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Measuring, Manipulating, and Predicting Student Success: A 10-Year Assessment of Carnegie R1 Doctoral Universities Between 2004 and 2013

Nathaniel L. Wade[1]

Abstract

Student success measurements for 4-year institutions of higher education are a topic of importance for numerous stakeholders including prospective and current students, parents, staff, faculty, administrators, governing boards, policymakers, and citizens. Common measures of student success are retention rates and 4- and 6-year graduation rates. However, the standardization, accuracy, and reporting of these rates are less than scientific due in part to the operational definition provided by the federal government for reporting graduation rates. The current system for reporting retention and graduation rates are flawed. As accountability continues to increase for institutions of higher education, this analysis provides comparative, qualitative, and quantitative research with the goal of informing and assisting universities, as they strive to increase the rates at which their students succeed. A particular emphasis will be placed on an empirical analysis over a 10-year period of time for retention and graduation rates of 115 Carnegie R1 doctoral universities.

[1]School for the Future of Innovation in Society, Center for Organization Research and Design, Arizona State University, Phoenix, AZ, USA

Corresponding Author:
Nathaniel L. Wade, School for the Future of Innovation in Society, Center for Organization Research and Design, Arizona State University, 550 North 3rd Street, Phoenix, AZ 85004, USA.
Email: nathaniel.wade@asu.edu

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Introduction

The emphasis on retention and graduation rates of colleges and universities over the past half century has increased significantly. Accountability for institutions of higher education has evolved over time through multiple initiatives including performance-based funding, strategic planning of institutions, strategic planning of governing boards, the development of university ranking systems through media outlets, and public policies requiring increased transparency within higher education (Alexander, 2000; O'Meara, 2007; Pusser, 2004; Shin & Toutkoushian, 2011). Most of these initiatives track, measure, and report student success at universities and colleges in the form of 1-year retention and 6-year graduation rates. A continued focus on institutional retention and graduation rates has transformed student success into a major academic and financial business comprised of numerous scholarly articles, books, conferences, consulting agencies, and even a journal (Tinto, 2006). To better understand the current state as well as the future of student success, a review of the past should be undertaken in conjunction with empirical research to formulate and guide future recommendations and policies involving retention and graduation rates for institutions of higher education.

Literature Review

Historical Origin of Student Retention

Berger and Lyon (2005) provide a very thorough and comprehensive review of the history and early developments of retention and graduation rates. One of the earliest studies of student retention and persistence focused on students failing to thrive in institutions of higher education. The study's focus was on student mortality which likened student attrition to a figurative death of the student (McNeely, 1938). In his study, McNeely (1938) collected data from 60 institutions throughout the United States in an attempt to better understand student attrition at universities by assessing various factors including student attributes (age to part-time employment), when and why the student left the institution, and the average time it took for a student to obtain a degree (Berger & Lyon, 2005). It took nearly 30 years after McNeely's study for the field of student retention and persistence to move to its more formative stage.

Theory Development for Student Retention

During the 1970s, several scholars began to develop theories regarding student dropout, student retention, and student persistence. Spady (1970) conducted a review of empirical literature developed during the 1960s regarding dropouts. On completing the review, he implored others to perform more research regarding interactions between students and their environment (Spady, 1970). Shortly thereafter, Tinto (1975) developed his interactionist theory of student departure by applying Durkheim's (1951) theory of suicide to student dropout. Astin (1977) was also a major contributor to the foundational theories of student retention due to the extensive databases he built to explore student retention in order to build theory. Through his research, student involvement was deemed to be a major component of student retention (Astin, 1977). Bean (1980) also contributed to theory development within retention by applying worker turnover theory to better explain student retention and dropout. Collective theory building from scholars regarding student dropout led to an even more extensive analysis of retention and graduation rates through both quantitative and qualitative analysis (Astin, 1971; Bean, 1990; Tinto, 1987).

Understanding Student Retention and Graduation Through Empirical Research

Once a theoretical foundation was established, empirical analyses began to proliferate in order to test the developed theories, develop new theories, and explain the effects that individual and institutional characteristics had on student retention and graduation (Astin, 1991; Goenner & Snaith, 2004a; Pascarella & Terenzini, 1991; Tinto, 1987). Several studies demonstrated that a student's individual characteristics including high school grades, high school class rank, admissions test scores, and race were important for retention and graduation rates (Astin, 1991, 1993, 1997; Goenner & Snaith, 2004a, 2004b), while other studies established that institutional characteristics also affected student success and student completion rates (Goenner & Snaith, 2004a; Tinto, 1987, 1999). To develop a robust theoretical framework on a student's decision to depart college, Cabrera, Nora, and Castaneda (1993) merged Tinto's (1975, 1987) student integration model and Bean's (1985) student attrition model by deploying a two-step structural equation modeling strategy. In addition to the aforementioned empirical studies, other studies have been undertaken to quantitatively evaluate and understand factors that affect retention and graduation rates using various methods including stepwise linear regression analysis (Astin, 2005), Bayesian model averaging for variable selection (Goenner & Snaith, 2004b), survival of failure analysis (Murtaugh, Burns, & Schuster, 1999), logistic regression and probit analysis (Dey & Astin, 1993; Kroc, Howard, Hull, & Woodard, 1997), multiple regression analysis (Astin, 1997), linear regression (Dey & Astin, 1993),

