Finding the Best Fit: Exploring Postsecondary Undermatch in Tennessee

by

Emily A. House

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Doctoral Committee:

Professor Brian P. McCall, Chair
Professor Michael N. Bastedo
Professor Stephen L. DesJardins
Professor Jeffrey A. Smith

Dedication

In loving memory of Frances Geaglone and John Vorrasi

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Abstract

This dissertation explores the prevalence of postsecondary undermatch among recent high school graduates in Tennessee. Postsecondary undermatch occurs when high achieving students choose to attend colleges or universities that are less selective or of lower quality than those at which they are academically eligible to enroll. Using student-level data provided by the Tennessee Higher Education Commission and the Tennessee Student Assistance Corporation, I first investigate variation in undermatch rates when employing different definitions of undermatch. I then examine the effects of two state-sponsored financial aid programs on treated students' probabilities of undermatch across the state. Implications for policy and directions for future research are presented at length.

The opinions and findings discussed in this study do not represent the opinions of the Tennessee Higher Education Commission, the Tennessee Student Assistance Corporation, Tennessee Achieves, or any Tennessee state agency.

Chapter 1

Introduction and Higher Education in Tennessee

Over the past decade, groundbreaking public policy has transformed higher education in Tennessee. Under the leadership of two education-focused governors and a supportive legislature, the state has introduced a number of innovative higher education initiatives. These include, among others, a lottery-funded merit- and need-based scholarship program, an outcomes-based funding formula that allocates one hundred percent of higher education appropriations on the basis of student success, an ambitious statewide postsecondary completion and workforce alignment goal, and a well-publicized initiative to provide tuition-free community and technical college to recent high school graduates (Tennessee Higher Education Commission [THEC], 2015). This suite of policies and programs aims to improve access and affordability in higher education, as well as incentivize institutions to support, retain, and graduate their students.

More specifically, one of the stated objectives of both the Tennessee Education Lottery Scholarship (TELS) program and the Tennessee Promise, the free community and technical college program, is to encourage those who would not have otherwise pursued postsecondary education to do so (THEC, 2016a). What has been largely ignored in discussions of these initiatives, however, is another group of students: those who would have enrolled in higher education in the absence of these programs, but make different enrollment decisions in light of their availability. For example, students may choose to attend less selective institutions as a result of the TELS and Tennessee Promise programs, raising questions about postsecondary undermatch as a result of these initiatives.

What is Undermatch?

Postsecondary undermatch, broadly defined, occurs when a student chooses to attend a college or university at which he is academically overqualified relative to other students enrolled at that institution (Black & Smith, 2004, 2006; Roderick, Nagaoka, Coca, & Moeller, 2008, 2009; Bowen, Chingos & McPherson, 2009; Dillon & Smith, 2017; Smith, Pender, & Howell, 2013). The academic measures most commonly used to determine whether a student is appropriately matched to the institution he attends are his high school grade point average (GPA) and composite standardized test score (ACT or SAT).

Many education researchers and policymakers are concerned about undermatch, as this phenomenon results in highly qualified students enrolling in less selective, lower quality higher education institutions. These institutions often provide fewer resources per student, have lower graduation rates, and the workforce outcomes of graduates are less favorable than those of students who graduate from more selective institutions (Bound, Lovenheim, & Turner, 2012; Bowen, et al., 2009; Hoekstra, 2009; Reynolds, 2012). Further, undermatch is often reflective of a deficit in students' college search, application and enrollment processes (Roderick, et al., 2008, 2009). Student groups that typically struggle with these processes - first generation, nonwhite, and lower income students – are those who most often undermatch, often reducing their access to high quality higher education (Fry, 2002; Alon & Tienda, 2003; Bowen, et al., 2009; Roderick, et al., 2008, 2009; Smith et al., 2013).

Much of the existing literature investigating undermatch is lacking on a number of dimensions. First, each author employs a unique definition of what it means to undermatch. These definitions are often a result of data availability and/or the author's specific research

questions. For this reason, findings related to the prevalence of undermatch are often not comparable between different studies, and are sometimes not generalizable to states, cities, or institutions other than those included in a particular sample. Second, undermatch is often explored at the individual level (i.e., college-going decisions of individual students or particular subgroups of students) and is rarely investigated in light of policies and programs at the state-, city-, system- or institution-levels. As such, undermatch is often explored in a vacuum, without regard for unique higher education contexts and state and institutional policies that may impact enrollment decisions.

Significance of the Study

This dissertation will first explore the various definitions of undermatch employed in prior research, and the impact of these different definitions on conclusions about undermatch in Tennessee. I will then investigate the effects of two higher education initiatives – the General Assembly Merit Scholarship (GAMS – one of three programs that comprise the Tennessee Education Lottery Scholarship program) and Tennessee Achieves, the regional precursor to the statewide Tennessee Promise tuition- and fee-free community and technical college program – on student match.

Merit aid programs and tuition-free community college initiatives are extremely relevant to policy discussions and empirical investigations of undermatch. State-sponsored merit aid programs often have strict parameters around the institutions at which scholarships may be used (i.e., in-state, public versus private institutions), and the buying power of the awards at different institution types (i.e., a community college versus a four-year university) may vary substantially. For this reason, students may choose to remain in-state rather than search nationally for a postsecondary option that is the best match, or attend an institution at which the merit aid can

most discount tuition, leading to increased undermatch. Further, as tuition-free community college programs are becoming popular policy proposals, there is great concern among educators and policymakers that these initiatives may result in increased undermatch among high achieving students. These programs are often widely publicized, and may incentivize students to enroll at a less-than-four year institution at which they are undermatched relative to their peers, such that they may take advantage of the "free" college option.

These analyses provide guidance to future researchers about the importance of using explicit definitions when discussing undermatch, as well as the impact of large scale, high-publicity higher education initiatives on undermatch. The findings of these papers should encourage more explicit conversations about measuring undermatch, and about how large-scale programs may affect this phenomenon.

Organization of Dissertation

Following this introduction, Chapter 1 discusses the higher education context in Tennessee. This chapter describes and maps where higher education institutions are located, outlines how public higher education is funded and governed, outlines the role of private institutions in state-level policymaking and implementation, and describes the demographic, socioeconomic and academic characteristics of students in Tennessee. This chapter also discusses tuition, fees, and cost of attendance, as well as resources available to students (i.e., per pupil spending) at each institution across the state.

Chapter 2 reviews prior literature and presents the theoretical frameworks that moor this dissertation. Prior literature investigating undermatch discusses the college search and application processes, student decision-making about enrollment, and the returns to attending and earning a degree from a more selective or higher quality institution. This chapter also

includes a review of literature discussing statewide merit aid programs, the success of place-based financial aid programs and the "community college penalty," topics related to the Tennessee Education Lottery Scholarship and Tennessee Achieves programs explored in Chapters 4 and 5. In addition, two theoretical frameworks, human capital theory (i.e., Becker, 1993) and theories of college choice (i.e., Hossler & Gallagher, 1987; Perna, 2006) will be presented at length, as they are the theories that anchor this work. This chapter concludes by discussing counterfactual theories of causation (i.e., Lewis, 1973).

Chapter 3 applies five definitions of undermatch used in prior research to a sample of first-year students entering higher education in Tennessee. Using data from the Tennessee Higher Education Commission Student Information System (THEC SIS) and the National Student Clearinghouse (NSC), this chapter demonstrates that the measured prevalence of undermatch in a given geography (i.e., the state of Tennessee) is a direct result of how undermatch is defined.

Chapter 4 investigates undermatch as a result of the General Assembly Merit Scholarship (GAMS) program. Whereas merit aid programs have been researched at length, there is a dearth of literature directly addressing whether such programs contribute to undermatch. This paper employs student-level data from the THEC SIS and the Tennessee Student Assistance Corporation (TSAC), Tennessee's state granting agency, to determine whether students enroll in more or less selective institutions as a result of receiving a GAMS award. I hypothesize, consistent with findings of Cohodes and Goodman (2014), that these high-achieving GAMS recipients will attend lower quality institutions, as compared to their peers who receive a different, lesser merit-based award.[1] Following the model of Bruce and Carruthers (2014), I

[1] The structure of the Tennessee Education Lottery Scholarship (TELS) program will be discussed in depth in Chapter 4.

employ a sharp regression discontinuity approach to explore the enrollment behavior of those who receive a GAMS award compared to those who do not.

Chapter 5 explores undermatch in light of a more recent county-level initiative: Tennessee Achieves, a tuition- and fee-free community and technical college program that served as the model for Governor Bill Haslam's widely publicized Tennessee Promise program. Although thousands of students have participated in Tennessee Achieves since 2009, it is unclear whether this program resulted in students attending a community or technical college in lieu of a four-year institution at which they would have been a better academic match. I hypothesize that students in treated counties enroll at community and technical colleges at higher rates than neighboring, untreated counties as a result of Tennessee Achieves, but that they are substituting away from less selective four-year institutions that enroll students with low academic qualifications. This paper will use data provided by the THEC SIS and from Tennessee Achieves, a 501(c)(3) nonprofit which coordinated the county-level program prior to its statewide implementation. I employ difference-in-differences and propensity score matching methodologies to explore the impact of this program on undermatch rates in the three largest of the 27 Tennessee Achieves counties.

In conclusion, Chapter 6 discusses the implications of the previous three chapters, and outlines directions for future research about undermatch, both in Tennessee and throughout the United States.

Higher Education in Tennessee

Public Institutions

Public higher education in Tennessee is comprised of fifty universities, community colleges, and colleges of applied technology across the state (Tennessee Higher Education Commission [THEC], 2016a). These institutions are governed by two boards: the University of

Tennessee Board of Trustees (UT) and the Tennessee Board of Regents (TBR). These two systems, which have governing authority over these institutions, are overseen by the Tennessee Higher Education Commission (THEC), the state's coordinating board established in 1967 with the mission to "achieve coordination and foster unity" among the two systems of higher education in Tennessee (THEC, 2015). For example, THEC approves capital projects from ranked lists provided by the systems, approves new academic programs to minimize duplication across institutions, and provides recommendations each year related to increases in tuition and fees (THEC, 2015). As of 2012, the executive director of THEC is appointed by the Governor of Tennessee, and the agency reports to the state's Executive and Legislative branches. Figure 1.1 presents graphically the coordinating and governance structure of public higher education in Tennessee.

The University of Tennessee (UT) system in comprised of four institutions across the state. The University of Tennessee at Knoxville is the system's flagship campus, and is one of Tennessee's two land grant institutions. The Universities of Tennessee at Chattanooga and Martin are regional campuses, both serving a student body that is more racially, socioeconomically, and academically diverse than that of the University of Tennessee at Knoxville. The University of Tennessee Health Science Center is located in Memphis. This institution trains health and medical professionals, and offers primarily post-baccalaureate degrees. A map of UT institutions is presented in Figure 1.2.

The Tennessee Board of Regents (TBR) governs six universities, thirteen community colleges, and 27 colleges of applied technology (TCATs). Relative to the UT system, TBR institutions have more comprehensive and teaching-oriented missions, admitting students with lower academic qualifications and/or those who intend to pursue more technical careers.

Community and technical colleges in Tennessee are open admission, within the bounds of program capacity (THEC, 2015). A map of the universities governed by the Tennessee Board of Regents is provided in Figure 1.3. Figures 1.4 and 1.5 present maps of community colleges and technical colleges governed by the Tennessee Board of Regents, respectively.

There is a substantial difference in the academic characteristics of students, available resources, and completion rates among public higher education institutions in Tennessee. This is true not only *between* (i.e. two-year colleges versus four-year universities) but also *within* (i.e., the 13 community colleges across the state) institution types. For example, Southwest Tennessee Community College, which is the state's largest community college and serves students in Memphis, has an average freshmen ACT score of 16, and a 13 percent six-year graduation rate (THEC, 2016a). Students at Pellissippi State Community College, which serves the Knoxville metropolitan area, have an average entering ACT score of 20 (higher than the state average of 19) and graduate at a rate greater than 30 percent. Pellissippi State Community College also boasts the highest rate of transfer from any community college to the University of Tennessee at Knoxville, the state's flagship public university (THEC, 2016a). This variation in quality among community colleges, particularly along geographic lines is concerning, as Tennessee now offers students the opportunity to attend community college tuition-free.

Private Institutions

Private colleges and universities are not overseen by THEC or either governing body. These institutions participate voluntarily in the Tennessee Independent Colleges and Universities Association (TICUA). TICUA engages with 34 private institutions around public policy issues, cost containment, and professional development opportunities for administrators, faculty, and staff. TICUA interacts with the General Assembly on behalf of many of its member institutions,

and serves as a data clearinghouse for all mandated federal and state reporting (TICUA, 2015). TICUA institutions are two- and four-year institutions, and degree offerings range from associate's to doctoral and professional degrees. All regionally accredited, not-for-profit private institutions in Tennessee but one (a small college in Nashville that specializes in mortuary science) participate in TICUA (TICUA, 2015). A map of TICUA institutions is presented in Figure 1.6.

Higher Education Enrollment

Approximately 393,000 students were enrolled in higher education in Tennessee in Fall 2015. Of these students, 34 percent attend a public four-year institution in Tennessee (governed by the UT or TBR systems), 27 percent attend less-than-four year institutions in Tennessee (community colleges and TCATs), and 21 percent enroll in private institutions in-state. The remaining students enroll out-of-state or at private, for-profit institutions (THEC, 2016a). In 2015, approximately 62 percent of high school graduates in Tennessee enrolled in higher education immediately following high school graduation. This percentage (Tennessee's college-going rate) reflects an increase of 4.6 percentage points over the high school class of 2014, due in part to implementation of the Tennessee Promise, Tennessee's tuition-free community and technical college program (THEC, 2016a). Despite this increase, Tennessee remains below the national college-going rate (68 percent) and has a much lower college-going rate than some of its peer states in the Southeast (i.e., Georgia and Mississippi).

Student Demographics

The vast majority of students – approximately 70 percent - who participate in higher education in Tennessee are white. African American students comprise 17.8 percent of the statewide student body, while Hispanic students make up 3.8 percent. Students of color are

overrepresented at community and technical colleges, and at less selective four-year institutions (THEC, 2016a). Less than half (41 percent) of students enrolled in higher education in Tennessee are low income.[2] The majority of undergraduate students are under 25 years of age (75.1 percent); non-traditional age students are overrepresented at less-than-four year institutions. Approximately sixty percent of undergraduate students in Tennessee are female (THEC, 2016a).

Student academic characteristics[3]

The average ACT composite score for first-time freshmen in Tennessee, across all systems and institution types, is a 19.0 (ACT, 2015). For those enrolled in community colleges, the mean ACT composite score is 18.8; it is 21.2 for first-time freshmen enrolled at public and private universities (THEC, 2016a). ACT scores vary dramatically by institution: the mean ACT Composite score at Vanderbilt University, for example, is 33; it is 26.2 at the University of Tennessee at Knoxville and 16.6 at Southwest Tennessee Community College, an open admission institution in Memphis (THEC, 2016a; TICUA, 2015).

