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Student Retention Analytics: Modeling the Effect of Poverty on College Student Retention

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ABSTRACT: Utility maximization theory is used to construct a rational choice model that examines the effects of the determinants of college student retention. The current research examines the impact that poverty has on year-to-year student persistence probabilities for freshmen students enrolled at a multicampus nonprofit private university that serves students from culturally diverse backgrounds. Institutional database records were used to generate a sample of 480 first-time full-time freshmen who were observed in between their freshmen and sophomore years. The dependent variable is a dichotomous measure of persistence taking the value of one if a student re-enrolled during the following academic year, making it possible to cross-examine the results of multiple econometric estimation methodologies including the linear probability model, logistic regression, and probit regression analysis. Additional variables, some of which are new to the persistence literature, are included to control for academic, social, financial, economic, and student background contexts. The study ends with policy-recommendations centered on the creation of attrition-minimization programs for students who come from disadvantaged backgrounds.

KEYWORDS: student retention, student persistence, poverty, attrition, neighborhood effects

Introduction

The goal of higher education is to improve economic prosperity through the development of human capital (Mulvenon, Denny, Stegman, and McKenzie 2005). Unfortunately, of the two-thirds of high school students who go to college, fifty percent drop out, and of those fifty percent who drop out, fifty percent drop out during their first year of study (Seidman 2005). Consequently, decision-makers in higher education must examine the factors that affect college student success during the first year of study. The problem of college student dropout, also known student attrition, has been an ongoing concern of stakeholders in higher education including policymakers, administrators, donors, faculty, staff, and students. Over fifty years ago, Spady (1970) used Durkheim's theory of suicide to motivate a critical review of the dropout literature. Shortly after, Astin (1972) empirically examined economic, academic, social, and psychological predictors of student dropout. Since then, the topic of college student retention is one of the most widely studied in the higher education literature.

The current study uses a rational choice model to estimate persistence probabilities for first-time freshmen enrolled in classes at a multi-campus nonprofit private university. Retention is modeled as a function of explanatory variables commonly cited in the retention literature including student background characteristics, indicators of student financial and economic contexts, and the levels of academic and social integration. Neighborhood effects, measured as student zip-code-based poverty rates, are used to assess the relationship between neighborhood context and student success. Although modeling the effect of poverty on persistence probabilities is rare in the retention literature, it is common in research that evaluates student success at the primary and secondary school levels. Another variable unique to the current study is a direct measure

of social integration calculated as the number of credits earned in an institution-specific program dedicated to building social relationships through volunteer work and service-learning activities. Finally, a series of categorical variables are included to measure the effect of location on freshmen to sophomore year persistence decisions.

Literature Review

Student retention has been examined from many different points of view, from literature incorporating qualitative analyses of the determinants of retention (Hazel and Moria 2004, Hickson 2002, Johnson and Watson 2004, Lau 2003, Taylor and Bedford 2004, Watson, Johnson, and Austin 2004) to quantitative studies that use empirical data to model persistence decisions (Bailey, Bauman, and Lata 1998, Blose 1999, Cabrera and Castaneda 1993, Dey and Astin 1993, Kerkvliet and Nowell 2005, Sandler 2000, Wetzel 1999). Two of the most widely cited theories used to study student retention include Tinto's theory of goal and institutional commitment and Bean's student attrition model (Bagayoko 1994, Blose 199l, Cabrera and Castaneda 1993, Kerkvliet and Nowell 2005, Wetzel 1999).

Vincent Tinto (1975 and 1987) argued that the alignment between student social preferences and academic capabilities and the institution's academic and social frameworks affects the decision to persist. The probability that a student leaves a particular institution of higher education is affected by variables that act as proxies for student and university-specific academic and social characteristics. Since indicators of major area of study and choice of course affect academic and social integration, they are often included in retention studies (Johnson and Watson 2004, Bagayoko and Kelly 1994). On the other hand, Bean (1985 and 2000) contends that attrition is like customer turnover and that attitudinal variables such as student satisfaction and perceptions are important predictors of persistence.

Retention studies have elaborated upon these theoretical perspectives to include variables that measure financial aid, wage-based opportunity costs, major area of study, and demographic variables including gender, race, and ethnicity (Dey and Astin 1993, Wetzel 1999, Leppel 2001, Kerkvliet and Nowell 2005). Cabrera, Nora, and Castaneda (1993) accounted for external factors that affect persistence, ranging from indicators of a student's sociocultural and economic situation to those of parental and peer valuation of the importance of getting a college education. Finally, studies investigating the effect of financial aid on persistence have provided inconsistent results, with some authors finding a direct relationship between student financial need and persistence and other authors reporting an indirect effect (Wetzel 1999, Kervliet 2005).