factor analysis, multivariate analysis of covariance, setwise discriminant analysis, and classification analysis (Pascarella & Terenzini, 1980). As student retention and graduation theory continued to be strengthened by scholars from the 1980s to the 2000s, other developments were slowly taking form within higher education through enrollment management, institutional accountability, public policy, and university ranking systems.

Institutional, Governmental, and Media Involvement in Student Success Measures

In an effort to sustain and even increase revenues during a period of stagnant enrollment growth during the 1980s, administrators began to focus on retaining students while simultaneously creating a student body of quality and quantity through a process known as enrollment management (Berger & Lyon, 2005). Concurrently with the development of enrollment management in the 1980s, *U. S. News and World Report* (*USNWR*) published its first *Best College Rankings* during 1983. *USNWR* switched its methodological ranking formula during 1988 to include retention and graduation rates which

> increasingly created greater public awareness about and institutional responsiveness to retention rates. As a result, campuses around the country have become increasingly concerned about retention rates as a source of prestige that can be converted into other kinds of symbolic, material, and human resources—particularly in the competition for more students. (Berger & Lyon, 2005, p. 5).

USNWR continues to use retention and graduation rates as part of its ranking methodology formula. *USNWR*'s 2016 best colleges methodology has retention set as 22.5% of the total score where 6-year graduation rates contribute to 80% of the retention score and first-year retention rate contributes to the final 20% of the retention score (Morse, Brooks, & Mason, 2015). As media outlets like *USNWR* began publishing their data publically to better inform consumers of higher education, sell magazines, and keep stakeholders in suspense year to year (Machung, 1998), the federal government began its attempt to hold institutions of higher education more accountable by passing legislation requiring the publication of graduation rates.

The Student Right-to-Know and Campus Security Act (1990) was a bill passed by the 101st Congress that became public law on November 8, 1990, in order to provide better information to potential consumers of higher education while holding colleges and universities more accountable. The bill amended the Higher Education Act (HEA) of 1965 to require:

> . . . all institutions of higher education participating in any program under HEA title IV (Student Assistance) to disclose the completion or graduation rate of

> certificate- or degree-seeking, full-time students entering those institutions. Sets forth formulas for determining such rates. Allows institutions to exclude from such rates students who leave school to serve in the armed services, on official church missions, or with a recognized Federal foreign aid service. (Student Right-to-Know and Campus Security Act, 1990).

To assist institutions with reporting their graduation rate, the Graduation Rate Survey was developed by the National Center for Education Statistics and housed within the Integrated Postsecondary Education Data System (IPEDS) of the U.S. Department of Education (Albright, 2010). The following are current operational definitions for retention rates and graduation rates that can be found within the U.S. Department of Education's IPEDS glossary of terms:

> *Retention Rate*: A measure of the rate at which students persist in their educational program at an institution, expressed as a percentage. For four-year institutions, this is the percentage of first-time bachelors (or equivalent) degree-seeking undergraduates from the previous fall who are again enrolled in the current fall. For all other institutions this is the percentage of first-time degree/certificate-seeking students from the previous fall who either re-enrolled or successfully completed their program by the current fall. (U.S. Department of Education, 2016a)
> *Graduation Rates:* The rate required for disclosure or reporting purposes under Student Right-to-Know Act. This rate is calculated as the total number of completers within 150% of normal time divided by the revised adjusted cohort. This annual component of IPEDS was added in 1997 to help institutions satisfy the requirements of the Student Right-to-Know legislation. Data are collected on the number of students entering the institution as full-time, first-time, degree/certificate-seeking undergraduate students in a particular year (cohort), by race/ethnicity and gender; the number completing their program within 150 percent of normal time to completion. (U.S. Department of Education, 2016a)

Calculating Retention and Graduation Rates

To calculate retention and graduation rates for 4-year institutions, a cohort must be developed and tracked over time according to the terms provided by the Student Right-to-Know and Campus Security Act as well as the above retention rate and graduation rates definitions. To track each year's cohort of first-time, full-time freshmen, an institution's response to the Institutional Characteristics survey question regarding its predominant calendar system determines how the cohort for reporting is formed (Albright, 2010). Institutions with standard academic terms must annually identify a fall cohort of first-time, full-time freshmen who entered either the summer or fall of the year in which they initially enrolled. Institutional cohorts are determined by

institutional census dates that can range from the end of the institution's drop-add period until October 15 for the year in which the freshmen class entered (Albright, 2010). The technical definitions of retention rates, graduation rates, cohort formation, and census dates provide a springboard to discuss several fundamental flaws and loopholes that prohibit a complete or accurate measurement of student success, decrease the reliability of the reported data, and provide vague or loose definitions for institutions to interpret. Through institutional interpretation, the possibility arises for institutions to manipulate or game the system.