Barron's selectivity rankings

The most selective higher education institutions in Tennessee, per the Barron's selectivity rankings, are Vanderbilt University, Rhodes College, Sewanee, the University of the South, and the University of Tennessee at Knoxville.[4] Three of these institutions are private (Vanderbilt, Rhodes, and Sewanee) and one is public (University of Tennessee at Knoxville). These four institutions are classified by Barron's as Most (Vanderbilt), Highly (Rhodes and Sewanee), or Very Competitive (University of Tennessee at Knoxville) based on their admission rates and the

[2] Low income is defined as a student who is/was ever Pell eligible.
[3] Students' high school grade point averages (GPAs) are complete and reliable in the THEC Student Information System (THEC SIS) only for those students receiving Tennessee Education Lottery Scholarship (TELS) awards. For this reason, this variable is not often used to describe the academic achievement of the population of students enrolled in Tennessee.
[4] These institutions' Barron's Selectivity Rankings are relevant to Chapter 3, which investigates the impacts of different definitions of undermatch.

ACT Composite scores of admitted first-year students (Barron's Educational Series, Inc., 2008). All other public and private four-year institutions are ranked as Competitive or Less Competitive (Barron's Educational Series, Inc., 2008). Less-than-four year institutions (community and technical colleges) in Tennessee are open admission, and are therefore not ranked by Barron's.

Tuition and Fees

Average in-state tuition and fees (sticker price) for Tennessee residents enrolled at a public four-year institution in 2015 was $8,690, ranging from $7,417 at Tennessee State University to $11,948 at the University of Tennessee at Knoxville (THEC, 2016a). Average tuition and fees at community and technical colleges in Fall 2015 was $4,121 and $3,554, respectively (THEC, 2016a). Tuition and fees have increased over time: over the past five years, average tuition across all public institutions increased by approximately 35 percent; over the past decade, the increase is closer to 90 percent (THEC, 2016a). This is due in part to diminishing state appropriations to higher education in Tennessee.

Annual tuition and fees vary greatly across private institutions – from approximately $15,000 at many small private colleges to approximately $50,000 at Vanderbilt University, the most expensive institution in the state (TICUA, 2015).

Institutional Resources

Tables 1.1 through 1.11 contains per pupil instructional spending, academic support spending, and student services spending at each public and private institution in Tennessee.[5] Per pupil spending in each of these three categories varies substantially both between and within institution types. In general, two-year institutions (community and technical colleges) spend much less per student in each of these areas than public and private four-year institutions.

[5] Colleges of Applied Technology in Tennessee (TCATs) do not report academic support spending to IPEDS, so this figure is excluded for TCATs.

Additionally, within four-year institutions, there is great variation in spending. Many smaller private institutions spend much less per pupil than larger, more selective private institutions (i.e., Vanderbilt University) and the University of Tennessee – Knoxville, as the state's flagship and most selective public institution, spends much more per pupil than all other public universities.

Regional Comparison

Tennessee is one of sixteen states in the southeast that comprise the Southern Regional Education Board (SREB). Analysts often compare Tennessee's postsecondary enrollment, completion rates, state higher education funding and tuition and fees with that of other member states (SREB, 2016). On many metrics, Tennessee falls squarely in the middle of its regional peers. The state is ranked seventh for full-time equivalent (FTE) enrollment at four-year institutions (N = 117,242) and eighth at two-year institutions (N = 31,618) during the 2014-15 academic year. Tennessee ranks ninth and eighth for degrees awarded by four-year (N = 28,326) and two-year institutions (N = 9,501), respectively, during this same time period. Per pupil spending on education and general (E&G) expenses was approximately $15,000 at four-years (ranked ninth) and $8,300 at two-years (ranked sixth). Tuition and fees at public institutions in Tennessee, however, are well above the SREB average: average tuition and fees at a four-year institution is approximately $8,000, more expensive than eleven of the sixteen SREB states, while average tuition at two-year colleges (approximately $4,000) is greater than thirteen of Tennessee's regional peers (SREB, 2016).

Higher Education Innovation in Tennessee

Higher education in Tennessee has evolved substantially over the past decade. Many initiatives and programs have been introduced by two education-focused governors (Phil

Bredesen (Democrat, served as Governor 2003-2011) and Bill Haslam (Republican, serving as Governor 2011-present) and signed into law by a supportive, Republican-dominated legislature.

The Tennessee Education Lottery Scholarship (TELS) program, a statewide merit-based aid program was signed into law in 2002; the first recipients entered higher education as freshmen in Fall 2004. This program was modeled after existing merit aid programs in the southeast United States, namely the Georgia HOPE Scholarship program. Since its implementation, the TELS program has served over 300,000 students each year and has administered over $1 billion in total grant aid (THEC, 2016b). This program will be discussed in greater detail in Chapter 4.

In 2010, Tennessee was a recipient of the United States Department of Education's inaugural Race to the Top grant. While much of this funding was used for K-12 education initiatives, a long-lasting project resulting from this grant is the Tennessee Longitudinal Data System (TLDS), Tennessee's student-level P-20 data system. The interagency partnership that facilitates data collection and organization has grown to include five state agencies and the Boyd Center for Business and Economic Research (BCBER) at the University of Tennessee at Knoxville (THEC, 2015). The robustness of this data system is extremely useful for research and policy making. For this reason, sustainability funding for the TLDS is now included annually in the Governor's budget, as Race to the Top funding has expired.

Also in 2010, the Complete College Tennessee Act (CCTA) was enacted. The CCTA dramatically changed public higher education in Tennessee by implementing a one hundred percent outcomes-based funding formula, developing formalized transfer pathways between community colleges and universities, and reducing the availability of remedial and developmental coursework, such that it is now delivered only at community colleges (THEC,

2015). The CCTA also began statewide conversations about improved alignment between higher education and Tennessee's workforce, a discussion that continues today.

In 2013, Governor Bill Haslam announced an ambitious college attainment goal: Tennessee's "Drive to 55." In the spirit of the Lumina Foundation's "Goal 2025" (Lumina Foundation, 2013) and based on the work of Carnevale and colleagues (2012) at the Georgetown University Center on Education and the Workforce, the Drive to 55 asserts that 55 percent of working-age Tennesseans will have a postsecondary credential by the year 2025. While this initiative is an attainment goal, it is as much meant to align postsecondary degrees earned with available employment opportunities throughout the state.

The Drive to 55 is supported by many innovative programs and projects. These programs include further changes to remediation (the Seamless Alignment through Integrated Learning Support [SAILS] program), increased use of predictive analytics in advising (Degree Compass, an online tool for academic advisors), initiatives to reengage adults in higher education (Tennessee Reconnect), and competitive grants to postsecondary institutions to align their program offerings with the needs of local industry (the Labor and Education Alignment Program [LEAP] program) (THEC, 2015). Tennessee Reconnect and LEAP rely heavily on partnerships with American Job Centers (AJCs; established and maintained by the Workforce Investment Act [WIA] and the Workforce Innovation and Opportunity Act [WIOA]) and regional career centers throughout the state. Through these partnerships, state agency and AJC staff members identify, recruit, and support adults who would benefit from engaging or reengaging with higher education. Unlike WIA and WIOA, however, Tennessee Reconnect and LEAP emphasize solely that adults earn postsecondary degrees, rather than participate in workforce training programs that do not result in a credential.

The crux of this suite of programs, and the program receiving the most press and interest, is the Tennessee Promise. The Tennessee Promise provides two years of tuition and fee-free community or technical college to recent high school graduates. The Tennessee Promise is modeled after and is identical (at a statewide scale) to Tennessee Achieves, the regional program described at length in Chapter 5.

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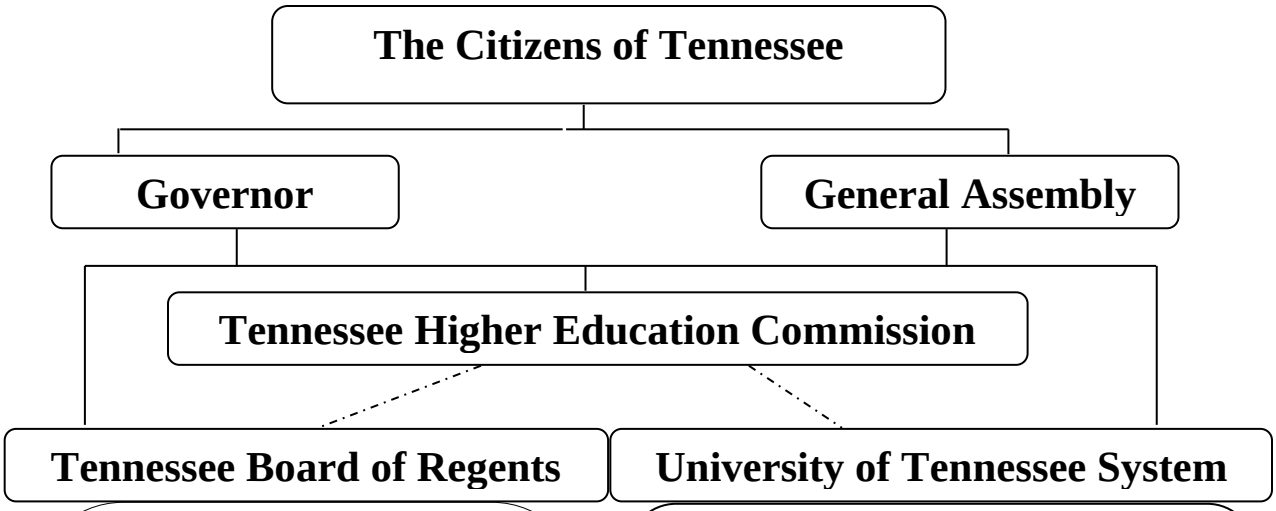
Figure 1.1. Public higher education governance in Tennessee



Universities

Austin Peay State University
East Tennessee State University
Middle Tennessee State University
Tennessee State University
Tennessee Technological University
University of Memphis

Community Colleges

Chattanooga State Community College
Cleveland State Community College
Columbia State Community College
Dyersburg State Community College
Jackson State Community College
Motlow State Community College
Nashville State Community College
Northeast State Community College
Pellissippi State Community College
Roane State Community College
Southwest State Community College
Volunteer State Community College
Walters State Community College

Colleges of Applied Technology

Athens
Chattanooga
Covington
Crossville
Crump
Dickson
Elizabethton
Harriman
Hartsville
Hohenwald
Jacksboro
Jackson
Knoxville
Livingston
McKenzie
McMinnville
Memphis
Morristown
Murfreesboro
Nashville
Newbern
Oneida/Huntsville
Paris
Pulaski
Ripley
Shelbyville
Whiteville

University of Tennessee at Chattanooga
University of Tennessee at Knoxville
University of Tennessee at Martin
University of Tennessee Health Science Center

Figure 1.2. Universities governed by the University of Tennessee system

Figure 1.3. Universities governed by the Tennessee Board of Regents

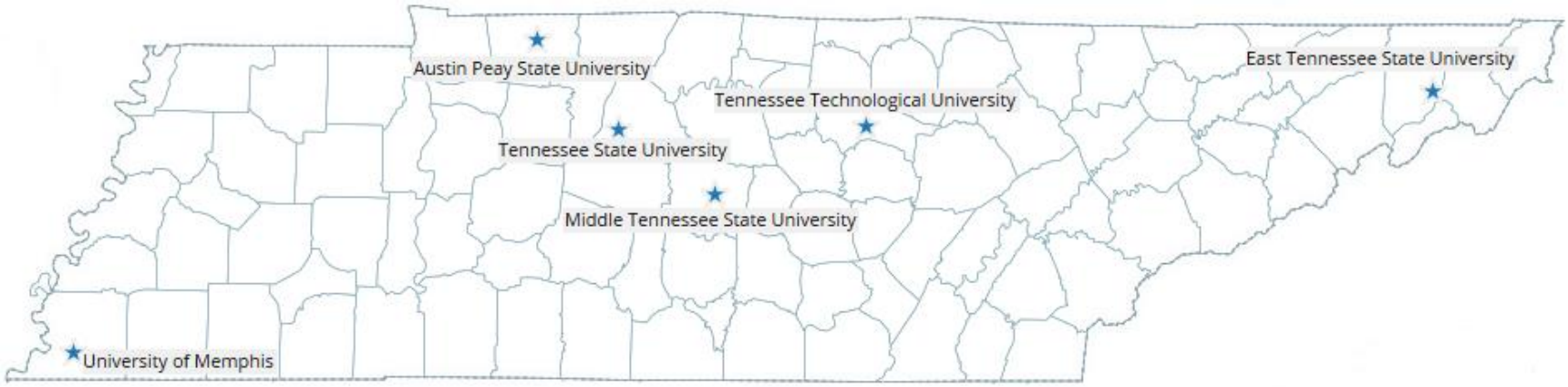


Figure 1.4. Community colleges governed by the Tennessee Board of Regents

Figure 1.5. Technical colleges (TCATs) governed by the Tennessee Board of Regents

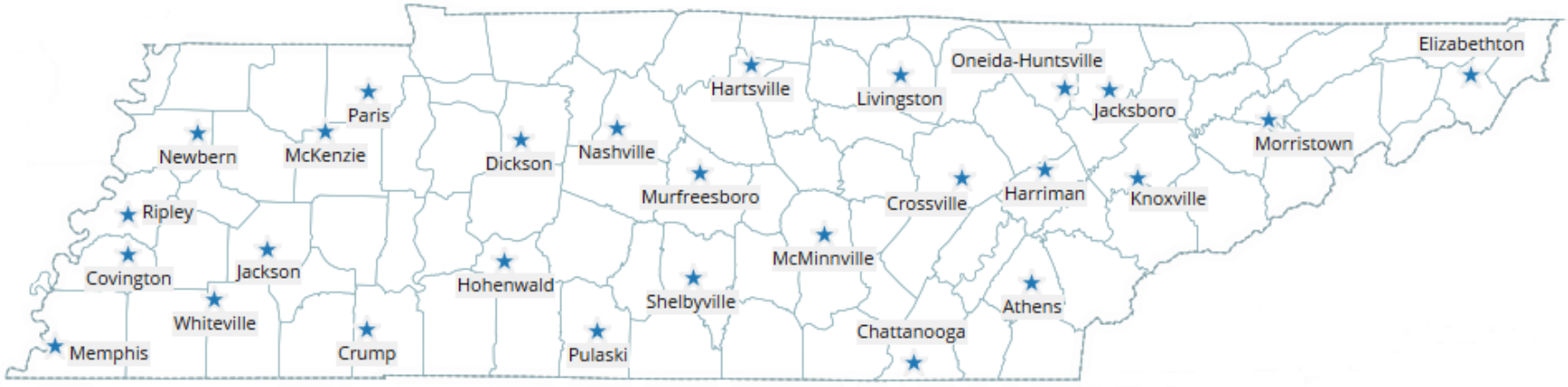


Figure 1.6. Tennessee Independent Colleges and Universities Association (TICUA) member institutions