Methods

Utility maximization theory is used to motivate the construction of a simple rational choice model that examines the effects of the determinants of college student persistence. Although some scholars have argued that students lack the sophistication required to conduct complex cost-benefits analyses that entail estimating the monetary and non-monetary benefits of persistence (Bean and Eaton 2000), others have argued that a rational choice model simply requires individuals to be able to formulate and act on reasonable estimates of the benefits and costs of persistence decisions (DesJardins and Toutkoushian 2005). Following is a revised version of Kerkvliet and Nowell's (2005) application of utility maximization theory to the problem of college student retention.

A student's utility from matriculating at the i^{th}university at time t depends on the subjective probability of graduating, P_{it}, the market and nonmarket benefits of attending the i^{th} school, Y_{it}, the explicit and implicit costs of completion, E_{it}, and the consumptive

benefits of attending the i^{th} educational institution, Z_{it}. The subjective probability that an individual will graduate from college depends on his or her background characteristics, Θ, and level of academic integration, Φ. The explicit and implicit costs of attending a particular school depend on the availability of financial aid, ξ_{it}. Finally, a student's consumptive benefits depend on his or her level of social integration, ζ_{it}. To empirically examine persistence decisions, the above categories of variables should be contained in the right-hand-side equations of empirical models of college student success, $X_i B$.

If a student's decision to enter higher education is narrowed down to the i^{th} university, he or she enrolls if the utility associated with doing so is greater than the utility from entering the workforce, denoted as U_0. That is,

$$U[P_{it}(\Theta, \Phi), E_{it}(\xi_{it}), Z_{it}(\zeta_{it}), Y_{it}] > U_0 \quad (1)$$

At the end of the year, students will revise their expectations, costs, and benefits based on their academic and social experiences at the i^{th} college or university. Students will exit their current institution if the benefits of persisting to the next term are less than the utility of entering the workforce. That is,

$$U[P_{it+1}(\Theta, \Phi), E_{it+1}(\xi_{it+1}), Z_{it+1}(\zeta_{it+1}), Y_{it+1}] < U_0 \quad (2)$$

This model can be expanded to examine how students evaluate multiple schooling options by allowing students to put side-by-side their expected utilities from attending different universities. Thus, if the expected utility from attending the j^{th}school is greater than the expected utility from remaining enrolled in classes at the i^{th} educational institution, a student will dropout. That is,

$$U[P_{it}(\Theta, \Phi), E_{it}(\xi_{it}), Z_{it}(\zeta_{it}), Y_{it}] < U\left[P_{jt}(\Theta, \Phi), E_{jt}\left(\xi_{jt}\right), Z_{jt}\left(\zeta_{jt}\right), Y_{jt}\right] \quad (3)$$

To empirically model persistence decisions, explanatory variables from constructs above including student background characteristics, indicators of student financial and economic contexts, and the levels of academic and social integration are contained in estimated models of revealed preferences. Since it is difficult to measure utility functions, rational choice models of persistence based on observed behavior, or revealed preferences, are used in empirical analyses. Econometric models used in current study include the linear probability model (LPM) estimated using ordinary least squares (OLS) and logistic regression and probit regression models estimated using maximum likelihood estimation. Dey (1993) and Wetzel (1998) outline some of the major troubles associated with using OLS and the linear probability model in the analysis of college student retention, namely counterintuitive predictions, the incorrect functional form, and the violation of the assumption of independent, randomly distributed error terms.

Logit and probit regression analysis are based on more reasonable assumptions than LPM and are therefore more theoretically appropriate in the analysis of student retention (Dey, 1993, Wetzel, 1999). Further, point estimates of parameter coefficients estimated using maximum likelihood are asymptotically consistent, efficient, and normally distributed (Long 1997). In logit and probit regression analysis, the probability of a student staying or leaving a particular school is linked to both the magnitude and the sign of parameter coefficients for explanatory variables included in the model. The logistic regression function is S-shaped and is considerably more vertical when the probability of retention is 0.5 and flattens out on both ends as the probability approaches 0 and 1 (Dey 1993). Since probit regression analysis uses the cumulative normal distribution function,

which is also S-shaped, to estimate persistence probabilities, it is based on distributional assumptions similar to logit regression analysis (Wooldridge 2003).