Comparing colleges and their outcomes has been a contentious matter within higher education (Anderson & Rucker, 2013). In fact, defining and calculating retention and graduation rates has been a source of confusion for many colleges and universities (Albright, 2010; Anderson & Rucker, 2013). By excluding all first-time, full-time freshmen who begin in the spring semester, all part-time students, and all students who transfer into the institution, the definition used to measure graduation rates has excluded nearly 61% of students at 4-year institutions according to calculations from the American Council on Education (Cook & Hartle, 2011; Glenn, 2010).

Hagedorn (2005) notes that some institutions only admit students with the highest admission test scores to their fall cohorts while allowing students with lower admission test scores to only be admitted during the spring semester. Other institutions allow students to meet admission requirements by increasing the acceptable criteria to include a combination of Scholastic Aptitude Test (SAT)/American College Testing (ACT) score, high school class rank percentage, or overall grade point average (GPA). This allows students who struggle with standardized testing to avoid taking or reporting their standardized test while allowing the institution to also avoid reporting a test score for that student. This type of admissions criteria allows institutions to provide access to students while also allowing the institution to potentially avoid lowering its institutional SAT mean.

Astin (1993) argues that a simple retention rate is more indicative of who a university admits rather than the effectiveness of the institution's retention strategy. Through the development of formulas from multiple regression analysis, Astin conducted a longitudinal study of 39,243 students from 129 four-year colleges and institutions to demonstrate that expected rates versus actual rates of student retention can vary drastically. The comparison between expected to actual retention rates illustrates how effective an institution can be in retaining and graduating its students while accounting for the complexity involved in comparing dissimilar institutions (Astin, 1993; Cook & Hartle, 2011).

Critics of the statistics used to calculate retention and graduation rates often cite the issue of student mobility due to the inability of institutions to count students who transfer between institutions and complete their degree elsewhere (Carey, 2004). A report by the National Center for Education Statistics

demonstrated a 7% increase in reported student completion when adding in students who completed their degree at their original institution or any other 4-year institution (Berkner, He, & Cataldi, 2002).

The variability in census date per institution demonstrates a lack of national standardization in defining institutional cohorts by one defined date, length of time, or percentage of time. The lack of standardization for institutional census dates is less than scientific and has the potential to muddle comparative studies of similar institutions. For example, one institution may select to have its census date very early in the semester, while another institution may wait until October 15 to set its census date. Overall, there are several fundamental flaws in the current operational definition used to report and calculate retention and graduation rates of 4-year institutions.

Research on Retention and Graduation Rates

The study of retention and graduation has developed rapidly over the past 50 years with an ever increasing focus on accountability with many states linking resources to specific measures of retention and graduation rates (Tinto, 2006, 2002). Despite the continued emphasis on accountability, the federal definitions and methodologies used to calculate student success remain limited in scope. In fact, taking advantage of loopholes and gaming the system has recently been reported for Mount St. Mary's, Claremont McKenna, Villanova University, and the University of Illinois (Brown, 2016; Bult, 2016; Perez-Pena & Slotnik, 2012).

This study will use comparative analyses and several examples of colleges and universities in an attempt to explain changes in retention and graduation rates over 10 years. In addition, this study will focus on how both student characteristics and institutional characteristics affect retention and graduation rates over a 10-year period of time between 2004 and 2013 at Carnegie R1: doctoral universities through the use of a multiple linear models including random and fixed effects.

The review of several previous studies involving student and institutional characteristics aided in developing the hypotheses for this study. Knott and Payne (2004) conducted a review of previous studies that demonstrated that autonomous private universities were superior performers as compared with public universities. The governance of universities may affect organizational management and strategy by forcing highly regulated systems like public institutions to focus on politically prioritized strategies (i.e., keeping tuition low, increasing retention, and graduation rates) compared with minimally regulated systems like private institutions that tend to focus on research productivity and income or tuition revenues (Enders, De Boer, & Weyer, 2013). Campus size has been positively correlated with university performance (Eykamp, 1995), while a study of 258 Carnegie I institutions found that SAT scores affect graduation rates in a significant and positive manner (Goenner & Snaith, 2004a). Astin (2005)