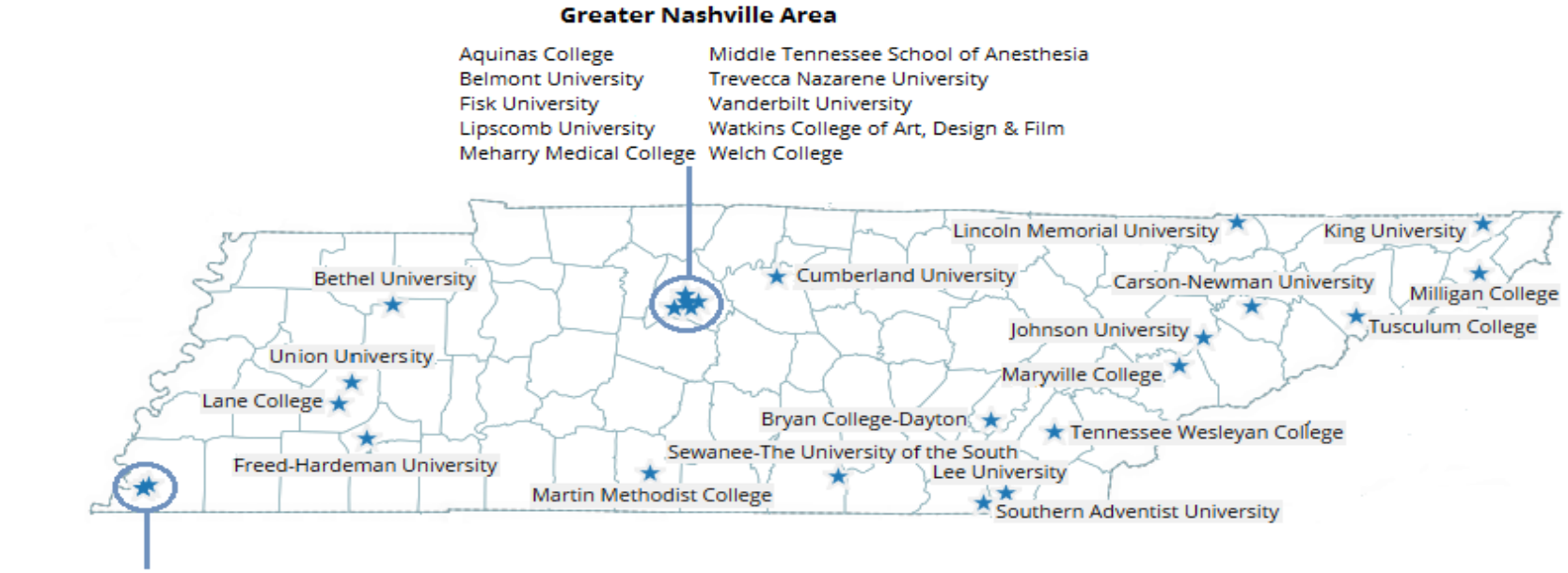


Table 1.1. Per pupil instructional spending at private institutions, 2010-2013

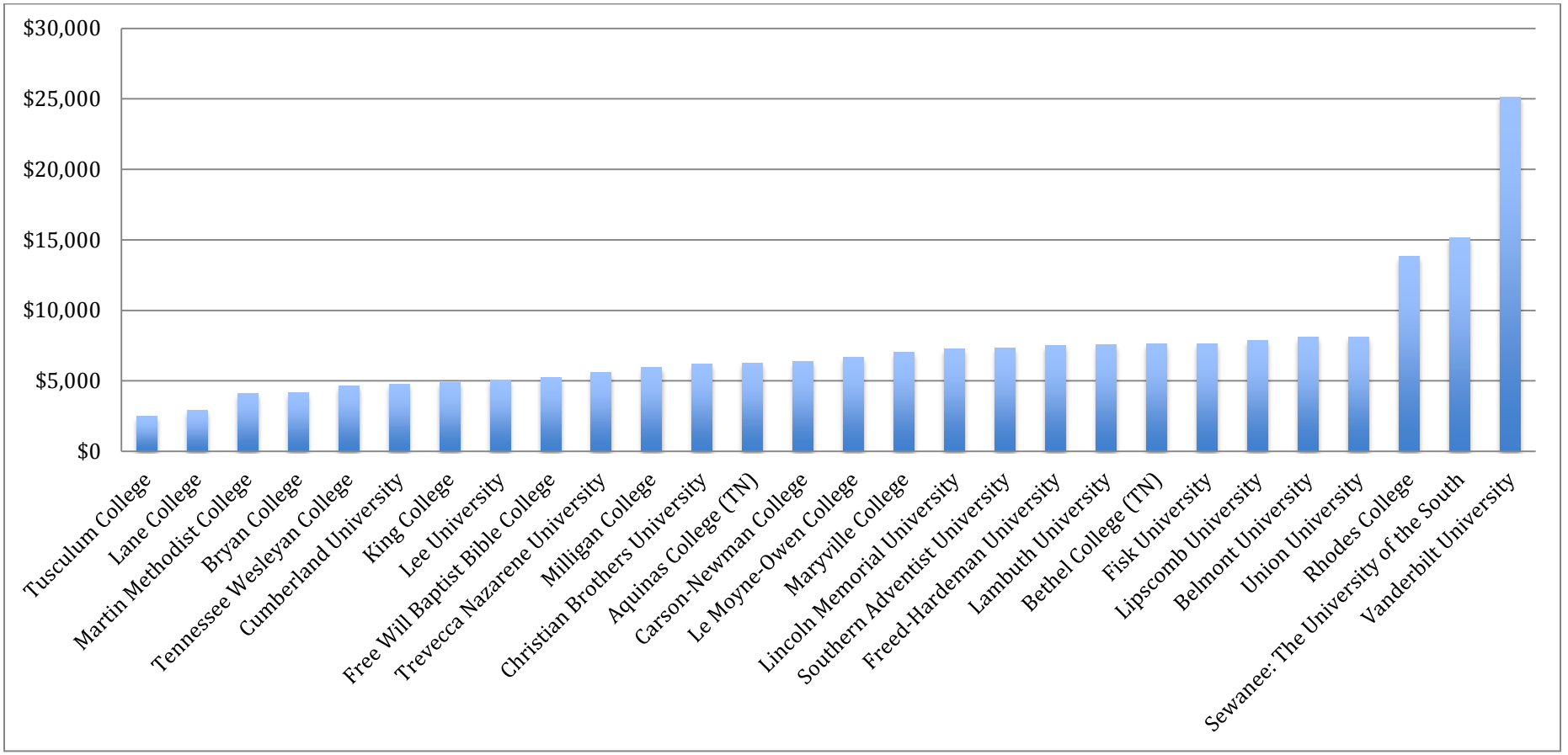


Table 1.2. Per pupil instructional spending at public 2-year institutions, 2010-2013

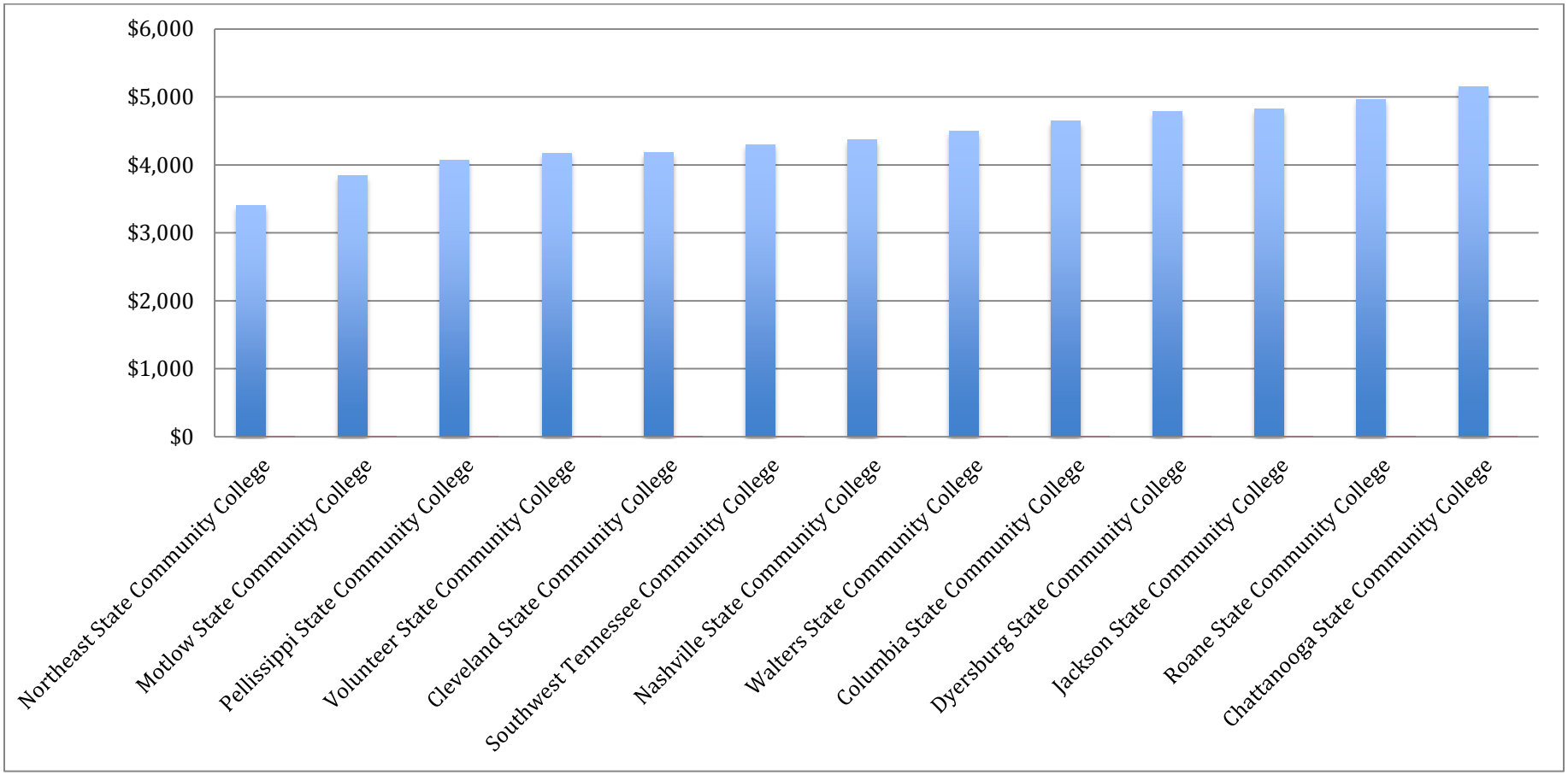


Table 1.3. Per pupil instructional spending at public 4-year institutions, 2010-2013

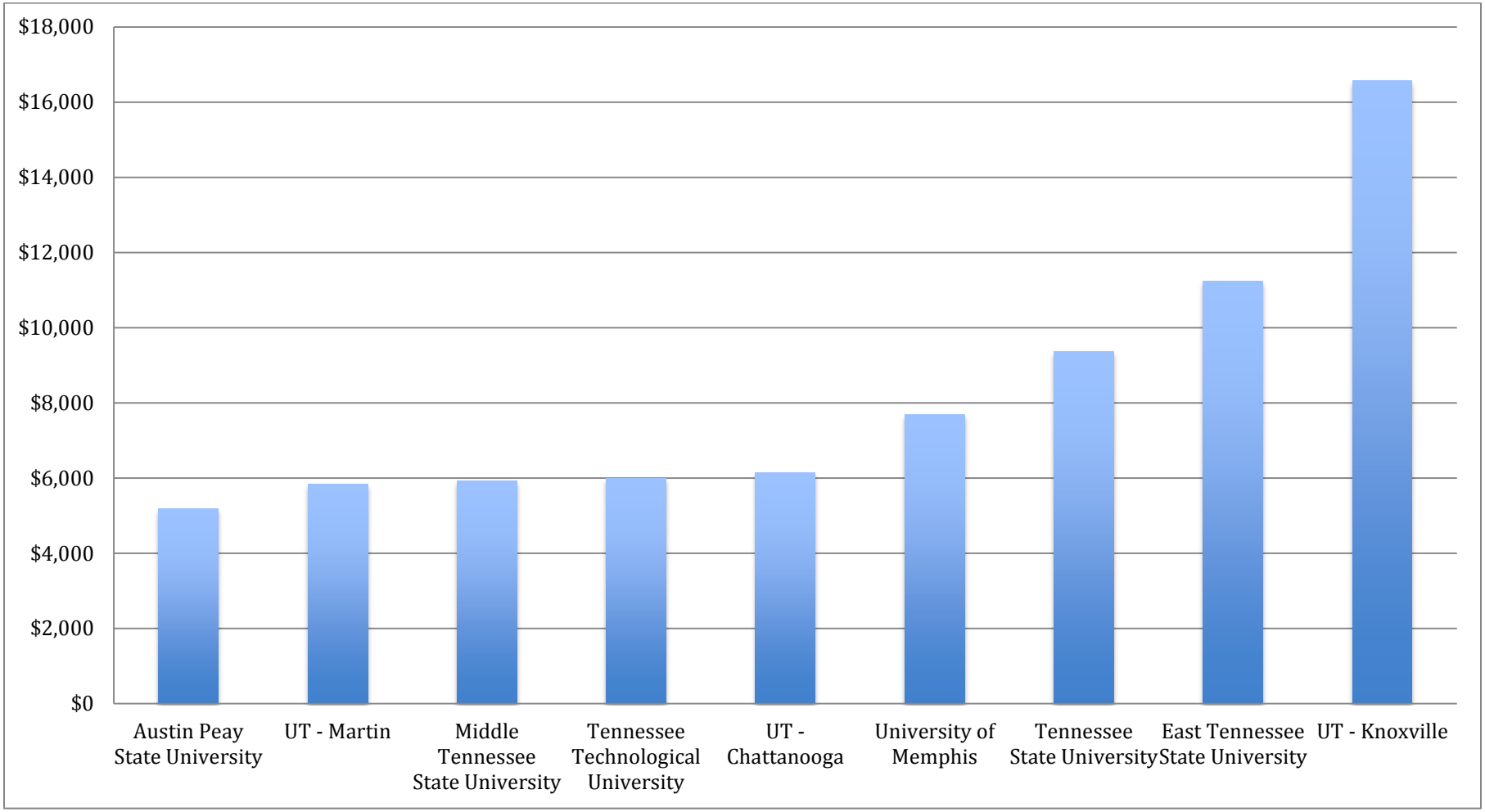


Table 1.4. Per pupil instructional spending at colleges of applied technology, 2010-2013