Sample and Data

The current research uses LPM, logit, and probit regression analysis to empirically examine the effect of student background variables, student financial and economic contexts, and the levels of academic and social integration on year-to-year persistence decisions for traditional students enrolled at a small private business university with campuses located in the Midwest, Southeast, and Southcentral regions of the United States. Traditional students are first-time full-time freshmen who are United States citizens under twenty-five years of age. Data obtained on a cohort of traditional freshmen students for the 2000-01 and 2001-02 academic years were merged with 2000 census data to include zip-code-based poverty rates. Out of the sample of 1,496 freshmen students in attendance on all three campuses, a total of 651 students fit the definition of traditional students. Due to data limitations, 480 students were included in the sample. Table 1 provides an overview of variable definitions and descriptive statistics for the dependent variable and explanatory variables used in this study.

The dependent variable, stay, is a dichotomous measure of persistence taking the value of one if a student re-enrolled during the 2001-02 academic year and zero otherwise. Student background variables including location, zip-code-based poverty rates, expected family contribution, race, gender, and ethnicity are included as explanatory variables. Variables included as controls for the academic and social environments include high school class percentile rankings, the change in college grade point averages, major area of specialization, and whether students participate in a Greek organization, are a merit scholar, or are a recipient of athletic scholarships. A direct measure of student social integration equal to credits earned engaging in community service is also included, *excel01*. The financial and economic context are controlled for using student loans measured in thousands of dollars and the effective price measured as tuition less all sources of financial aid.

Table 1: Descriptive Statistics and Variable Definitions

Variable	Description	Mean	Stdev	Min	Max
stay	1=Stay, 0=Otherwise	0.711	0.454	0.000	1.000
female	1=Female, 0=Otherwise	0.392	0.488	0.000	1.000
black	1=Black, 0=Otherwise	0.220	0.414	0.000	1.000
hisp	1=Hispanic, 0=Otherwise	0.089	0.286	0.000	1.000
povrate	Zip Code Based Poverty Rates	9.815	8.056	0.899	46.308
excel01	Total Excel Credit 2001	3.369	4.423	0.000	35.000
greek	Greek System Participation	0.157	0.364	0.000	1.000
athl	Total Athletic Scholarships	0.549	1.969	0.000	18.965
hsrnkpct	HS Class Ranking	44.887	24.315	0.22	98.990
chgpa	Change in College GPA	-0.205	0.970	-3.930	3.350
merit	1 = Merit Scholar, 0=otherwise	0.610	0.488	0.000	1.000
loans	Total Loans 2001	2.702	3.055	0.000	2.063
efc	Estimated Family Contribution	8.502	15.364	0.000	100.000
price	Tuition Less Financial Aid	3.168	6.463	0.000	15.000
MGT	1=Management Major, 0=Otherwise	0.178	0.383	0.000	1.000
FIN_ECN	1=Fin and Ecn Major, 0=Otherwise	0.091	0.288	0.000	1.000
FMM	1=Fashion Major, 0=Otherwise	0.049	0.216	0.000	1.000
SouthC	1=Texas Attendance, 0=Otherwise	0.154	0.361	0.000	1.000
SouthE	1=Florida Attendance, 0=Otherwise	0.173	0.379	0.000	1.000

**Dollar amounts in thousands*

Research Hypotheses

It is hypothesized that student background variables affect the probability of retention in between the first and second years of study. Since research that examines the impact of student background variables including gender, race, and income is uncertain in terms of the magnitude and sign of the effect, the precise nature of the effect of demographics is unknown (Bagayoko 1994, Bean and Metzner 1985, Dey and Astin 1993, Leppel 2001, Wetzel 1999). Bean (1985) noted that such inconsistencies exist because researchers that include student demographic data in retention models use different controls leading to different results. To the extent that sociocultural and economic factors differ for students from poverty-stricken neighborhoods, and to the extent that such differences affect student persistence probabilities, it is hypothesized that students from poverty-stricken neighborhoods are less likely to persist.

Variables that measure the degree to which students are academically integrated including high school rank percentiles, whether a student is a merit scholar, the change in college grade point averages, and major area of study are hypothesized to impact retention. Categorical variables are included to control for academic majors including general management, fashion merchandising, and finance and economics. Indicators of social integration including participation in social organizations, extracurricular activities, and college sports are all hypothesized to affect student social integration, and therefore college student retention. The financial and economic context are controlled for using student loans, the effective price, and estimated family contribution, all of which are measured in thousands of dollars and hypothesized to impact student success. Estimated family contribution is a federally computed income-based figure that reports the dollar amount families must contribute to the annual costs of a higher education.