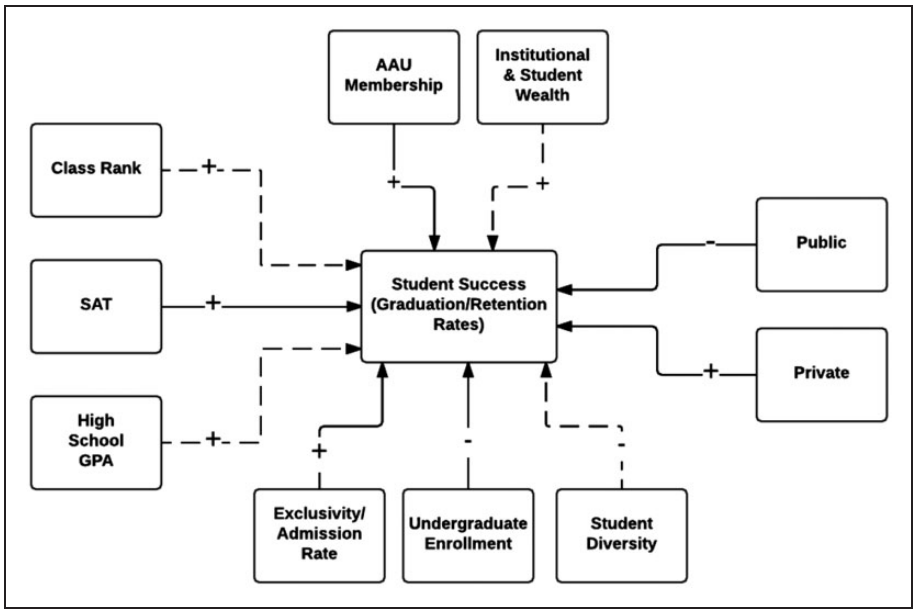

Figure 1. Factors influencing student success at R:1 doctoral universities. AAU = Association of American Universities; GPA = grade point average.

found institutional selectivity to be "the most important college characteristic affecting the student's chances of completing the baccalaureate degree" (p. 10).

Research Hypotheses

The hypotheses for this study are shown in Figure 1. The hypothesized factors being investigated are indicated with solid arrows with positive and negative effects. The dotted arrows illustrate variables from past empirical research shown to influence retention and graduation rates. As each hypothesized factor increases, the effect on retention and graduation rate is indicated by a (+) or (−). The variables with dotted arrows were mentioned in earlier sections of this study but are not included within the hypotheses due to the College Scorecard not having certain metrics available (high school GPA, class rank, alumni giving, and institutional endowment) as well as changes that occurred in the definition of race/ethnicity over time (student diversity). The hypotheses for this study are as follows:

Hypothesis 1: The mean institutional SAT will have significant and positive effects on 1-year retention and 6-year graduation rates.

Hypothesis 2: The more selective an institution is (admission rate) a significant and positive effect on 1-year retention and 6-year graduation rates will be observed.
Hypothesis 3: Smaller institutional enrollment will have significant and positive effects on 1-year retention and 6-year graduation rates.
Hypothesis 4: Compared with public institutions, private institutions will have significantly increased 1-year retention and 6-year graduation rates.
Hypothesis 5: Membership in the Association of American Universities (AAU) will have a significantly positive effect on 1-year retention and 6-year graduation rates.

Data Collection

Previous studies have investigated Carnegie I research universities (Goenner & Snaith, 2004b) as well as members of the AAU and Land Grant universities (Kroc, Woodard, Howard, & Hull, 1995). For this study, a data set was constructed from raw data obtained through the College Scorecard (U.S. Department of Education, 2016b) for a 10-year period beginning in 2004 and ending in 2013. Using the most recent Carnegie Classification of Institutions of Higher Education (2016), each of the 115 R1: doctoral universities with the highest research activity was selected out of 7,234 postsecondary title IV institutions of higher education with 4,706 of those being degree granting institutions (U.S. Department of Education, 2015). The use of Carnegie R1 institutions for this study allowed for institutional variability to be limited by using only one type of institution from a well-established university categorization system. The data set was constructed to have 115 subjects based on each university's identification number. The City University of New York was removed for each year due to a lack of reported data. The repeated measure for this study was time (10 individual years 2004–2013) due to it being nested within each institution. Each year contained the variables listed from the College Scorecard for each institution including 1-year retention rate, 6-year graduation rate, mean SAT, admission rate, and total enrollment. Dummy variables were made for private institutions ($0 = public$ and $1 = private$) and AAU members ($0 = nonmember$ and $1 = member$). In addition, to control for year effects, individual years were added and coded as dummy variables. All 10 individual years were combined to create panel data.

Methodology

Comparative analyses were performed for all 115 Carnegie R1 institutions in order to yield the 10-year change in retention and graduation rates, the 10 highest 1-year increases in retention and graduation rates, and the 10 highest 10-year increases in retention and graduation rates. Further investigation using the comparative analyses allowed for specific institutions to be explored.