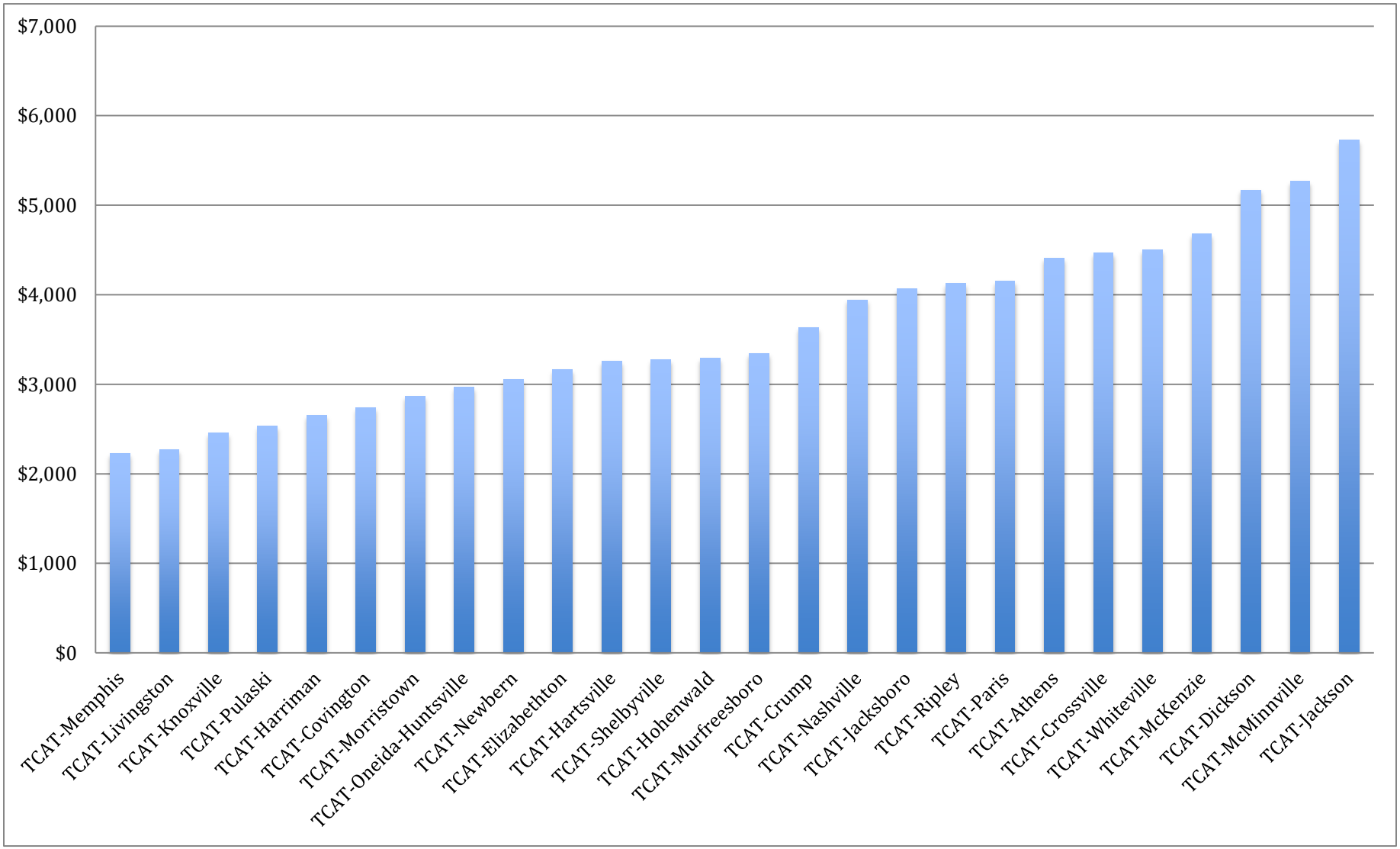


Table 1.5. Per pupil student services spending at private institutions, 2010-2013

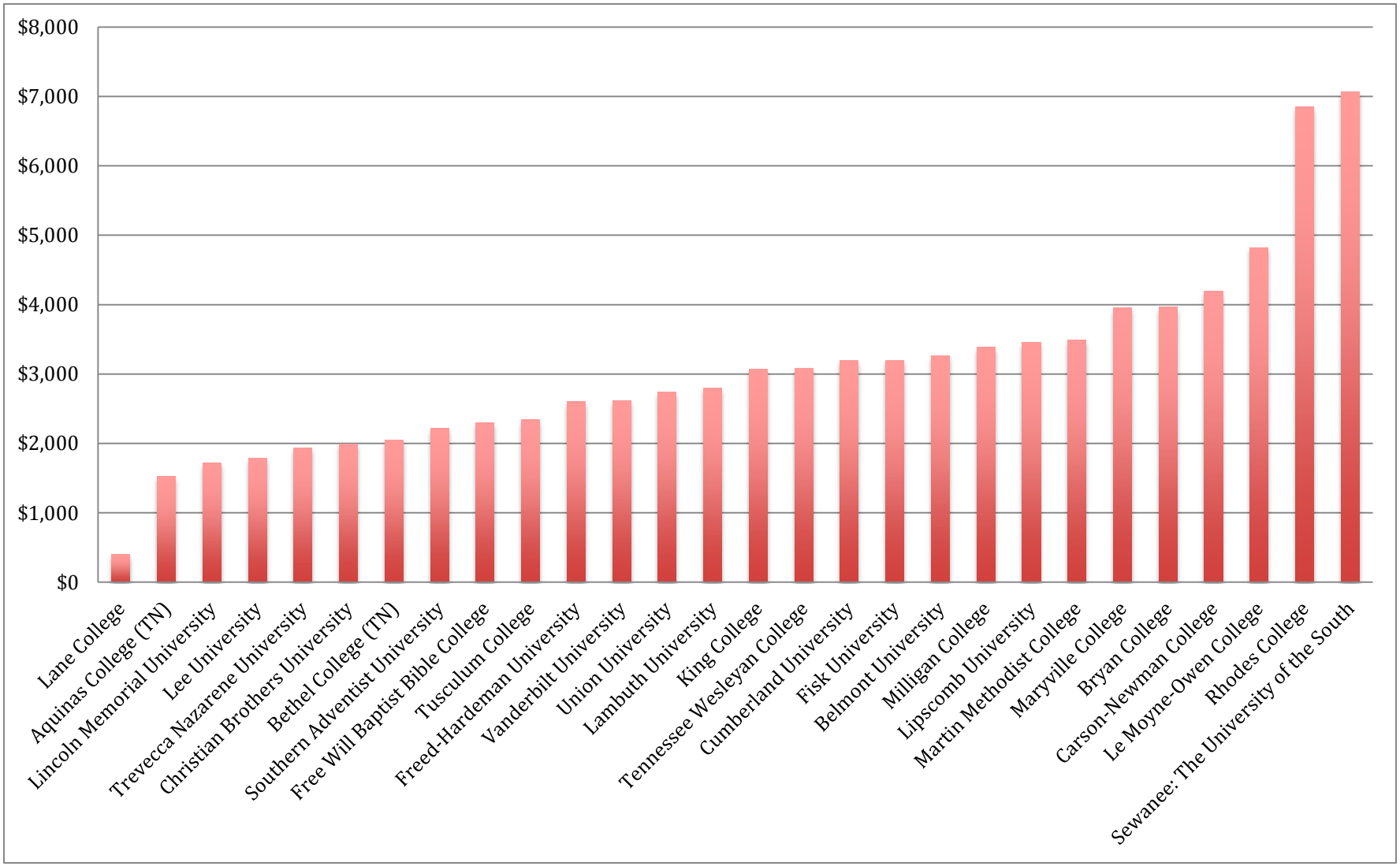


Table 1.6. Per pupil student services spending at public 2-year institutions, 2010-2013

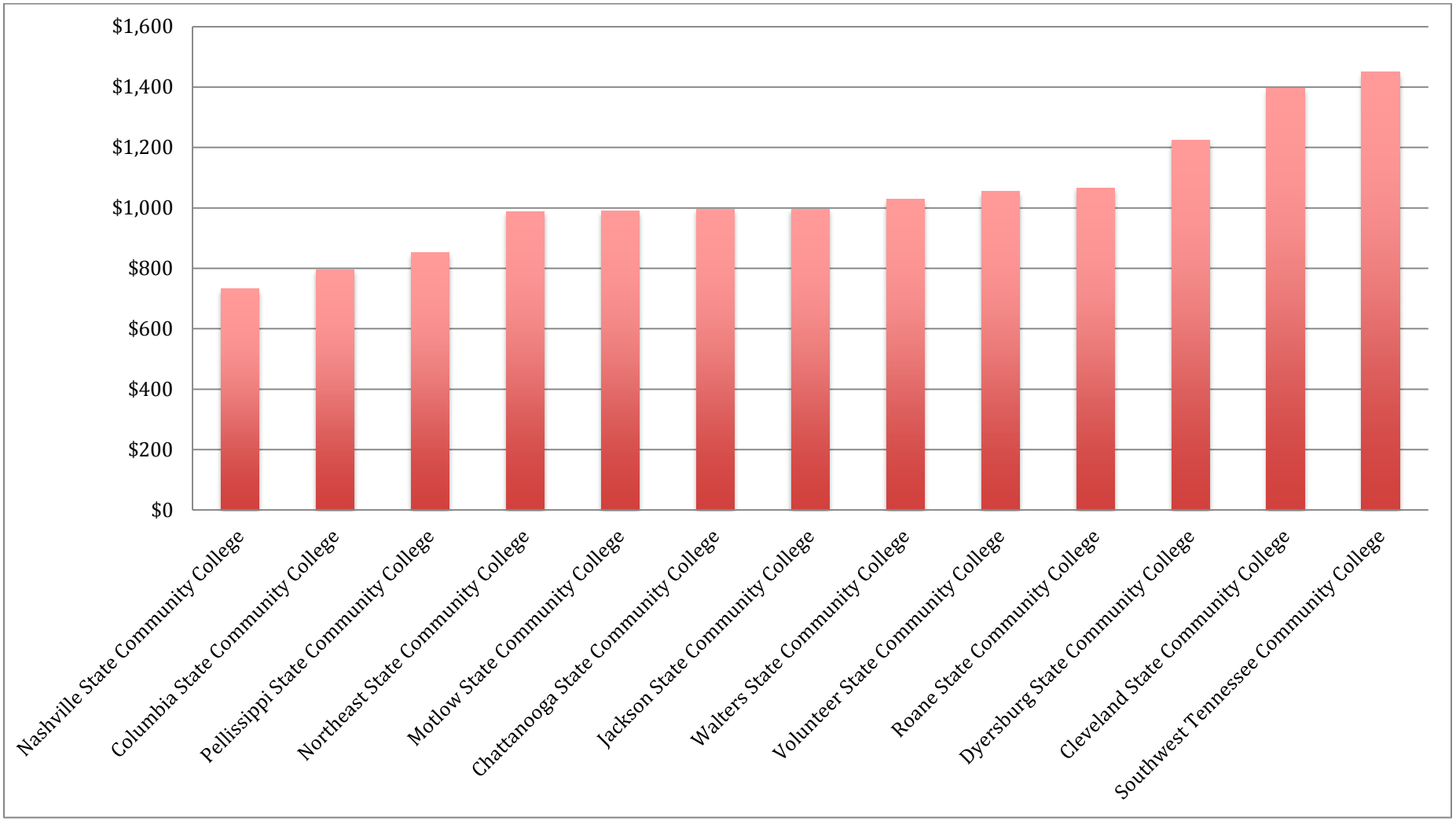


Table 1.7. Per pupil student services spending at public 4-year institutions, 2010-2013

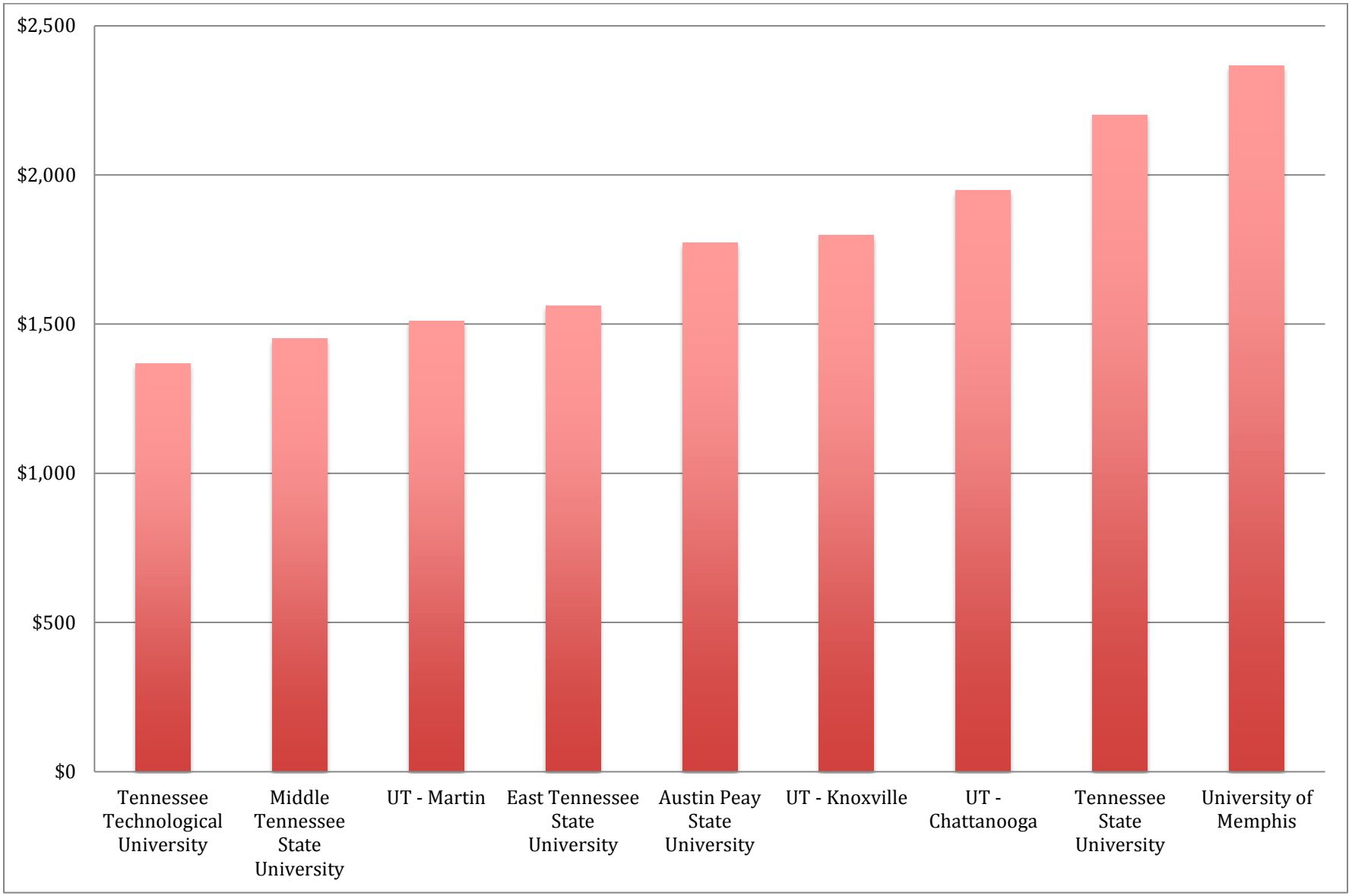


Table 1.8. Per pupil student services spending at colleges of applied technology, 2010-2013

