	(1.17, 2.24)*	(0.83, 2.80)	(0.55, 1.48)	(0.44, 5.65)

Note. CAED = College of Architecture and Environmental Design; CAFES = College of Agriculture, Food and Environmental Sciences; CENG = College of Engineering; CLA = College of Liberal Arts; CSM = College of Science and Mathematics; COB = Orfalea College of Business
*Indicates odds of changing majors are significantly higher (interval limits are both above 1).

2004). Because the interaction between gender and first college was significant in the discrete-time hazard model, the risk of changing majors over time between male and female students within each first college was examined, and the risks of changing majors to a new college were compared for male and female students.

Table 4 displays the 95% CI for the true ratio, which was made by comparing the odds of changing majors for females to the odds of changing majors for males who had enrolled in the same first college. In any given quarter (and adjusted for other variables) for CAED-enrolled students, females showed statistically significant higher odds of changing majors than males, and CENG-enrolled female students showed statistically significant higher odds of changing majors than CENG-enrolled males (the CI limits for the true odds ratios were both greater than 1). For example, the CIs (1.17, 2.24) shown in Table 4 were interpreted as follows: The odds of changing majors for female students who had initially enrolled in CENG fell between $(1.17–1) \times 100\% = 17\%$ and $(2.24–1) \times 100\% = 124\%$ higher than the odds of changing majors for male students who had initially enrolled in CENG (regardless of quarter of enrollment and after controlling for the remaining predictors). Hence, after adjusting for the remaining variables in the model, the data showed that female students who had initially enrolled in the CAED or the CENG were at a significantly greater risk of changing majors than male students who had initially enrolled in the CAED or the CENG. Kutner et al. (2004) provided an explanation and the interpretation of estimated odds ratios and CI construction for true odds ratios.

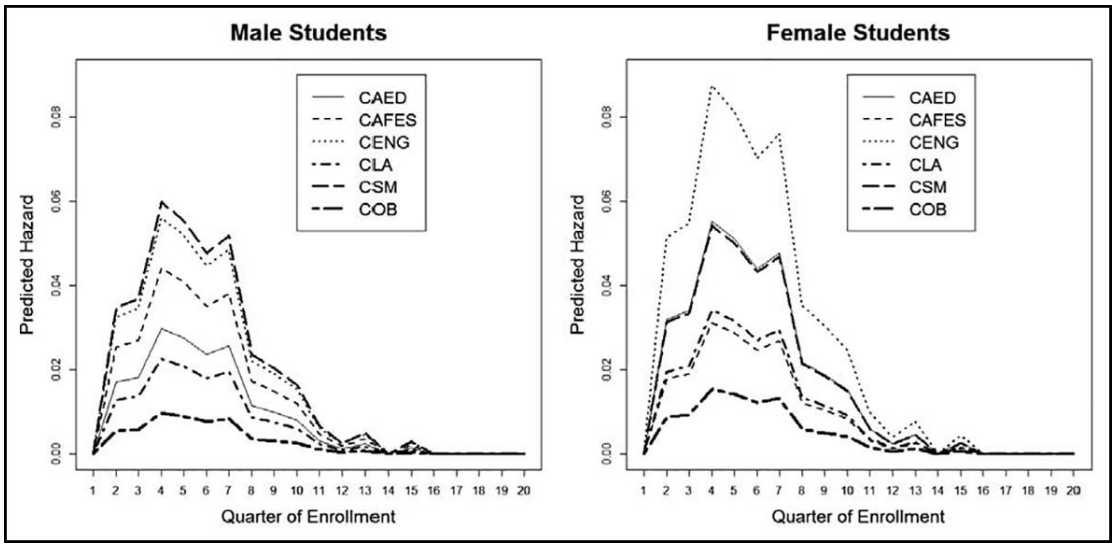
Table 5 shows the 95% CI for the true ratio, which compares the odds of changing majors between select colleges for female and male students. The odds of changing majors for male and female students who first enrolled in the CENG or the CSM were statistically significantly higher than the odds of changing majors for students with the same backgrounds (i.e., the values of the remaining predictors were adjusted or fixed) who had initially enrolled in the CLA (the CI limits were greater than 1). In general, male and female students who had initially enrolled in colleges primarily consisting of STEM majors (i.e., the CENG or CSM) were at a greater risk of changing majors than were males and females with the same backgrounds who had initially enrolled in colleges consisting of non-STEM majors (e.g., the CLA). For example, the odds of changing majors for male students who had initially enrolled in the CENG were between $(1.42–1) \times 100\% = 42\%$ and $(4.60–1) \times 100\% = 360\%$ higher than the odds of changing majors for males who had initially enrolled in the CLA; furthermore, the odds of changing majors for female students who had initially enrolled in the CENG fell between $(1.83–1) \times 100\% = 83\%$ and $(4.03–1) \times 100\% = 303\%$ higher than the odds of