In addition to the comparative analyses, multiple linear models were performed with one dependent variable being institutional retention rates and the other dependent variable being graduation rates over a 10-year period of time. The National Center for Education and Regional Assistance within the Institute of Education Sciences of the U.S. Department of Education has developed a helpful primer for analyzing nested data through the use of multilevel modeling (O'Dwyer & Parker, 2014). For this study, the plm statistical package for R was used to perform both random and fixed effects models (Croissant & Millo, 2008).

Results

Comparative Analyses of Retention and Graduation Rates

A comparative analysis can be found in the Supplementary Material demonstrating changes over a 10-year period of time (2004–2013) for each institution's retention rate (Supplementary Table A1) and graduation rate (Supplementary Table A2).

To better understand individual institutions and the highest increases in retention and graduation rates, a comparative analysis was conducted to identify the 10 highest increases in retention rates from 2004 to 2013 for R1 institutions (Table 1), the 10 highest increases in graduation rates from 2004 to 2013 for R1 institutions (Table 2), the 10 highest increases in retention rates for a 1-year period of time during 2004 to 2013 for R1 institutions (Table 3), and the 10 highest increases in graduation rates for a 1-year period of time during 2004 to 2013 for R1 institutions (Table 4).

Table 1. Ten Highest Increases in Retention Rate from 2004 to 2013 at R1: Doctoral Universities.

University name	2004 (%)	2013 (%)	Change (%)
The University of Texas at Dallas	80	88.11	8.11
University of South Florida—Main Campus	81	88.78	7.78
University of Houston	77	84.63	7.63
The University of Tennessee–Knoxville	78	85.63	7.63
University of Cincinnati—Main Campus	77	84.62	7.62
Virginia Commonwealth University	79	86.59	7.59
Northeastern University	88	95.53	7.53
Arizona State University–Tempe	77	84.40	7.40
University of Massachusetts–Amherst	82	89.30	7.30
George Mason University	81	87.28	6.28

Table 2. Ten Highest Increases in Graduation Rate From 2004 to 2013 at R1: Doctoral Universities.

University name	2004 (%)	2013 (%)	Change (%)
Northeastern University	59.87	82.56	22.69
Ohio State University—Main Campus	62.10	83.23	21.13
University of Louisville	33.07	53.43	20.36
University of Minnesota—Twin Cities	56.43	75.40	18.97
University of Cincinnati—Main Campus	41.31	57.90	16.59
University of South Florida—Main Campus	46.69	63.21	16.52
University of Alabama at Birmingham	37.73	53.77	16.04
Virginia Commonwealth University	40.78	56.81	16.03
George Mason University	52.77	66.70	13.93
University of Pittsburgh—Pittsburgh Campus	67.38	80.44	13.06

Table 3. Ten Highest Yearly Increases in Retention Rate During 2004 to 2013 at R1: Doctoral Universities.

University name	Retention (%; year)	Retention (%; year)	Change (%)
University of South Florida—Main Campus	80.93 (2007)	88.01 (2008)	7.08
Wayne State University	69.68 (2008)	76.11 (2009)	6.43
Florida International University	78.00 (2006)	83.91 (2007)	5.91
University of Texas at Arlington	60.09 (2008)	65.11 (2009)	5.02
University of Nebraska–Lincoln	79.00 (2004)	84.00 (2005)	5.00
University of Texas at Arlington	65.11 (2009)	69.86 (2010)	4.75
University of Mississippi	80.84 (2012)	85.58 (2013)	4.74
Kansas State University	74.28 (2008)	78.99 (2009)	4.71
Arizona State University–Tempe	79.95 (2012)	84.40 (2013)	4.45
University of Kentucky	76.37 (2007)	80.80 (2008)	4.43

Notable Institutions

For this study, the University of Texas at Dallas (UT-Dallas) had the greatest positive increase in retention rates over a 10-year period (Table 1), while Northeastern had the greatest positive increase in graduation rates over a 10-year period of time (Table 2). These two institutions will serve as examples of institutions that significantly increased their retention and graduation rates. After running descriptive statistics for the data set, Arizona State University (ASU) emerged as an outlier due to having both the highest increase and decrease in enrollment over a 10-year period of time for all 115 institutions. ASU also appears as one of the top highest increases in yearly retention rates

Table 4. Ten Highest Yearly Increases in Graduation Rate During 2004 to 2013 at R1: Doctoral Universities.