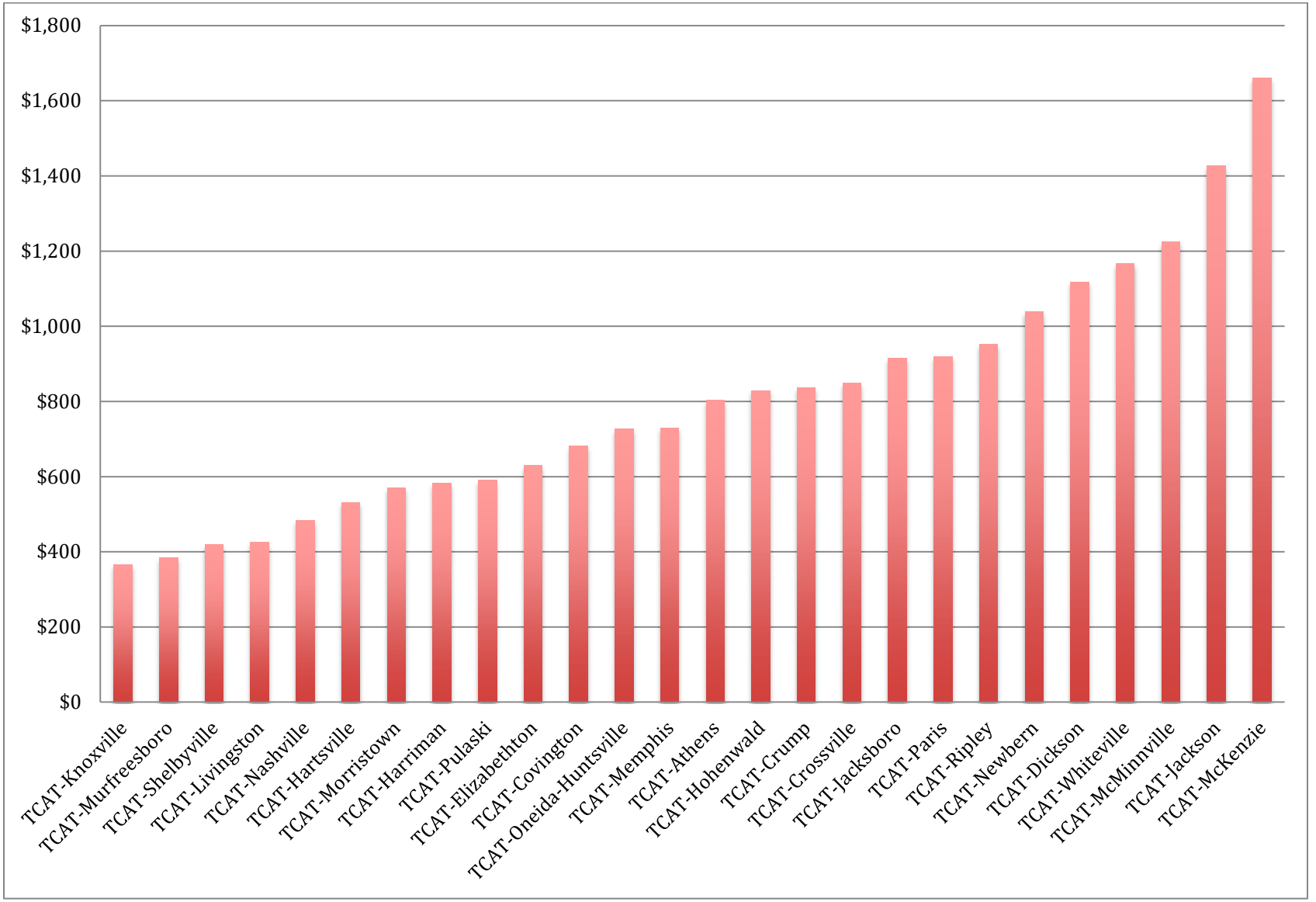


Table 1.9. Per pupil academic support spending at private institutions, 2010-2013

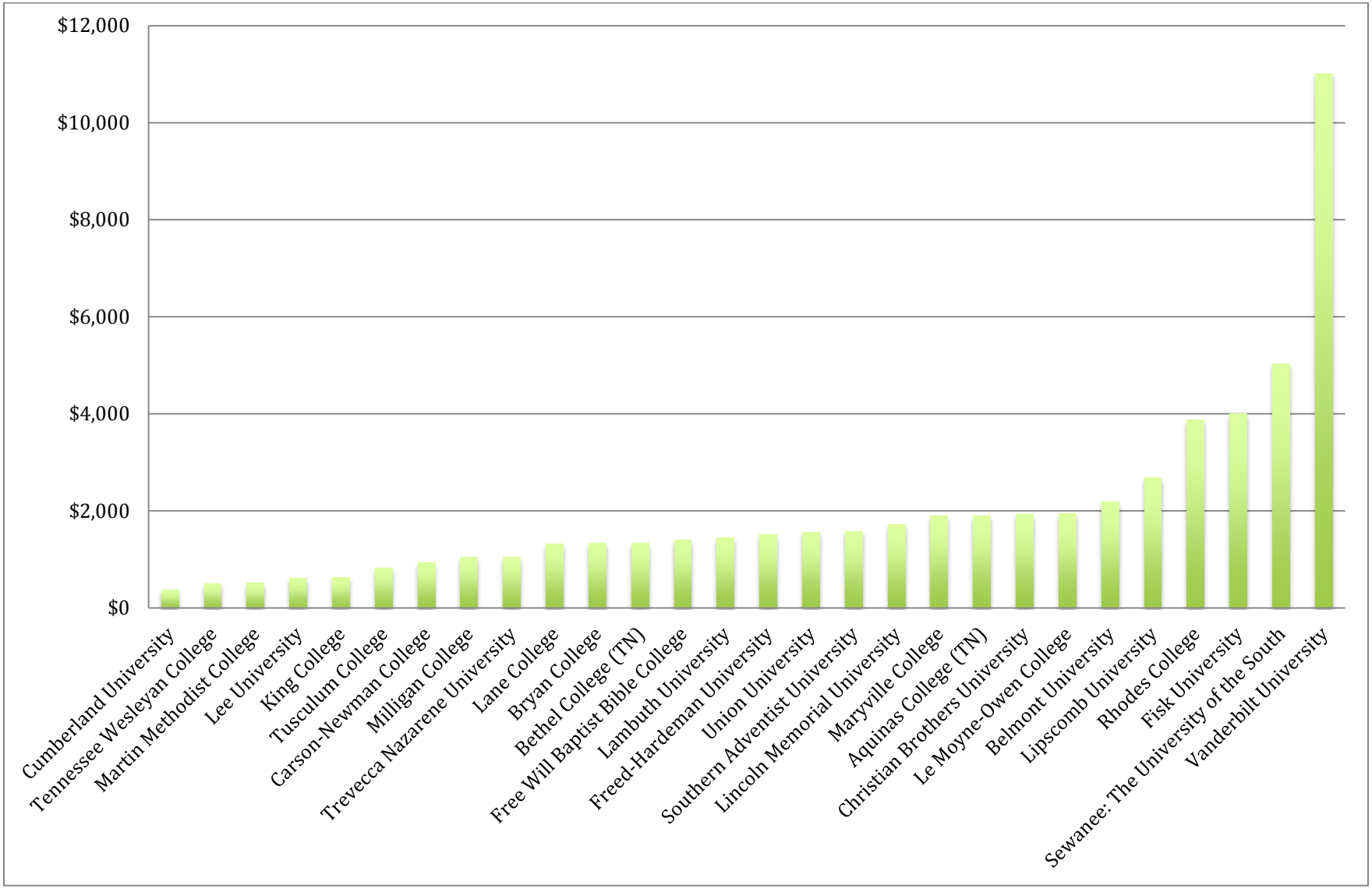


Table 1.10. Per pupil academic support spending at public 2-year institutions, 2010-2013

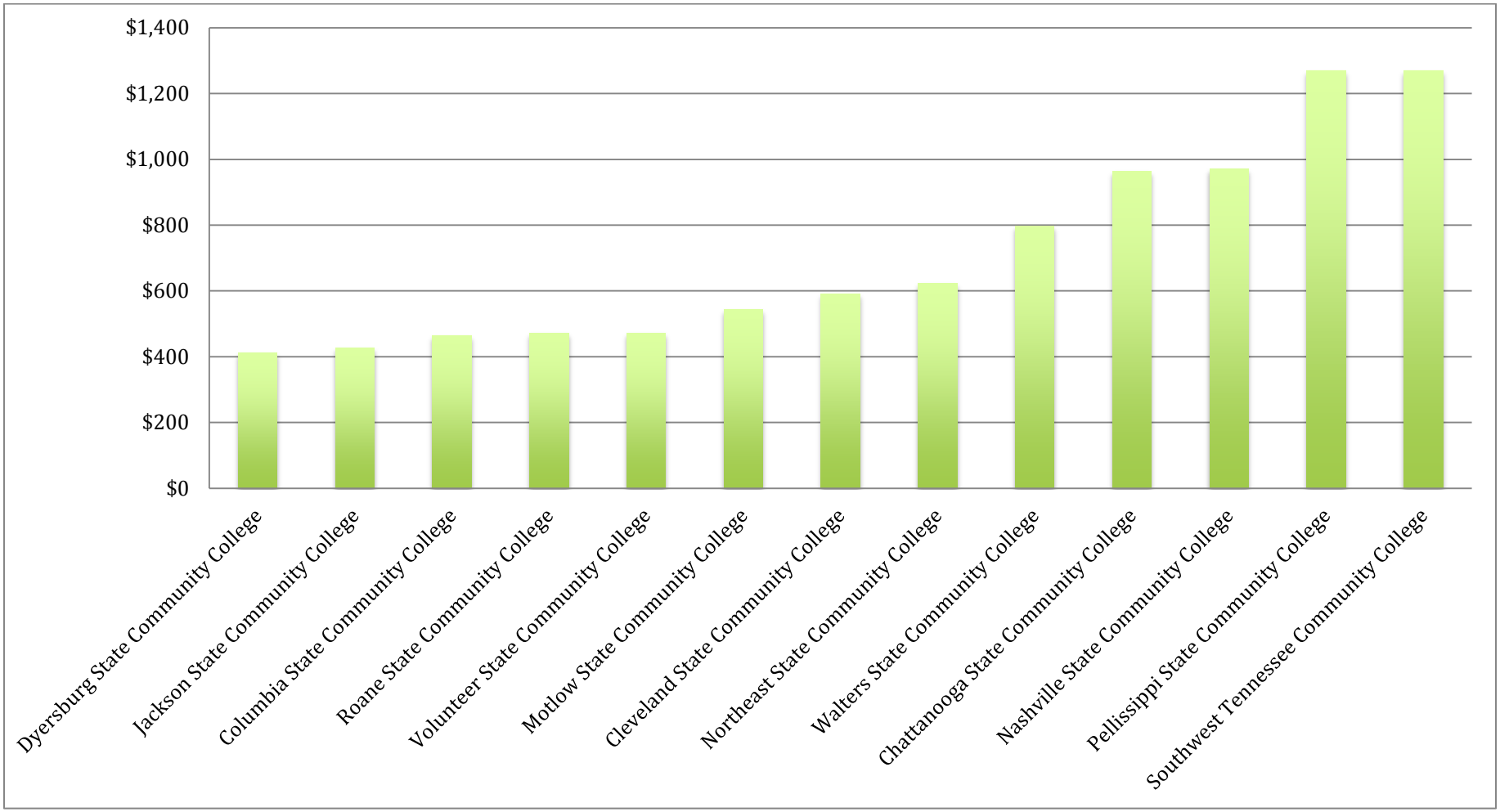
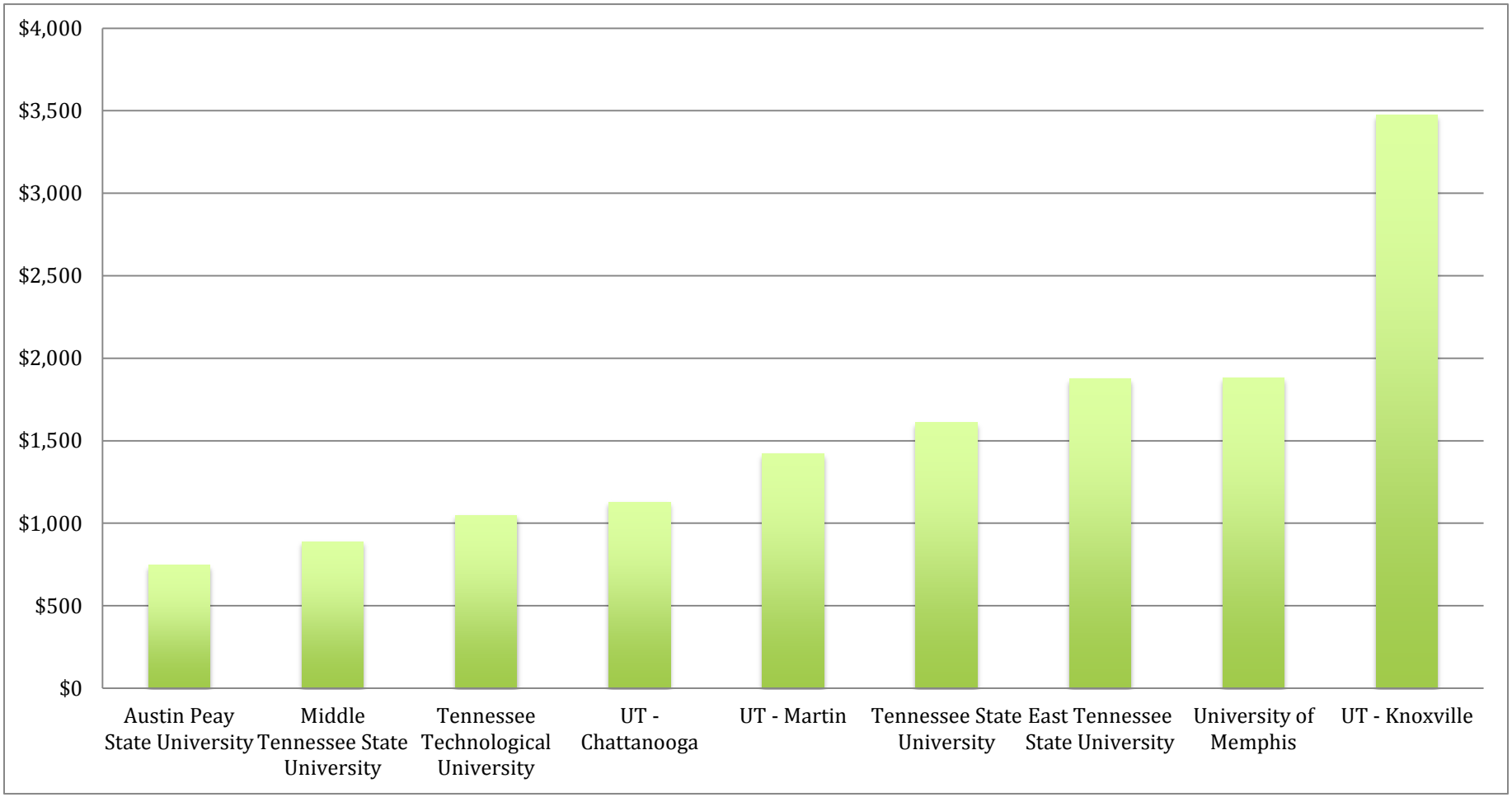


Table 1.11. Per pupil academic support spending at public 4-year institutions, 2010-2013



Chapter 2

Literature Review and Theoretical Frameworks

This literature review is guided by two questions: what are the contributors to and consequences of undermatch, and what is the influence of county- and state-level financial aid programs on undermatch? I begin with a discussion of prior literature that investigates undermatch, and why it is of concern to students, educators, and policymakers. I will then discuss the literature related to statewide merit scholarships and place-based tuition-free college programs, to explore the effects of these programs on students' enrollment decisions. These programs may increase undermatch rates if students are incentivized to attend less selective, lower quality institutions. I then present the theoretical frameworks that motivate this work: college choice models and human capital theory. I conclude with a discussion of theory surrounding the statistical counterfactual and the control groups employed in the analyses conducted in Chapters 4 and 5 of this dissertation.

Literature Review

Prevalence of Undermatch

Recent research estimates that approximately 20 to 60 percent of high school graduates undermatch, depending on each study's sample and definition of undermatch (i.e., Roderick et al., 2008, 2009; Bowen, et al., 2009; Smith et al., 2013; Dillon & Smith, 2017; Rodriguez, forthcoming). For example, Bowen, Chingos, and McPherson (2009) explore undermatch in their often-cited Crossing the Finish Line text, using a sample of 60,000 high school graduates in North Carolina. The authors consider a student's likelihood of admission to North Carolina State

University (NCSU) or the University of North Carolina at Chapel Hill (UNC), the two most selective public universities in North Carolina. If a student is academically eligible to attend NCSU or UNC but does not, he is classified as having undermatched, even if he attends an equally selective out-of-state or in-state private institution. Using this definition, Bowen and colleagues determine that 43 percent of high school graduates in North Carolina who are eligible to attend NCSU or UNC undermatched (Bowen et al., 2009).