Results and Discussion

Regression results are presented in Table 2. Columns are arranged to facilitate comparisons between base and elaborated models to examine how parameter coefficients change when new variables are entered into estimation equations. Tables 2 and 3 show that LPM, logistic regression, and probit regression analysis provide similar results in terms mean predicted probabilities. The size, sign, and level of statistical significance of coefficients estimated using logit and probit regression are also extremely similar, which will be ascertained more completely by examining marginal effects at variable means and odds ratios. Due to the previously discussed problems with LPM and the advantages of the logit and probit models estimated using maximum likelihood estimation, the results from the logit and probit regressions will be emphasized.

Table 2: Econometric Models of Student Retention

	Logit Models 1-3			**Probit Models 1-3**		
Stay	**L1**	**L2**	**L3**	**P1**	**P2**	**P3**
female	0.0285	-0.4289	*-0.6360	0.0127	-0.2657	**-0.3910
	0.9080	0.1610	0.0520	0.9310	0.1280	0.0350
black	*-0.6060	-0.3874	*-0.7889	**-0.3801	-0.2263	*-0.4281
	0.0590	0.3290	0.0640	0.0500	0.3260	0.0800
hisp	0.0569	0.0593	-0.5687	0.0392	0.0254	-0.2947
	0.8820	0.8930	0.2660	0.8630	0.9190	0.2970
povrate	-1.4740	**-4.7387	**-4.1370	-0.7988	**-2.5178	*-2.2423
	0.3960	0.0180	0.0440	0.4410	0.0290	0.0570
excel	***0.1954	***0.1262	***0.1678	***0.1106	***0.0657	***0.0934
	0.0000	0.0090	0.0030	0.0000	0.0100	0.0020
greek	***1.9289	***1.6674	***1.5945	***1.0450	***0.8892	***0.8417

	0.0000	0.0040	0.0070	0.0000	0.0030	0.0050
athl	***0.0003	0.1654	0.1672	***0.0002	0.0918	0.0812
	0.0040	0.1650	0.1680	0.0030	0.1500	0.1880
hsrankpct		**-0.0163	**-0.1631		***-0.0098	**-0.0098
		0.0120	0.0160		0.0090	0.0110
chgpa		***1.0582	***1.0637		***0.6247	***0.6233
		0.0000	0.0000		0.0000	0.0000
merit		0.4396	0.4409		0.2466	0.2509
		0.1630	0.1740		0.1730	0.1760
loans		**-0.1125	*-0.1102		**-0.0629	*-0.0623
		0.0410	0.0540		0.0450	0.0530
efc		0.0084	0.0080		0.0046	0.0046
		0.3740	0.4300		0.4030	0.4350
price		**-0.0905	***-0.0836		***-0.0506	***-0.0475
		0.0020	0.0060		0.0020	0.0060
MGT			0.5586			0.3490
			0.1550			0.1110
FIN_ECN			**-0.9894			**-0.5648
			0.0240			0.0250
FMM			0.7233			0.4000
			0.2930			0.3150
SouthE			-0.3066			-0.1793
			0.3660			0.3510
SouthC			**1.0124			**0.5547
			0.0150			0.0150
P-R²	0.13	0.31	0.34	0.13	0.31	0.34
LR	68.93	168.41	186.95	69.17	168.45	187.53
LL	-237.63	-187.89	-178.62	-237.51	-187.87	-178.33

***Significant at 1 percent
**Significant at 5 percent
*Significant at 10 percent

Table 3: Mean Predicted Probabilities

Variable	Mean	Std. Dev.	Min.	Max
Stay	0.7458	0.4359	0	1
LPM	0.7458	0.2453	-0.0025	1.3617
Logit	0.7458	0.2565	0.0316	0.9998
Probit	0.7462	0.2543	0.0254	0.9999

A series of likelihood ratio tests based on the chi-square distribution indicate that all categories of variables hypothesized to affect persistence probabilities including student background variables, indicators of academic integration, measures of social integration, major area of study, and location, are statistically significant at below the five percent level of significance. Base logit and probit models estimated include student background variables and measures of student social integration as regressors. These models are elaborated upon to include indicators of academic integration and financial status, and then again to account for major area of specialization and location. Whether key categories of variables are included in the elaboration paradigm has an impact on the size, sign, and statistical significance of parameter coefficients.