University Name	Retention (%; year)	Retention (%; year)	Change (%)
University of Texas at Arlington	41.66 (2006)	51.90 (2007)	10.24
University of Utah	46.20 (2006)	55.99 (2007)	9.79
University of South Florida—Main Campus	56.55 (2012)	63.21 (2013)	6.66
University of Utah	51.12 (2008)	57.59 (2009)	6.47
University of Delaware	75.61 (2011)	81.98 (2012)	6.37
Ohio State University—Main Campus	62.10 (2004)	68.22 (2005)	6.12
University of Illinois at Chicago	48.14 (2008)	54.13 (2009)	5.99
Georgia State University	41.44 (2006)	47.19 (2007)	5.75
Stony Brook University	61.36 (2008)	67.08 (2009)	5.72
University of Delaware	68.32 (2009)	74.02 (2010)	5.70

over a 1-year period (Table 3) and 10-year period (Table 1). Finally, a very recent example will be explored in which a retention plan developed by the president of Mount St. Mary's came under intense national scrutiny. Several institutions in the past 10 years have either inflated their reported scores or misreported their statistics including Claremont McKenna, Villanova University, and the University of Illinois (Perez-Pena & Slotnik, 2012). This study does not allege any dishonesty or make a value judgment on the institutions involved in the examples. Instead, each institution within three of the four examples (Northeastern, UT-Dallas, and ASU) has demonstrated over a 10-year period of time that they have had some of the most significant gains in retention and graduation rates. The final example of Mount St. Mary's made national headlines and concluded with the resignation of its president (Brown, 2016; Svrluga, 2016). Three of these cases may serve as examples for administrators and policy makers who are interested in increasing their retention and graduation rates. The fourth case serves as an example for institutions on how to avoid disastrous public relations due to trying to game their retention or graduation rates.

Northeastern University

Kutner (2014) provides an extensive review of how Northeastern University climbed the *USNWR* Best College rankings from 162 to 49 over 17 years. In his very detailed examination of Northeastern University, Kutner chronologically displays the multiple methods that Joseph Aoun, the school's 12th president, took over time to infuse the gaming of college rankings into the institution's DNA. Northeastern spent a tremendous amount of time and

money in their attempt to break into the top 100 of *USNWR*, and the fruits of their labor are demonstrated in Table 2 as being the institution that has had the greatest graduation rate increase from 2004 to 2013. Aoun was determined to understand the ranking formula used by *USNWR* in order to strategically adjust institutional practices to increase Northeastern's rank (Kutner, 2014). Northeastern deployed multiple methods including allowing first-time, full-time freshmen with lower SAT scores or academic deficiencies to study abroad during their fall semester in order to enroll in the spring semester, which allowed the institution to not count those students in its initial cohort (Kutner, 2014). The institution also increased its tuition, spent over $1B on construction, reduced student to faculty ratios to 19:1, and began using the Common Application for admissions to reject more applicants in order to appear more selective (Kutner, 2014).

The University of Texas at Dallas

During the 1990s, the UT-Dallas began accepting its first cohort of freshman and sophomore students, but its governing board required it to use the same admission standards at the University of Texas at Austin in order to not compete with local community colleges (Watkins, 2016). Both UT-Dallas and the University of Texas Board of Regents developed accountability plans as well as strategic plans that incorporated enhancing the graduation rate (UT-Dallas, 2016). To increase graduation rates, UT-Dallas invested $1B on campus construction, provided full scholarships to National Merit semifinalists, and fixed their tuition rate, which incentivized students to graduate in 4 years (Cardona, 2013; Watkins, 2016). According to Watkins (2016), UT-Dallas' 4-year graduation rates have increased from 30% to 50% since 2005.

Arizona State University

ASU is the largest public institution in the country with multiple campuses under a single administration, and its aspiration to design and become the New American University has led it to be considered a bastion of access, community embeddedness, and innovation within institutions of higher education (Crow & Dabars, 2015). As a test bed for new education technologies like the eAdvisor and adaptive learning platforms like Knewton, ASU has helped raise its 1-year freshmen retention rate by 7 percentage points from 77% to 84% (Selingo, 2013). Crow and Dabars (2015) also track an impressive increase in 6-year graduation rates of students at ASU by 14.9 percentage points from the Fall 1995 cohort's 6-year graduation rate of 49.2% to the 2007 entering cohort whose 6-year graduation rate was 58.6%. Through descriptive statistics for this data set, ASU was also an extreme outlier for both spectrums of student enrollment. In 2008, ASU's overall enrollment increased by 14,286 students from 2007

according to the data collected from the College Scorecard. In 2013, ASU's reported enrollment decreased by 20,703 total students compared with 2012. The change in enrollment was due to the inclusion of multiple campuses reported as ASU beginning in 2008 through 2012 followed by a transition in 2013 to report the individual ASU–Tempe campus instead of the multiple campuses together. Also in 2013, ASU's retention rate showed a 1-year gain of 4.5% (Table 3). ASU continues to strive to increase its retention and graduation rates by infusing analytics and technology to improve student success via direct targeting of individuals rather than general populations or cohorts of students. This newly developed method is called precision advising and is defined as delivering an immediate and intentional intervention at the right time—every time—to the right student.