Table 5. Confidence intervals of 95% for true ratio of odds of changing majors comparing selected colleges

	CENG vs. CLA	CSM vs. CLA	CENG vs. CSM
Males	(1.42, 4.60)*	(1.40, 5.37)*	(0.23, 3.74)
Females	(1.83, 4.03)*	(1.08, 2.44)*	(1.09, 2.56)*

Note. CAED = College of Architecture and Environmental Design; CAFES = College of Agriculture, Food and Environmental Sciences; CENG = College of Engineering; CLA = College of Liberal Arts; CSM = College of Science and Mathematics; COB = Orfalea College of Business
*Indicates odds of changing majors are statistically significantly higher.

Figure 1. Hazard curves for baseline male and female students by initial college major



changing majors for females who had initially enrolled in the CLA. Hence, after adjusting for the remaining variables and regardless of the quarter, male and female students who first enrolled in the CENG or the CSM were at a significantly greater risk of changing majors than males and females who had initially enrolled in the CLA.

In another important finding, also shown in Table 5, the odds of switching majors for females initially enrolled in the CENG were significantly higher than they were for females who had initially enrolled in the CSM (limits of the CI for the true odds ratio ranged from 1.09 to 2.56). Hence, females who first enrolled in the CENG were at a greater risk of switching majors than were females who had initially enrolled in the CSM.

Timing the Risk of Switching Majors

To address the second research question and identify the quarters when the risk of changing majors was greatest, predicted hazard curves were constructed for typical (*baseline*) male and female students. Baseline data for students were defined as White with an average SAT math score of 638, average SAT reading score of 596, average HSGPA of 3.78, average quarterly college GPA of 3.00, and a mother and a father who had graduated college. The predicted hazard curve consisted of the values of h_j (found by solving Equation 1 for h_j) computed for each quarter j; $j = 1,\ldots,20$. Figure 1 displays the predicted hazard curves for baseline male and female students who first enrolled in the six colleges described.

Both panels of Figure 1 show that, regardless of a student's first college, the risk of switching majors for the baseline male and female students peaked during the fourth consecutive quarter of enrollment (fall quarter of the second year), with a second, slightly lower, peak emergent during the seventh quarter (fall quarter of the third year). Baseline female students who first enrolled in the CENG had the overall greatest predicted risk of changing majors in any given quarter, peaking in the fall quarter of the second year with approximately 9% in newly declared majors either within or outside the CENG (see right panel of Figure 1). Baseline male students who first enrolled in the CENG or the CSM had the highest predicted risk of changing majors during the fall quarter of the second year with approximately 5.6 and 6.0% of male students who started in the CENG and the CSM, respectively, switching majors. Students from the CLA tended to show a small risk of changing majors over time with the predicted hazard probability of switching peaking at approximately 2.0 and 3.5% for males and females, respectively, in the fall quarter of the second year. Regardless of quarter, students from the COB had the lowest predicted risk of changing majors; that is, 1 and 2% of males and females, respectively, were predicted to

declare new majors in the fall quarter of the second year, while the risk of switching majors was even smaller in other quarters.

Summary and Conclusions

Several interesting outcomes were uncovered in the current study. As expected, the statistically significant risk of changing majors varied over the course of enrollment. A peak in new major designations was found for the fall quarter of the second college year. Hence, advisors at Cal Poly, or at other institutions with similar change-of-major policies, may expect interest in changing majors to peak during the winter or spring quarters of a student's first year; that is, during these quarters more students may seek advice and inquire about the change-of-major process than at other times.

The findings for baseline male and female students did not indicate a mass exodus from first majors in any particular quarter. The highest (conditional) probability of changing majors in any quarter was approximately 9%, which was found for baseline females in the CENG. This result implies that, for most quarters, advisors need not be concerned about an overwhelming percentage of students requesting information about the change-of-major process.