Whether a student is black is statistically significant in models that only account for student background variables and indicators of social integration but becomes statistically insignificant once measures of academic integration and financial status are included as

controls. In fully elaborated models, whether a student is black has a negative effect on retention and is statistically significant at below the five percent level. Whether a student is female has a negative and statistically significant impact on retention, a finding that replicates Leppel's (2001) observation that females majoring in business are less likely to persist. The relative magnitude of the effect of zip-code-based poverty rates stabilizes after the base-case model is elaborated upon to include measures of academic integration and financial status. Even after controlling for expected family contribution, zip-code-based poverty rates are negatively and statistically significantly related to college student retention. Those from poverty-stricken neighborhoods might have social and cultural capital that is less transferrable to a higher education setting.

Indicators of the degree to which students are socially integrated including whether a student is a member of a Greek social organization, participation in varsity sports, and the number of volunteer and service-learning credits earned have a statistically significant correlation with persistence decisions. All variables take their expected signs, although competing in sports becomes statistically insignificant when academic integration, financial aid, major area of study, and location are included as explanatory variables. Positive changes in college grade point averages have a positive and statistically significant effect on persistence probabilities, whereas high school rank percentiles have an inverse effect. The dollar value of tuition less financial aid and loans are statistically significantly and inversely related to first-year retention. The negative coefficient on loans might be more indicative of socioeconomic status than the financial benefits of additional funding. Finally, whether students major in finance and economics is negatively correlated with retention and whether students are enrolled in classes at the south-central campus is positively related to first year success.

The degree to which the size, sign, and level of statistical significance of coefficients are consistent from one estimation methodology to the next can be determined through an examination of marginal effects at variable means and odds ratios. As you can see by looking at Table 4 below, the marginal effect on the probability of retention for a one-unit change in a regressor, holding other variables constant at their means, can vary significantly by estimation technique, a finding that contradicts Dey's (1993) observation that there is little practical significance of using maximum likelihood estimation despite its theoretical advantages. For example, the probit model predicts that the probability of persistence will decrease by 32.94 percent for students who are black, whereas logistic regression and the linear probability model predict a change equal to 5.82 percent and 5.16 percent respectively.

Given a discrete change in whether a student is a female, i.e., from 0 to 1, the probability of persistence decreases by 0.06, or roughly 6 percent. Furthermore, as zip code-based poverty rates increase by one percentage point, the probability of persistence decreases by roughly 0.01*0.6534 = 0.65 percentage points. The remaining variables can be interpreted similarly in terms of marginal effects. A quick review of the odds ratio for females indicates that female students are about 34.88 percent less likely to persist as compared to male students. Similarly, for a one percentage point increase in a student's home zip code-based poverty rate, a student is roughly 4.63 percent less likely to persist from one year to the next. The linear probability model predicts that a one-unit change in *excel01* increases the probability of persisting by 0.99 percent, whereas the logit and probit models predict changes equal to 1.74 percent and 1.71 percent respectively.

Table 4: Marginal Effects at Means and Odds Ratios

	Marginal Effects			Odds Ratio
Variable	LPM	Logit	Probit	Logit
female*	-0.0676	-0.0610	-0.0708	0.6512
black*	-0.0516	-0.0582	-0.3294	0.6788
hisp*	0.0304	0.0081	0.0065	1.0611
povrate	-0.0069	-0.0065	-0.0065	0.9537
excel01	0.0099	0.0174	0.0171	1.1345
greek*	0.1316	0.1573	0.1681	5.2987
athl	0.0057	0.0228	0.0239	1.1799
hsrankpct	-0.0023	-0.0023	-0.0025	0.9838
chgpa	0.1773	0.1460	0.1624	2.8812
merit*	0.0745	0.0634	0.0663	1.5521
loans	-0.0184	-0.0155	-0.0163	0.8936
efc	0.0012	0.0012	0.0012	1.0084
price	-0.0157	-0.0125	-0.0131	0.9135

*Discrete changes in dummy variables from 0 to 1

Conclusion

The current research used a rational choice model to examine the determinants of college student retention for students enrolled at a multi-campus private university. A base model consisting of student demographics and indicators of social integration was expanded upon to include categories of variables identified in the persistence literature. Excluding variables known to affect student retention distorts the relative importance and the direction of the effect of included variables. The findings of fully elaborated upon models of retention varied by estimation methodology. More specifically, the magnitude of the effect on probability of persistence for a one-unit change in independent variables under analysis can vary considerably depending on whether the linear probability model, logistic regression, and probit regression analysis is used to obtain results. Statistical evidence supports the inclusion of a variable unique to the current study, a direct measure of student social integration. Statistical evidence also supports the inclusion of zip code-based poverty rates in econometric models of college student success. Since it is likely that the effects of poverty compound over time and permeate all aspects of life, attrition minimizations programs should be focused on early intervention strategies that make it possible for students from disadvantaged backgrounds to thrive in higher education.

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