Mount St. Mary's University

Simon P. Newman, the former president of Mount St. Mary's, came under intense fire and scrutiny when the university's student-run newspaper published Newman's retention strategy to reduce the amount of first-time, full-time freshmen by 20 to 25 before the fall census date (Brown, 2016). The strategy would potentially yield a 4% to 5% gain in 1-year retention rates for the institution (Brown, 2016). Coupled with his strategy, Newman used extreme language to characterize how faculty members often view students as cuddly bunnies, but Newman explained that the bunnies needed to be drowned or have Glocks put to their heads (Bult, 2016). Newman's attempt to game the retention rating system forced the institution to undergo a tremendous amount of undo anguish, turmoil, and stress.

Linear Models for Retention and Graduation Rates

Due to the study using panel data with time nested in years for R1 doctoral universities, multiple linear models were performed with one dependent variable being institutional retention rates from 2004 to 2013 (Table 5) and the other dependent variable being graduation rates from 2004 to 2013 (Table 6). The various regression models per dependent variable are as follows: ordinary least square (OLS) using robust standard errors (Model 1), random effects using clustered standard errors (Model 2), fixed institutional effects using clustered standard errors (Model 3), fixed time effects (Model 4), and fixed time effects using clustered standard errors (Model 5). Independent variables for each model included mean SAT, admission rate, total enrollment, private institutions ($0 = public$ and $1 = private$), and AAU members ($0 = nonmember$ and $1 = member$). The model using fixed time effects with clustered standard errors (Model 5) is the preferred model for this study due to reducing both omitted variable bias and error variance. The use of fixed effects eliminates variable bias

from omitted variables that varied over time but not across institution (fixed time effects) or those that varied over institution but not across time (fixed institution effects). To reduce autocorrelation/serial correlation due to repeated annual measure per institution, the use of clustered standard errors was necessary.

Discussion

Tables 5 and 6 demonstrate that the OLS model using robust standard errors (Model 1) yields more variables that significantly influence retention and graduation rates compared with the regression model with fixed time effects using clustered standard errors (Model 5). Using Model 5, this study finds that mean SAT is a positive and significant influencer of retention and graduation rates. For a 1-point increase in mean SAT for an institution, an institution's retention rate would be expected to increase 0.024% and its graduation rate would be expected to increase 0.031% holding all else constant. Admission rate does not appear to significantly influence retention or graduation rates; therefore, Hypothesis 2 is not supported when using Model 5. The hypothesized relationship between smaller enrollment and increased retention and graduation rates was not supported. Instead, an increase in undergraduate enrollment has both positive and significant effects on retention rates only. When an institution increases its enrollment by one student, an institution's retention rate would be expected to increase by0.0002% holding all else constant. Hypothesis 5 was rejected due to AAU membership not significantly influencing retention or graduation rates. The private institution variable was dropped from the fixed effects models but did significantly and positively influence retention and graduation rates within the random effects model (Model 2). Serial correlation was accounted for by using clustered standard errors for the fixed time effects models (Model 5). Some variables that appeared significant using OLS, random effects, or fixed effects without clustered standard errors were no longer significant within the fixed effects model using clustered standard errors. The only constant and positively significant influencer of both retention and graduation rates for all models was mean SAT (Tables 5 and 6). The only other constant and significant influencer was undergraduate enrollment on retention rates (Table 5).

Retention rates at many institutions appear to undergo a seesaw effect due to significant variance in retention rates per year with some schools increasing +5% during 1 year but then falling −4% the following year. As an example, the University of Alabama at Birmingham (UAB) started at 77% retention in 2004 and ended at 80.16% retention in 2013. The highest retention rate was 81.56% in 2009, but then it fell −2.8% points over the next 2 years. For UAB's graduation rate, a steady increase has occurred over 10 years from 37.73% to 53.77%. The change in overall graduation rate is one of the top 10 in R1s over the 10 years at 16.04% (Table 2).

Table 5. Model Summaries for Linear Models Including Random and Fixed Effects for Retention Rates From 2004 to 2013 at R1: Doctoral Universities.

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Average SAT	0.048***(0.002)	0.033***(0.004)	0.029***(0.005)	0.024***(0.003)	0.024***(0.004)
Admission rate	−0.047***(0.008)	−0.027*(0.014)	−0.025*(0.015)	−0.019**(0.008)	−0.019(0.015)
Undergraduate enrollment	0.0001***(0.000)	0.0001*** (0.000)	0.0002***(0.000)	0.0002***(0.000)	0.0002***(0.000)
AAU	1.34***(0.230)	1.18**(0.532)	0.317 (0.586)	0.359(0.461)	0.359(0.492)
Private	−2.23***(0.444)	2.68**(1.186)			
(Constant)	30.13*** (3.020)	45.76*** (5.192)			
Years	2004–2013	2004–2013	2004–2013	2004–2013	2004–2013
Robust *SE*	Yes	No	No	No	No
Clustered *SE*	No	Yes	Yes	No	Yes
Fixed effects	No	No	Yes	Yes	Yes
Random effects	No	Yes	No	No	No
Institution effects	No	Yes	Yes	No	No
Time effects	No	Yes	No	Yes	Yes

Note. AAU = Association of American Universities; *SE* = standard error.
*$p < .10$. **$p < .05$. ***$p < .01$.