Another widely cited study conducted by Roderick and colleagues (2008) at the Chicago Consortium for School Research uses a much different definition of undermatch. Using two cohorts of Chicago Public Schools (CPS) graduates, the authors determine the Barron's selectivity categories of institutions at which students are eligible to enroll. They conclude that 62 percent of CPS graduates undermatch, as they do not attend an institution with the highest Barron's rating at which they are academically eligible.

These highly-publicized studies provide two examples of how estimates of undermatch differ substantially based on the definition used. As such, the stated rates of undermatch cannot be compared, and one is not necessarily more correct than the other. The pitfalls of researchers using multiple definitions of undermatch are explored at length by Rodriguez (forthcoming) and in Chapter 3 of this dissertation. It is worth noting, however, that irrespective of the definition, students who undermatch are disproportionately nonwhite, lower income, graduated from less resourced high schools, and have parents who have not earned a postsecondary degrees (i.e., Fry, 2002; Alon & Tienda, 2005; Bowen, et al., 2009; Roderick, et al., 2008, 2009; Smith et al., 2013; Dillon & Smith, 2017; Rodriguez, forthcoming).

Contributors to Undermatch

Undermatch often occurs due to students' lack of information about the college search and application processes, college costs, and financial aid (i.e., Ikenberry & Hartle, 2008; Bowen et al., 2009; Hoxby & Avery, 2003; Scott-Clayton, 2012; Smith, et al., 2013; Roderick et al., 2008, 2009). Literature exploring each of these contributors will be examined at length below. Nonwhite, lower income, and first generation college students have more limited access to this information relative to their white, higher income peers, resulting in an increased likelihood of undermatch (i.e., Horn, Chen, & Chapman, 2003; Avery & Kane, 2004; Roderick, et al., 2008, 2009; Rodriguez, forthcoming).

College search and application processes. Many high school students, particularly those who are nonwhite and lower income, rely on their high school guidance counselors for support when conducting a college search (Terenzini, Cabrera, & Bernal, 2001; Horn et al., 2003; Zarate & Pachon, 2006). Guidance counselors, however, often lack the necessary information to advise these students, and are frequently overloaded or unavailable (Burdman, 2005; Avery, Bettinger, Hoxby, & Turner, 2009; Roderick et al., 2009; Smith, 2012). As such, these students who have the greatest need for their support do not get it, and therefore may seek information about college-going from less credible sources (i.e., peers, unreliable online resources).

High achieving students from low income backgrounds struggle with the college search process as much as their low achieving peers (Roderick et al., 2009). Avery and colleagues (2009) conclude that 82 percent of high achieving, low income students do not apply to institutions that are on par with their academic abilities. Further, Alon & Tienda (2005) determine that high achieving Hispanic students are disproportionately likely to enroll in a community college or vocational program, as compared to their non-Hispanic peers. The authors

conclude that this is due to a lack of information and support from teachers, guidance counselors, and other adults during high school (Alon & Tienda, 2005).

To address the lack of knowledge about the college search and application processes, Hoxby and Turner (2013) conducted a randomized controlled trial, randomly assigning high achieving, low income students to receive information about postsecondary opportunities via mail. These materials include information about colleges and universities at which students would be an appropriate academic match and/or information for parents, fee waivers for college applications, and net cost calculators. Students who received this information were more likely than their peers to apply to and enroll at institutions at which they are a better academic match, that boast higher graduation rates, and have increased instructional resources, relative to their peers who did not receive these materials (Hoxby & Turner, 2013).

Students who do not conduct a thorough college search are less likely to apply to institutions that are appropriate academic matches (Bowen et al., 2009; Smith, 2012). Surveys and interviews conducted by the Chicago Consortium on School Research conclude that high achieving graduates of Chicago Public Schools know little about the colleges and universities at which they would be well-matched, and instead apply to the institutions most often attended by their peers (Roderick et al., 2009). They apply to institutions that sound familiar, are near home, or at which they know a number of friends or high school classmates (Roderick, et al., 2009).

College costs and financial aid. Many students and their families cannot accurately estimate the costs of college. They often overestimate how much college costs, while underestimating how much financial aid is available (Government Accountability Office, 1990; Horn et al., 2003; Avery & Kane, 2004). As such, they may assume they cannot afford to attend a selective college or university, as these institutions are more expensive than those that are less

selective (Bowen, et al., 2009; Scott-Clayton, 2012). Horn and colleagues (2003) report that only 24 percent of surveyed high school students could accurately predict college costs, while 28 percent estimated the cost of college to be more than double the actual cost. Those surveyed by Ikenberry and Hartle (2008) overestimated the cost of attending a four-year institution by 212 percent, and a two-year college by 193 percent (Ikenberry & Hartle, 2008; Scott-Clayton, 2012). Given these gross overestimates, many students believe college to be unaffordable and out of reach. Knowledge of college costs is related to family income and student race (Horn et al., 2003; Avery & Kane, 2004, Grodsky & Jones, 2007). Low income students were 24 percentage points less likely than higher income students to accurately estimate college costs, while only 18 percent of Latino students were able to accurately identify college costs and sources of financial aid (Horn et al., 2003; Zarate & Pachon, 2006).

Students' access to institutions at which they are academically well-matched is further inhibited when they do not know how to complete the Free Application for Federal Student Aid (FAFSA) and apply for financial aid. The complexity of the FAFSA presents a significant barrier to students applying for financial aid, as many items on the FAFSA are confusing and redundant (Dynarski & Scott-Clayton, 2006; Avery et al., 2009; Scott-Clayton, 2012; Dynarski & Wiederspan, 2012). An experiment conducted by Bettinger and colleagues (2012) provided FAFSA filing support for students and their families when their taxes were prepared. These researchers found a dramatic increase in students' likelihood of completing and filing a FAFSA, and a subsequent 8 percentage point increase in a student's probability of attending college.

Consequences of Undermatch

Economic returns to attending a selective institution. Many researchers have concluded that there is a substantial economic benefit to attending a highly selective, high quality

postsecondary institution (i.e., Kingston & Smart, 1990; Loury & Garman, 1995; Bowen & Bok, 1998; Brewer, Eide, & Ehrenberg, 1999; Zhang, 2005). Undermatched students who attend less selective institutions than those at which they are academically eligible, experience diminished lifetime earnings relative to those who attend more selective institutions. This is particularly important when considering the social mobility often attributed to attending selective institutions, especially among nonwhite and lower income students – those who most often undermatch (Bowen & Bok, 1998, Fry, 2002; Alon & Tienda, 2005; Brand, 2010; Brand & Xie, 2010).

Brewer and colleagues (1999) demonstrate that attending an elite, private university results in increased economic returns for all students who enroll. Zhang (2005) confirms this finding, stating that the returns to high quality schooling differ by one's definition of "high quality." The definition notwithstanding, attending a high quality institution yields a greater economic return than one of lower quality (Zhang, 2005). Black & Smith (2004) determine that men and women who attend a high quality college or university earn 11 and 7.5 percent more, respectively, than those who do not. Additionally, Brand & Halaby (2006) posit that economic returns to attending a more selective institution are experienced through educational attainment and occupational status, which translate for many students into increased wages and lifetime earnings.

Using a sample of students who applied to an identical set of colleges and universities, Dale & Krueger (2002) compare the earnings of those who were accepted to a selective university but did not attend, with those of students who did attend. The authors demonstrate that the economic returns to attending a selective institution were higher for students from lower income backgrounds. In 2011, the same authors conclude that the relationship between

institutional selectivity and earnings is substantial only for black, Hispanic, and lower income students (Dale & Krueger, 2014).

Some debate surrounds the economic returns to attending a community college, in isolation or en route to a bachelor's degree (i.e., Reynolds, 2012; Hoekstra, 2009; Zimmerman, 2014; Doyle, 2009; Long & Kurlaender, 2008). The "community college penalty" is relevant when discussing college choice and undermatch, as many states are proposing or have recently implemented tuition-free community college initiatives. Reynolds (2012) concludes that attending a community college results in negative labor market outcomes relative to those who attend four-year institutions. Men and women who attend a community college earn 7.7 percent and 10.3 percent less, respectively, when they first enter the workforce, relative to those who graduate from a four-year institution (Reynolds, 2012). Hoekstra (2009) uses a regression discontinuity design to determine that students who were barely academically eligible to attend the state flagship university earned 20 percent more over their lifetimes than did those who were barely ineligible. Similarly, Zimmerman (2014) demonstrates that a marginal student who attends a four-year institution instead of a community college earns approximately 8 percent more over the first 8 years of his career, relative to his academically-comparable peers who attended a community college.

Increased graduation rates and institutional resources. Highly selective postsecondary institutions boast higher graduation rates relative to less selective colleges and universities (i.e., Bowen & Bok, 1998; Melguizo, 2008; Alon & Tienda, 2005; Kane, 1998; Kingston & Lewis, 1990). As such, students who undermatch reduce their likelihood of graduating when they attend an institution that is less selective than one in which they could have enrolled. Melguizo (2008) uses data from the National Education Longitudinal Study (NELS) to

explore whether high graduation rates are a function of enrolling high achieving high school graduates, or if institutional quality itself affects degree completion. She concludes that students who attend selective institutions are more likely to earn a Bachelor's degree compared to their peers of similar ability who attend less selective institutions. Alon and Tienda (2005) determine that this is particularly true of black and Hispanic students. The authors investigate the "mismatch hypothesis" that nonwhite students who attend selective institutions as a result of affirmative action programs graduate at lower rates than their peers at nonselective institutions (Alon & Tienda, 2005, p. 295). They find the opposite to be true: nonwhite students who attend higher quality institutions are more likely to earn a degree than their peers who attend less selective institutions (Alon & Tienda, 2005).

Highly selective institutions also have additional resources available to their students, compared to less selective colleges and universities (i.e., Bound, Lovenheim, & Turner, 2010; Hoxby, 2009; Kane, Orszag & Gunter, 2003; Light & Strayer, 2000). Bound and colleagues (2010) determine that less selective four-year institutions have fewer resources (as measured by faculty-student ratios) available. As such, students who attend these institutions, particularly males, have a lower likelihood of earning a Bachelor's degree. Hoxby (2009) confirms this finding, asserting that more selective four-year institutions spend, on average, almost eight times as much per pupil than a less selective four-year colleges and universities, to say nothing of the modest resources provided to community college students (Hoxby, 2009). Hoxby states that irrespective of the measure of resources (instructional resources, faculty qualifications, or facilities, for example) more selective colleges and universities are better resourced. This stratification in resources can be seen in the appendix to Chapter 1 of this dissertation, which display the differences in resources by institution type in Tennessee. More selective, private

four-year institutions have many more resources than those that are less selective, which have only slightly greater resources than community and technical colleges across the state.

Statewide Merit Aid Programs and Undermatch

Statewide merit aid programs have been studied at length since the inception of the Georgia HOPE Scholarship program in 1993. It is well documented that while these programs do not necessarily induce students to enroll in higher education (i.e., Dynarski 2004; Bruce & Carruthers, 2014) they do influence where students enroll. While some have concluded that students receiving merit scholarships substitute away from two-year institution into four-years, as the cost of doing so is reduced (Dynarski, 2004; Bruce & Carruthers, 2014; Zhang, Hu, Sun, & Pu, 2016), others have determined that students enroll in lower quality (often public) institutions rather than more selective (often private) institutions because they are able to use the state's merit aid funds (i.e., Goodman, 2008; Cohodes & Goodman, 2014; Rodriguez, 2016). These conflicting findings demonstrate the need for increased investigation of the impact of these programs on student match.

Cohodes (2014) and Goodman (2008, 2014) determine that students in Massachusetts are willing to sacrifice institutional quality for relatively little merit aid and enroll in less selective public institutions, so they may use their award dollars. These students subsequently earn degrees at lower rates compared to their peers who did not take advantage of the state-sponsored merit aid and attended more selective institutions. Goodman (2008) concludes that students who are lower income and lower achieving respond to the reduction in price at higher rates than their higher income, higher achieving peers (Goodman 2008). As it is often lower income students who undermatch, this is cause for concern, because these students are choosing to attend lower quality institutions than others at which they were eligible to enroll. Further, Rodriguez (2016)

states that average achieving students who receive merit aid may be induced to attend four-year institutions that have resources and a study body more similar to a community college than selective four-year institutions. This finding again leads to questions of match and fit, and the returns to attending less selective four-year institutions in light of receiving merit aid.

Place-Based Tuition-Free College Initiatives and Undermatch

While the national conversation around tuition-free college is relatively new, a number of communities (i.e., Knox County, Tennessee and Kalamazoo, Michigan) have had free college programs in place for almost a decade. As such, the literature exploring these initiatives is limited to those that have been implemented for a few years. These programs may have differing impacts on match, increasing or decreasing local rates of undermatch depending on the structure of each free college opportunity.

Carruthers and Fox (2016) investigate Knox Achieves, a free community and technical college program in Knox County, Tennessee that served as the model for Tennessee Achieves and the Tennessee Promise, regional and statewide free college programs that will be discussed at length in Chapter 5 of this dissertation. Using difference-in-differences and propensity score matching techniques, the authors determine that Knox Achieves increased students' likelihood of enrolling in higher education following high school, particularly among low income students. Further, they determine that Knox Achieves led to some "down shifting" from four-year to two-year institutions, raising questions about undermatch among treated students (Carruthers & Fox, 2016).

In 2005, the Kalamazoo Promise was implemented in Kalamazoo, Michigan. This program provides free tuition to any public postsecondary institution in Michigan to graduates of Kalamazoo Public Schools. The Kalamazoo Promise is not limited to less-than-four year

institutions and as such, has resulted in an increased number of students from Kalamazoo submitting their ACT scores to the most selective public institutions in Michigan – the University of Michigan and Michigan State University (Andrews, DesJardins, & Ranchhod, 2010). As undermatch most often occurs during the search and application stages of students' college decision-making, sending standardized test scores to selective institutions may indicate that the Kalamazoo Promise has decreased the rate of undermatch among students with access to this program.

Further study of the Kalamazoo Promise by Bartik and colleagues (2015) demonstrates that this program resulted in an increase in overall college-going (as was the case with Knox Achieves) and decreased enrollment at non-Promise eligible institutions (i.e., ineligible private institutions). They also found a positive effect on degree attainment within six years of enrollment. The authors conclude, based on this evidence, that simple and generous scholarships have the potential to increase postsecondary enrollment and attainment (Bartik, Hershbein, & Lachowska, 2015). Paired with messaging and outreach, free college programs have been found to increase enrollment at relatively low cost to the state (Pharris-Ciurej, Herting, & Hirschman, 2012; Bartik & Lachowska, 2013; Pluhta & Penny, 2013). However, little is known at this time about the role of these programs and student match – a deficit I address with Chapter 5 of this dissertation.

Limitations of Prior Literature

This dissertation contributes to existing literature by addressing a number of limitations to prior literature. First, each study of undermatch employs a unique definition of undermatch, based on authors' specific research questions and available data. These varied definitions lead to different conclusions about the prevalence of undermatch. The first paper in this dissertation

applies five definitions of undermatch to one sample of high school graduates to determine the influence of the definition on conclusions about undermatch. This extends the work of Rodriguez (forthcoming) by using administrative data from a state student information system, rather than a national dataset.