When all other variables were controlled, the COB students showed the smallest risk of changing majors than students did from any other college. The majority of students in the COB work toward a bachelor of arts in business administration, which is an offering at few other universities. Because of the uniqueness of this program, students at Cal Poly may feel more committed to completing this specialized degree. Students in the CENG or the CSM (STEM majors) showed the greatest risk for changing majors over the entire study period. This result aligns with previous findings suggesting that students leave STEM majors at higher rates than do non-STEM majors (Chen, 2013).

The significant interactions in the final model (Table 3) imply that the relationship between the QCGPA and risk of changing majors varies by HSGPA. Also, the relationship between first college and risk of changing majors differed for males and females.

For students with high grades in high school, the risk of changing majors tended to decrease for those experiencing an increase in QCGPA. For students with relatively low high school GPAs, the risk of changing majors increased along with QCGPA increases, possibly indicating that students with relatively good high school and college academic performances persist in their original major. Students who performed less well in high school, as determined by GPA, who also face doubts about their current major may be encouraged by a good college performance to change majors.

With regard to the interaction between gender and college, females originally enrolled in the CAED or the CENG showed a greater risk of changing majors than male students initially enrolled in these colleges. In addition, male and female students who had initially enrolled in the CSM were generally at greater risk of changing majors than similar students in the CLA. In sum, females in some colleges showed a greater risk of changing majors than males in the same colleges, but in other colleges, the risk of switching was not significantly different between male and female students.

In a final and somewhat surprising finding, after adjusting for the remaining variables in the model, the risk of changing majors did not significantly vary by ethnicity, the level of education of either parent, or SAT scores. In contrast, past studies suggested that pre-college academic measures, such as high school GPA (Allen & Robbins, 2008; Crisp et al., 2009; King, 2015), SAT math score (Crisp et al., 2009), and ACT score (Allen & Robbins, 2008; Leuwerke et al., 2004), were significantly associated with major persistence.

Implications for Advisors

The major findings of the current study point to several implications for academic advising strategies at Cal Poly and other institutions with similar characteristics and change-of-major policies. They can be used to help identify the quarters when advisors might expect more student inquiries regarding changing majors. Advisors might plan for the highest interest in changing majors during a student's second or third quarter, and they can use this information to schedule change-of-major workshops. The results also provide evidence that interest in changing majors varied by initial college and quarter, and advisors in different colleges can gauge whether and when interest may be strongest for changing majors. For example, unlike those in the CSM or the CENG, advisors in the COB will likely not encounter predictable interest about switching majors from current students in any quarter.

Because interest in changing majors appeared to peak during the second and third quarters of a student's first year, advisors need to be available

to meet students during these times (or earlier) to assess whether students seem to be progressing in a major or may need information about ways to pursue developing academic and career interests. Previous research suggests that advisors should proactively engage with students in their first year and discuss college course work and expectations in a particular major, when possible, prior to entering the major (Shaw & Barbuti, 2010). Other researchers recommended that advisors meet early and work proactively with students to discuss career and self-exploration so that they can complete degree programs that interest and satisfy them (Milsom & Coughlin, 2015). Students considering a change in major need advisor recommendations as early as possible, possibly within the first college year. Evidence from previous studies indicates that switching majors early does not add significant time toward graduation (Sklar, 2014).

Some students need to change majors later in their college career, such as during the time corresponding to the second-highest peak in the hazard curves of Figure 1, fall of the cohort's third year, possibly because they could not satisfactorily complete prerequisites. These students may require substantial assistance in transitioning to a new major. A proactive, or intrusive, advising program for students seeking a new major, such as the Alternatives Advising Program instituted at The Ohio State University, as discussed in Gordon and Steele (1992) and Steele et al. (1993), might benefit them.

Although female students in engineering were at greater risk of leaving the major than their male counterparts, the reasons for this finding require more study. Advisors might benefit from closely monitoring the academic progress of female engineering students, as suggested by Shaw and Barbuti (2010), and document the reasons they cite for considering other programs or switching majors.