Table 6. Model Summaries for Linear Models Including Random and Fixed Effects for Graduation Rates From 2004 to 2013 at R1: Doctoral Universities.

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Average SAT	0.111***(0.005)	0.049***(0.009)	0.065***(0.011)	0.031***(0.004)	0.031***(0.011)
Admission rate	−0.011(0.018)	0.011(0.019)	−0.022(0.021)	0.022*(0.013)	0.022(0.018)
Undergraduate enrollment	0.0002***(0.000)	0.0002*(0.000)	0.0005***(0.000)	0.0001***(0.000)	0.0001(0.000)
AAU	4.554***(0.538)	2.843**(1.118)	0.172(0.966)	0.659(0.764)	0.659(0.425)
Private	−1.937*(0.000)	13.552***(2.948)			
(Constant)	−0.678*** (6.391)	1.413 (10.099)			
Years	2004–2013	2004–2013	2004–2013	2004–2013	2004–2013
Robust *SE*	Yes	No	No	No	No
Clustered *SE*	No	Yes	Yes	No	Yes
Fixed effects	No	No	Yes	Yes	Yes
Random effects	No	Yes	No	No	No
Institution effects	No	Yes	Yes	No	No
Time effects	No	Yes	No	Yes	Yes

Note. AAU = Association of American Universities; *SE* = standard error.
*$p < .10$. **$p < .05$. ***$p < .01$.

Conclusions

This article sought to understand the changes in 1-year retention rates and 6-year graduation rates at Carnegie R1 doctoral universities over a 10-year period of time from 2004 to 2013. Overall, one hypothesis was upheld, one was partially supported, and three were rejected. The institution's mean SAT was significant and predicted an increases in both 1-year retention and 6-year graduation rates, which supports similar results from previous empirical studies (Astin, 1997; Goenner & Snaith, 2004a, 2004b; Kroc et al., 1995; Porter, 2000). Being a member of the AAU or increasing the selectivity of the institution by decreasing admission rates did not significantly predict increases in either 1-year retention rate or 6-year graduation rate. Counter to the stated hypothesis regarding institutional enrollment, an increase in enrollment was actually found to have a significant and positive effect on 1-year retention rates. The explanation for this may be that as institutions increases their enrollment, students are being attracted to that institution (i.e., they want to be there), more tuition revenue is being generated, and through increased revenue more services focused on student retention are implemented.

This study also demonstrates a systematic increase in graduation rates for R1 institutions over a period of 10 years, but the trend is not seen for retention rates among the same institutions. In comparing 10-year retention and graduation rates (Tables 1–4), the top 10 highest changes in retention rate over the 10 years were between 6.28% and 8.11%. The top 10 highest changes in graduation rate over the same 10-year period were 13.06% to 22.69%.

In reviewing Tables 1 to 4, all institutions that are undergoing significant increases in 1-year retention and 6-year graduation rates are all public universities with the exception of Northeastern University. This can be explained by states emphasizing institutional accountability through the monitoring of retention and graduation rates. The accountability for retention and graduation rates is often tied to budgets, funding, and monetary incentives for both the institution and their administrators. Also, compared with public institutions of higher education, private universities are often more exclusive, wealthy, and elite, which has allowed them to have very high retention and graduation rates that are not able to be increased significantly over time. Finally, the four notable institutions in this study provide information that can be useful to institutions, administrators, and policy makers looking to affect their enrollment management, retention rate, or graduation rate strategies while simultaneously avoiding controversy.

Study Limitations and Future Research

This research has several limitations. As previously discussed, several student characteristics that may contribute to the model are not included—first-

generation status, socioeconomic status, underrepresented minority status, high school GPA, and class rank—resulting in omitted variable bias. Another limitation is that the study is limited to 115 R1 doctoral granting institutions. When compared with over 4,000 degree granting institutions in the United States, it is a very small segment of the higher education population. Observational methods and interpretation of national policy regarding retention and graduation rates may vary per institution and over time. Another threat to internal validity is the implementation of performance-based funding from individual states. Performance-based funding varies over both institution and time and can include retention and graduate rate metrics. For future research, the addition of the current missing student input variables to the current model could demonstrate a better model fit than the current construct proposed by this study. Finally, an analysis of private versus public institutions using the same empirical method could expand knowledge regarding how different institutional characteristics affect student success.

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Author Biography

Nathaniel L. Wade is a doctoral candidate in the School for the Future of Innovation in Society and senior director, Strategic Analysis and Performance Improvement within the College of Health Solutions at Arizona State University. His areas of research include student success, university rankings, diversity and inclusion, higher education policy, and science and technology policy.