While much of the literature investigating state merit aid programs discusses the effects of these programs on students' postsecondary enrollment decisions, little has been written to directly address the influence of these programs on undermatch. As the political context surrounding the award structure of the Tennessee Education Lottery Scholarship (TELS) program is evolving, concrete evidence about this program's effects on undermatch will be useful to policymakers, both in Tennessee and other states with similarly structured programs.

Additionally, the rise of free community college programs across the United States has garnered much attention. These initiatives are so new, however, that very little has been written about them. This dissertation's third paper investigates the influence of Tennessee Achieves, one of the first regional programs of this sort, on undermatch, using a quasi-experimental approach that will help states to more fully understand the effects of free college programs as many propose to implement their own.

As a whole, this dissertation provides improved information about undermatch to academics and policymakers alike, exploring the influence of decade-old (Tennessee Education Lottery Scholarship) and more recent (Tennessee Achieves) programs on undermatch. The findings will be applicable not only to policymaking in Tennessee, but in other states considering similar programs.

Theoretical Frameworks

The theoretical frameworks that anchor this work are human capital theory and college choice models. College choice models describe the process by which students decide to enroll in higher education, while human capital theory highlights the economic rationale for doing so. Each of these frameworks has implications for investigations of undermatch. While human capital theory clarifies and emphasizes why the implications of undermatch are of concern, college choice models can be applied differently to subpopulations of students who most often undermatch.

Human Capital Theory

Human capital theory is the economic framework most commonly applied to K-12 and higher education (i.e., Paulsen & Toutkoushian, 2008). This theory posits that students invest in their own human capital by pursuing higher education, to gain skills and knowledge to increase their future productivity, thereby increasing their expected lifetime utility (Becker, 1993; Manski, 1993; Paulsen, 2001). Productivity differs, according to Becker (1993), based not only on the quantity but the *quality* of higher education in which the student invests. Human capital theory is therefore relevant to discussions of undermatch: students who attend higher education institutions that are less selective or of lower quality than those they are academically eligible to attend may not be investing appropriately in their own human capital. Instead, they are perhaps minimizing short term actual costs (i.e., attending a less selective institution that is perceived to be less costly) or opportunity costs (i.e., attending a community college part time while working full time) at the expense of long term utility.

When deciding to invest in higher education, human capital theory assumes that students act rationally as they weigh short-term costs (i.e., tuition, fees, psychic costs, opportunity costs, and lost wages) against long-term benefits such as improved job opportunities and increased

future earnings. This rational behavior is based on available information (Becker, 1993; DesJardins & Toutkoushian, 2005). As students who are likely to undermatch often lack access to information about the college and financial aid application processes (Bowen, et al., 2009; Roderick et al., 2008, 2009), they are not always aware of or able to accurately estimate the short terms costs and future benefits of higher education. This is because they lack access to informed adults (i.e., teachers and guidance counselors), do not experience a college-going culture at their high school and in some cases, have inconsistent internet access (Bergerson, 2009; Bowen, et al., 2009; Roderick, et al, 2008, 2009). As such, the search costs to gather this information are high, resulting in an information deficit. Their enrollment decisions, while rational given the information available to them, may not result in increases to their human capital: they often enroll in colleges or universities that are local, are familiar, or where they know other students rather than those at which they are the best academic match (Roderick et al., 2008, 2009).

However, individuals make college-going decisions in ways that reflect their personal preferences (*utility*) and tolerance for risk and uncertainty (Paulsen, 2001; DesJardins & Toutkoushian, 2005). Students' utility is comprised of many factors (i.e., affordability, proximity to home, athletic opportunities), and they often make college-going decisions that optimize different portions of their utility curves. For example, while one student may seek to enroll in the most selective institution to which he is accepted, another may want to attend the lowest cost institution, or the institution closest to home, or an institution best known for stellar athletics. Students' and families' utility, as well as risk aversion, may explain why some students undermatch: their preferences are not to attend highly selective institutions, but those that meet other criteria (Paulsen, 2001; DesJardins & Toutkoushian, 2005). While this behavior is rational

based on a student's preferences, these college-going decisions still may reduce future earning potential when they result in students attending less selective, lower quality institutions.

From a policy perspective, interventions to mitigate undermatch must consider the myriad factors that comprise students' utility curves, and what factors students are attempting to optimize when making college-going decisions. Providing financial aid to encourage high achieving, low income students to attend selective institutions, for example, will not reduce undermatch if the reason that these students are not attending these institutions is not financial, but a desire to stay close to family and friends in his hometown. As different preferences will dictate students' responses to attempts at reducing undermatch, increased diversity in the methods by which educators and policymakers attempt to reduce undermatch is necessary to increase match among high achieving students.

In Tennessee, decade-old and more recent higher education policies - the Tennessee Education Lottery Scholarship and Tennessee Achieves programs, respectively, which are discussed at length in Chapters 4 and 5 - provide a financial incentive to students to attend two year or technical colleges, or lower cost, less selective in-state institutions. Therefore, it is possible that these programs are contributing to increased undermatch and diminished human capital statewide, if students' preferences lead them to enroll at lower quality institutions that are made more affordable and closer to home, rather than those that are the best academic match. Decreasing the state's human capital is the opposite of the programs' stated objectives, and as such, human capital theory will provide a critical framework for evaluating the effects of these programs on students' enrollment decisions.

Hossler and Gallagher's (1987) College Choice Model

While many stage-based college choice models exist, one of the most frequently cited (Bergerson, 2009, p. 21) is Hossler and Gallagher's (1987) three-stage model of college choice. Each stage of this model – *predisposition*, *search*, and *choice* – is of consequence to students making postsecondary enrollment decisions.

Predisposition. The predisposition stage represents the development of students' college aspirations and expectations (Bergerson, 2009, p. 22). Students' postsecondary ambitions are shaped by a number of factors. Socioeconomic status influences predisposition, as low income students are more price-sensitive than their higher income peers, and many assume they simply cannot afford to go to college (Callander & Jackson, 2008; Dynarski, 2002, 2003; Grodsky & Jones, 2007; Lillis, 2008). Parental involvement in the college-going process and whether the parents themselves have postsecondary experience also contributes to how a student thinks about going to college (Conley, 2001; Ellwood & Kane, 2000; Hossler & Stage, 1992). A peer group that aspires to go to college, along with supportive teachers and counselors, can also positively shape students ambitions (Muhammad, 2008; Perez & McDonough, 2008). Interactions with school personnel, as well as the college-going culture in a middle or high school, are additional positive influences on students' ambitions (Roderick, Nagoaka, Coca & Moeller, 2008, 2009). Finally, academic achievement – a student characteristic rather than a family or school characteristic –inform aspirations. A student who is higher achieving may have aspirations different from his lower achieving peers (Hossler, Schmit, & Vesper, 1999).

Search. The search stage of Hossler and Gallagher's (1987) college choice model occurs when students form a choice set of institutions to which they may apply (Bergerson, 2009, p. 24). The crux of this stage is information gathering (Hossler & Gallagher, 1987). Students seek information from campus resources, peers, teachers and counselors, and institutional

representatives, and, among recent cohorts of high school students, the internet (Hossler et al 1999; Hartley & Morphew, 2008; Roderick, et al., 2008). Also, as with the predisposition stage, parental engagement informs the search stage. Feedback from parents about price, proximity to home, and expectations about institutional quality inform students' choice set of institutions (Hossler, et al., 1999).

Choice. During the third stage of Hossler and Gallagher's (1987) college choice model, students select a higher education institution at which to enroll. As this point, institutional characteristics, particularly cost and financial aid, play a profound role in a student's decision about where to attend (i.e., Dynarski, 2002, 2003; Curs & Singell, 2002; DesJardins, Ahlburg, & McCall, 2006; Hossler et al., 1999; Paulsen & St. John, 2002). Further, students' choice also relies on institutional characteristics such as location, course and major offerings, and reputation (i.e., DesJardins, Dundar, & Hendel, 1999; Goenner & Pauls, 2006; Roderick et al., 2008, 2009).

Deficits in Process and Undermatch

Each stage of Hossler and Gallagher's (1987) college choice model unfolds differently for students who are traditionally underrepresented in higher education, particularly those who are nonwhite or low income. As these student subgroups frequently undermatch, it is probable that deficits in this process, especially during the *search* stage, contribute to students' likelihood of undermatching (i.e., Bergerson, 2009; Bowen, Chingos, & McPherson, 2009; Roderick et al., 2008; 2009).

Predisposition. Nonwhite and low income students attend schools lacking a college-going culture at rates that exceed their white and upper income peers (Lucas & Good, 2001; Solorzano & Ornelas, 2004). As such, they are not always exposed to school personnel with high expectations related to college-going, and interact with peer groups who are not college-minded

(i.e., Goodard, 2003; Roderick, et al., 2008, 2009). Further, many nonwhite and low income students are first generation college-goers, whose parents do not have experience or are disengaged from conversations about college-going (Hossler & Stage, 1992; Hossler & Vesper, 1993; Perna, 2000). These students are less predisposed to attend college at all, let alone aspire to attend an institution at which they are an appropriate academic match.

Search. Nonwhite and lower income students gather information about postsecondary options in ways that are different from their white, upper income peers. They often do not have access to teachers, guidance counselors, parents, friends and community members who are well-informed about the college search and application processes (Grodsky & Jones, 2007; Ikenberry & Hartle, 1998). Further, these student subgroups may lack reliable internet access at home or at school. As the internet has become a primary source of information gathering, these students are at a further disadvantage in the search process (Hartley & Morphew, 2008; Roderick, et al., 2008). In particular, nonwhite and low income students often lack information about financial aid, as many overestimate the costs of college and underestimate the availability of financial aid (Ikenberry & Hartle, 1998; Scott-Clayton, 2012). These students may assume they cannot afford to go to a high quality, more selective institution, as they are more price sensitive than their peers (Dynarski, 2002, 2003; Paulsen & St. John, 2002) so may limit their search to institutions they believe they can afford, leading to an increased likelihood of undermatch.

Choice. At this stage, students decide on the institution at which they will enroll. During this time, students focus on factors such as the cost of attendance and the institution's location (i.e. DesJardins, et al, 2006; Grodsky, 2002; Ikenberry & Hartle, 1998) and as such, may choose to enroll at the most affordable institution or the institution that is closest to home, irrespective of selectivity or quality. This is particularly true for student subgroups at high risk of

undermatching, increasing the prevalence of undermatch among nonwhite and lower income students (Roderick et al., 2008, 2009).

Perna's (2006) College Choice Model

Perna's model of college choice (2006) is more integrative, combining aspects of human capital theory and traditional sociological models of college choice. This model also accounts more explicitly for the role of social and cultural capital – students' knowledge of norms and language surrounding college going, which are often central to students' enrollment decisions and subsequent match (Perna, 2006; Dika & Singh, 2002). Rather than treat the college choice process as sequential (i.e., students do X, then Y, then Z), Perna discusses this process as embedded in a student's school, community, and social contexts, among others.

Perna's model is comprised of four layers. Layer one, the innermost layer, reflects a student's *habitus*: his or her demographic characteristics, social and cultural capital, demand for higher education and the supply of resources available to pursue higher education, and expected costs and benefits. As students often undermatch due to a lack of social and cultural capital related to higher education, and misunderstand the costs of enrolling, this layer is relevant to studies of undermatch, and emphasizes the need for access to information about the costs and benefits of college going, as well as support throughout the application process.

The second layer of Perna's model is the students' school and community context, which considers the structures and resources in the school and community environments that enhance or hinder students' college going decisions. For lower income, nonwhite students – those who most often undermatch – a lack of college going culture and personnel resources (i.e., a capable college counselor) in the high school may contribute substantially to undermatch rates (Stanton-Salazar, 1997; Bowen, et al., 2009).

The higher education context, the model's third layer, depicts the role of recruitment, communication and marketing from higher education institutions to high school students. As very selective, high quality postsecondary institutions often do not communicate with or recruit students who attend under resourced high schools, they forgo opportunities to enroll high achieving students from these schools, increasing undermatch. Also, colleges and universities often visit high schools close to their campuses, providing information about local postsecondary options. As undermatched students often enroll at institutions that are close to home, irrespective of academic match, this may be an additional factor contributing to undermatch.

The social, economic and policy context, the fourth layer of Perna's college choice model, is particularly relevant to explorations of undermatch in Tennessee. This is because many state-level higher education policies; state-funded financial aid programs (i.e., the Tennessee Education Lottery Scholarship program and Tennessee Achieves) in particular, provide a financial incentive for students to attend a two-year institution rather than a four-year college or university. As such, increased undermatch may be an unintended consequence of such programs. Further, there is pervasive conversation about the importance of higher education to finding and securing sustainable employment in the state, demonstrating the potential role of macro-level contexts on students' postsecondary decision making.

Relative to sequential, stage-based models, Perna's (2006) model of college choice may more accurately reflect the contexts in which a nonwhite or low income student at risk for undermatch is making college-going decisions – the family, school, higher education, and policy contexts. Each of these contexts may more accurately account for the different experiences of these student subgroups and subsequently, different rates of undermatch among different groups of students.

Counterfactual theory

Counterfactual analyses of causation attempt to explain what would have happened "had the world been different," had a treatment not occurred or a program not been established. These analyses focus on distinct, temporally successive events (i.e., if X did not first occur, Y would not have occurred) to determine causality (Lewis, 1973). Lewis (1973) discusses this theory in terms of a "possible world," a hypothetical universe in which one can determine what would have happened in the absence of an event (Lewis, 1973).

The next best option, as a "possible world" is an impossible idea, is a randomized controlled trial (RCT). When conducting an RCT, participants are randomly assigned to receive an intervention ("treatment") or not ("control") such that their outcomes may be compared. RCTs are considered to be the "gold standard" for causal research, but are not always possible to conduct due to resources, ethics, political constraints, etc.

In the absence of an RCT, quasi-experimental methods facilitate the creation of a statistical counterfactual, a group within the sample that serves as a control group. In Chapter 4 of this dissertation, I conduct a regression discontinuity analysis. The counterfactual for this study is the group of students just below the threshold for General Assembly Merit Scholarship receipt, whose outcomes are compared to those just above the threshold. These students are comparable to those who receive treatment on a number of observable characteristics, the difference being that they did not receive scholarship funds due to their ACT composite score, while their peers just above the threshold did. In Chapter 5, I use difference-in-differences and propensity score matching strategies to explore the effects of Tennessee Achieves, the tuition-free community and technical college program that preceded the statewide Tennessee Promise program. The counterfactuals when using these two methods are the difference in outcomes

before and after treatment between those who were and were not treated, and statistically comparable control students, determined based on their propensity to participate in Tennessee Achieves, respectively.

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Chapter 3

The Effect of Multiple Definitions on Undermatch Rates in Tennessee

Abstract

This paper discusses the prevalence of postsecondary undermatch among recent high school graduates in Tennessee. Using student-level data provided by the Tennessee Higher Education Commission, five definitions of undermatch are applied to one sample of high school graduates to determine the sensitivity of undermatch rates to the way undermatch is defined. These definitions yield undermatch rates of 21 to 69 percent of high school graduates, demonstrating that the definition of undermatch is relevant to the conclusions drawn about this issue. Irrespective of the definition applied, students who are nonwhite and lower income undermatch at higher rates than their white, more affluent peers.