A current issue facing the STEM fields in higher education, especially in engineering, remains the disproportionate ratio of males to females who persist. In Fall 2016, of the CENG students at Cal Poly, 24.1% were female (California Polytechnic State University, 2016). Advisors in the CENG or the CSM could offer services or activities to keep females in STEM majors motivated to persist in their field of study. Furthermore, to ensure that more female engineering students are not lost to non-STEM fields, advisors could consider encouraging female students with appropriate backgrounds and interest to switch to an engineering or other STEM major. Studies by Ma (2011) and Xie and Shauman (2003) showed that a substantial proportion of females who earned STEM degrees had switched to or declared STEM majors after entering college undeclared or in non-STEM fields, suggesting that women may develop an interest in STEM fields early in college.

Limitations

Data limitations of this study should be kept in mind when considering the usefulness and applicability of the results. The findings were based on data from a single institution, so results are not necessarily generalizable to all students in every postsecondary institution. Furthermore, only a single cohort of students was examined such that time-specific characteristics of these students might be intrinsically different from those of student cohorts who entered in a different year.

The current analysis was also limited by the availability of information offered by the Office of Institutional Research. For example, data regarding student's financial aid and parental income could not be obtained. Hence, the final hazard model presented in Table 3 may not present trends accurately because these and other variables were not included.

Perhaps the biggest limitation of the study, the analysis substantially depended on the current policies regarding choosing and changing majors at the study institution. The results of the current analysis are most applicable to those colleges and universities with similar program of study choices and change-of-major policies; that is, Cal Poly students must choose a major prior to enrolling, cannot change majors until after the first quarter, and must submit to the conditions of a program-specific change-of-major agreement. Furthermore, because all students enter the university with a declared major, some may feel more discouragement or reluctance to initiate the change-of-major process than they might if they could enter undeclared and select a major after exploration. Conditions at Cal Poly restrict, to some extent, when a student can pursue a new program of study.

Despite the limitations outlined, the study serves as an example of the way to apply appropriate statistical methodology to investigate the timing of specific college outcomes, such as time until change of major, using readily available

institutional research data. Similar analyses could be conducted at other institutions using relevant data to inform advising practices and decisions regarding change of major under the policies in place there.

Future Work

The model described herein might be considered a reference point by which expansion is explored. The scope of the study could be expanded either by including cohorts of students from several years, students from several institutions, different categories of degree-granting universities, such as those that confer doctoral and master's degrees or with varying major selections or relatively unrestrictive change-of-major policies. The findings of a replicate study at an institution on the semester system might prove interesting because the extended length of an academic term may exert a different influence on the risk of changing majors than was seen for the quarterly system examined in this study.

This research can also be extended to include additional predictors in the discrete-time hazard model. A variable omission bias may have affected the results, because potentially important predictors, such as parental income, high school or college course work in mathematics and science, and measures of academic or social integration in college were not included in the model. Students with strong intentions to persist or who express greater satisfaction with the current major may intrinsically face lower risk of switching majors. In the future, researchers might include information on these omitted variables, including survey data about the intention to persist in a major, (dis)satisfaction with the current major, or other latent characteristics.

The two main peaks in the hazard curves indicated a greater risk of changing majors during the beginning of the second and third years, which suggests the possibility of two distinct groups of major changers. This finding comports somewhat with those of Theophilides, Terenzini, and Lorang (1984) who described *early changers*, who modify their major plans during their freshman but not sophomore year, and *late changers*, who modify their major plans in their sophomore year. A comparison of student characteristics between the two high-risk groups of major changers and the types of advising the two groups received (e.g., formal advising or informal guidance through parents or peers) may determine the drivers of changing majors early or late in a student's college career.

In the current study, change of major was determined on the basis of the quarter when the new program was officially declared on the student's enrollment profile. Some students may have been taking course work in the new major without formally entering the change-of-major process. These students may have been paying greater attention to the best time to change majors than those who took substantially less course work in the new major but initiated the change process earlier. In an alternative explanation, the time at which the change-of-major process (i.e., ICMA) was initiated may have affected the findings. The time (or quarter) at which students decided to initiate the change-of-major process was not captured by the model used in this study.

In another direction for further research, the destination college (or major) for those students who switched programs might be further investigated. For example, some preliminary evidence from the 2008 cohort data suggested that the COB was a popular destination college among those students switching out of the CSM. Does the risk of changing to a major in the COB vary by first college, gender, or quarter? Answers to these types of questions may help advisors plan for higher interest in and inquiries regarding a particular major as trends are more clearly established.

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