Introduction

Postsecondary undermatch definition

Postsecondary undermatch occurs when a student attends a college or university at which he is academically overqualified relative to other students enrolled at that institution (i.e, Black & Smith, 2004, 2006; Roderick, Nagaoka, Coca, & Moeller, 2008, 2009; Bowen, Chingos & McPherson, 2009; Smith, Pender, & Howell, 2013; Dillon & Smith, 2017). The academic indicators most commonly used to determine whether a student is appropriately matched to the institution he attends are his high school grade point average (GPA) and composite standardized test scores (ACT or SAT score).

Prevalence of postsecondary undermatch in the United States

Prior research estimates that the nationwide undermatch rate ranges from 20 to 60 percent of high school graduates, depending on each study's sample and definition of undermatch (e.g., Roderick et al., 2008, 2009; Bowen, et al., 2009; Smith et al., 2013; Dillon & Smith, 2017). Each author who has written about undermatch has defined this phenomenon differently, and uses unique indicators of students' academic ability and of college quality. Because of this, these undermatch rates are not comparable. However, students who undermatch, no matter the definition, are disproportionately nonwhite, low income, graduated from under-resourced high schools, and have parents without a postsecondary degree (Fry, 2002; Alon & Tienda, 2003; Bowen, et al., 2009; Roderick, et al., 2008, 2009; Smith et al., 2013; Dillon & Smith, 2017).

Contributors to undermatch

Many high school graduates undermatch because they are not well informed about the college and financial aid application processes (i.e., application deadlines, how to complete the Free Application for Federal Student Aid) and/or the costs of college, as they believe the net cost

of attendance to be much greater than it is (Scott-Clayton, 2012). Further, they are unsure about the most appropriate postsecondary options for students with their academic abilities, they attend high schools that lack college-going cultures, and rely on the insights of their (often misinformed) peers and time-constrained teachers and guidance counselors when seeking information about higher education opportunities (i.e, Ikenberry & Hartle, 1998; Bowen et al., 2009; Hoxby & Avery, 2003; Roderick et al., 2009; Smith, et al., 2013). Because of these information deficits, many students enroll at an institution that is less selective (and often less expensive) than one they are academically eligible to attend.

Consequences of undermatch

Students who undermatch experience longer time-to-degree, and are less likely to graduate than their peers who are well-matched at an academically appropriate institution (Bowen, et al., 2009; Wyner, Bridgeland, & Diiulio, 2009). This may be due to a lack of fit between the student and the institution, as well as the fact that lower quality, less selective institutions often have fewer resources and support services available to aid students and increase success (Roderick et al., 2008, 2009; Bowen et al., 2009).

Further, the economic returns to high quality postsecondary education cause educators and policymakers to be concerned with undermatch. There exists a substantial economic benefit to attending a more selective institution, relative to a less selective, lower quality institution (i.e., Kingston & Smart, 1990; Loury & Garman, 1995; Bowen & Bok, 1998; Brewer, Eide, & Ehrenberg, 1999). As such, undermatched students who attend less selective institutions than those they are academically eligible to attend diminish their lifetime earnings. This is important when considering the social mobility often attributed to earning a degree at selective institutions, particularly among nonwhite and lower income student subgroups – the students who most often

undermatch (Bowen & Bok, 1998, Fry, 2002; Alon & Tienda, 2003; Brand, 2010; Brand & Xie, 2010).

The personal and social returns to high quality postsecondary education are also substantial. College graduates are more likely to have health insurance and employee-sponsored benefits, express higher levels of job satisfaction, be more engaged parents, and be in better health (Baum, Ma, & Payea, 2010). Additionally, those who graduate from college are twice as likely as high school graduates to vote, as well as volunteer with civic, community, and social welfare groups (Brand, 2010; Brady, Schlozman, & Verba, 1999; Nie, Junn, & Stehlik-Berry, 1996; Hauser, 2000; Dee, 2004).

Contribution and Research Questions

This paper contributes to existing undermatch literature by applying five definitions of undermatch to one sample of recent high school graduates to determine the effect of each definition on rates of undermatch in Tennessee. This paper updates and builds upon the work of Rodriguez (forthcoming) in which she uses ELS:2002 data to conduct a similar exploration of differing definitions of undermatch. Using more recent cohorts of high school graduates from one state controls for the ways in which the state's economy and state-level higher education initiatives (i.e., need- and merit-based financial aid programs) impact students' college choices, while exploring the prevalence of undermatch in the state.

In exploring further the effects of different definitions of undermatch, I emphasize the importance of researchers clearly stating how they are conceptualizing and defining undermatch, such that conversations about this issue are consistent and comparable. As Tennessee is at the forefront of many ambitious higher education initiatives, for example, it is imperative that any discussion of these programs' effects on undermatch (i.e., offering tuition free community

college to recent high school graduates) are determined using explicit, transparent definitions of what it means to undermatch.

This paper will apply five definitions of undermatch to determine the following:

1. How sensitive are estimates of undermatch in Tennessee to different definitions of undermatch?
2. What are the characteristics of recent high school graduates in Tennessee who undermatch? Do student characteristics differ by each definition of undermatch?

I hypothesize that, while each definition will yield a strikingly different estimate of undermatch, students of color, students who are first-generation college entrants and students who are Pell eligible will undermatch at higher rates than their white, upper income peers whose parents are college graduates.

Definitions of Undermatch

To determine the definitions of undermatch included in this paper, I consider the features and drawbacks of the definitions used in prior, often-cited works. These definitions and their use in prior analyses are discussed at length below.

Roderick et al. (2009)

I first apply the definition of undermatch used by Roderick et al. in their work published by the Consortium on Chicago School Research (CCSR). I adapt the authors' GPA and ACT score matrix to determine whether students are eligible to attend any four-year college or university in Tennessee, or if they are academically eligible to attend a less-than-four-year institution. Details related to this matrix are presented in Table 3.3. Using this matrix and considering the selectivity of four-year institutions in Tennessee, any student who scores an 18 or higher on the ACT and earns a high school GPA of 2.5 or higher is eligible to attend at least one four-year college or university in the state. Therefore, the first definition of undermatch

classifies those who did not attend a four-year institution when they were academically eligible to do so (and instead attended a community college or technical college) as having undermatched.[6] This is referred to by Rodriguez as the "enrollment rate" method.

Bowen, et al. (2009)

The second, narrower definition of undermatch is that used by Bowen, et al. (2009) in their Crossing the Finish Line text. These authors define undermatched students as those who were eligible to attend the most selective public universities in North Carolina (The University of North Carolina – Chapel Hill and North Carolina State University), but did not.

The four most selective institutions in Tennessee are Vanderbilt University, Rhodes College, Sewanee, the University of the South, and the University of Tennessee at Knoxville. Students entering these institutions have an average high school GPA of 3.7, and an average ACT composite score of 29. Using this second definition, any student who was eligible to attend any of these four institutions but enrolled elsewhere will be considered undermatched.[7] Rodriguez refers to this as the "acceptance rate method."

Barron's selectivity categories

The third definition of undermatch considers Barron's selectivity categories as a measure of institutional quality. Students are classified as undermatched if they enroll at an institution that is below the Barron's category of an institution at which they are academically eligible to enroll.

[6] Some debate surrounds the appropriateness of relying solely on high school GPA and/or standardized test scores to determine the college or university that is the best match for a student. Some contend that high school GPA is the preferred indicator, as it reflects non-cognitive, hard to measure student characteristics such as motivation (i.e., Bowen, et al., 2009). Others state that standardized test scores are more appropriate predictors of where students will be accepted and their academic success once they enroll (Bastedo & Jaquette, 2011; Bettinger, Evans, & Pope, 2011). In light of this debate, I use both high school GPA and ACT composite score, as well as Barron's selectivity rankings, to explore undermatch in Tennessee.

[7] Using this definition, students who attend highly selective colleges or universities out-of-state are still considered to have undermatched, as they did not attend one of the most selective in-state institutions.

For example, a student who earned a high school GPA of 3.5 and an ACT composite score of 30 is eligible to attend a "Most Competitive" college or university. If he attends a "Highly Competitive" or a "Very Competitive" college or university, he will be classified as having undermatched. The definitions of each Barron's selectivity category and the corresponding GPAs and ACT scores are presented in Table 3.4.

Distance from mean GPA and ACT

The fourth definition of undermatch classifies students as undermatched if their academic qualifications (high school GPA or ACT composite score) are higher than those of their peers, on average, at the institution they attend. Students are labeled as undermatched if their high school GPA is .25, .50, or 1 point higher than the mean GPA of their peers, or if they earned ACT scores that are 1.5 or 3 (one half or one standard deviation, respectively) or more points higher than the mean ACT score of the incoming class at the institution they attend. The objective of this definition is to determine "how undermatched" students are.

Dillon and Smith (2017)

The fifth definition of undermatch used in this paper is the definition created by Dillon and Smith (2017) to more fully account for student characteristics and institutional quality when exploring undermatch, rather than only students' ACT scores and high school GPAs. This definition first ranks students' academic achievement using their scores on the Armed Forces Vocational Aptitude Battery (ASVAB; I use ACT scores when exploring this definition.) The authors then create and weight by student body size a college quality index using variables from the Integrated Postsecondary Education Data System (IPEDS) that reflect selectivity and resources available to the institution: mean SAT score of entering students, the percent of applicants rejected, the average salary of teaching faculty, and faculty-student ratio. As the index

is weighted by the number of students enrolled at each institution, students in the n^{th} percentile of ability should, in the case of "perfect match," enroll in an institution in the n^{th} quality percentile. As such, students for whom the difference in percentile rankings is 20 or greater are considered to have undermatched.

Data

This study uses student-level administrative data for four cohorts of recent high school graduates in Tennessee (the graduating classes of 2010 through 2013) to explore the sensitivity of undermatch rates to different definitions of undermatch. These data are provided by the Tennessee Higher Education Commission (THEC), the state's public higher education coordinating board, and the Tennessee Student Assistance Corporation (TSAC), the state's financial aid granting agency. Variables provided by THEC include student demographic information (e.g., sex, race), academic qualifications (e.g., ACT score)[8], and the higher education institution at which students enroll, as well as the mean ACT composite score and high school GPA of incoming freshmen classes at each public institution. Data provided by TSAC includes family adjusted gross income (AGI), expected family contribution (EFC), and whether a student is ever Pell grant eligible.

Students' high school GPAs are captured from two sources: cumulative GPAs that are self-reported on the ACT (most often during the junior year) and from TSAC, to which GPAs are reported by guidance counselors and audited by TSAC staff when students apply for state-sponsored merit aid. As the latter source of this variable is audited and verified, data from TSAC are preferred. For students who do not apply for state-funded scholarships, however, this paper

[8] This study uses a student's *first* ACT score, as opposed to his maximum score. This is because, as the ACT is universal and mandatory in Tennessee, all students have a first ACT score irrespective of their postsecondary aspirations. Students who take the ACT multiple times may have different preferences or aspirations for higher education relative to their peers who take the exam only once.

relies on the self-reported GPA from the ACT data ,which, per ACT, is accurate for approximately 85 percent of students who take the ACT (Sanchez & Buddin, 2015).[9]

Data from the National Student Clearinghouse (NSC) is used to supplement data provided by THEC and TSAC, and to include in the sample high school graduates who do not enroll in a public college or university in Tennessee. This data accounts for those students who attend a private institution in Tennessee. The name, type (less-than-four or four-year institution), and Barron's selectivity category of each institution are provided by the NSC.

Sample

The initial sample for this analysis (N = 139,824) is comprised of four recent cohorts of public high school graduates in Tennessee. Students are included in the sample only if they enroll in a college or university following high school, as the objective of this analysis is to investigate *where* students enroll, not *whether* they enroll.

The sample is restricted to students who have a valid ACT composite score and high school GPA, as both ACT score and GPA will be used as indicators of academic undermatch. Because the ACT is universally administered in Tennessee, all students enrolled in public high schools should have taken the exam, regardless of their postsecondary aspirations. For this reason, very few students (less than 1 percent, N =41) are dropped from the sample due to a missing ACT score. Approximately 5 percent of the initial sample (N = 6,656) does not report a GPA on the ACT or have a GPA on record with the Tennessee Student Assistance Corporation[10], and are therefore dropped from the sample. The resulting sample is comprised of 133,127 recent graduates of public high schools in Tennessee who immediately enroll in higher education.

[9] The audited GPA provided by TSAC is used when students have a value for both audited and self-reported GPAs.

[10] Students who do not apply for merit-based financial aid are not required to submit ACT scores or high school GPAs to TSAC.

Table 3.1 presents the sample descriptive statistics. Students are predominantly white (68.4 percent), and those who are black and Hispanic comprise 24.6 and 3.2 percent of the sample, respectively. The sample is 56.5 percent female. Approximately 46 percent of students in the sample are Pell eligible (47 percent at community and technical colleges; 44 percent at four-year institutions). The mean high school GPA is 3.19 (3.0 at community and technical colleges; 3.4 at four-year institutions), and the average composite ACT score is 20.9 (19.9 at community and technical colleges, 22.3 at four-year institutions).

Approximately 55 percent of these high school graduates attend a community or technical college, while 45 percent attend a four-year college or university. Community and technical colleges in Tennessee are classified by Barron's as Noncompetitive or Not Rated. More than 90 percent of students who enroll in four-year institutions attend a college or university that has a Barron's selectivity category of Less Competitive, Competitive, or Very Competitive. The remaining students (eight percent) are those who attend very selective (Highly and Most Competitive) institutions.

Findings

Roderick et al. (2009)

Approximately 72 percent of students in the sample (N = 95,811) earned a high school GPA of 2.5 or greater, and an ACT score of 18 or higher. Per the definition of undermatch used by Roderick et al. (2009) and the academic qualifications to attend a four-year institution in Tennessee, each of these students is eligible to attend at least one in-state four-year college or university. Of these students, 47 percent (N = 45,224) did not enroll at a four-year institution, and instead enrolled at a community or technical college. Therefore, using this definition, 47 percent of recent high school graduates in Tennessee have undermatched.

Relative to students who meet these academic qualifications and enroll in a four-year institution, undermatched students earned slightly lower average ACT composite scores (22.4 versus 23.2; difference is significant at $p<.05$) and slightly average high school GPAs (3.43 versus 3.46; difference is statistically insignificant). Further, 51 percent of undermatched students are Pell eligible. While no substantial difference exists with regard to the proportion of nonwhite "matched" versus undermatched students, this finding suggests that lower income students are more likely than their more affluent peers to undermatch, a conclusion that mirrors prior research.

Bowen et al. (2009)

Approximately six percent of the sample (N = 8,305) earned a high school GPA of 3.7 or higher, and an ACT score of 29 or higher, the necessary academic criteria to attend one of the four most selective colleges and universities in Tennessee. Of these students, only 31 percent attended Vanderbilt University, Rhodes College, Sewanee, the University of the South, and the University of Tennessee at Knoxville. Using this definition, 69 percent of recent high school graduates in Tennessee who were academically eligible but did not attend the most selective colleges and universities in the state, have undermatched.

Given the narrowness of this definition, this rate is artificially high relative to undermatch rates calculated using less restrictive definitions. This definition disregards issues of capacity (do these four institutions have the space and resources to serve every academically eligible student?) or students' choice to attend out-of-state colleges. However, this definition remains relevant, as the findings of Bowen et al. (2009) are regularly cited in both policymaking and higher education, generating a call for action to combat undermatch.

Barron's selectivity categories

Approximately 59 percent of students (N = 78,555) attended a college or university that is classified by Barron's as at least one category below their appropriate academic match or enrolled in a non-ranked community or technical college. This undermatch rate is driven primarily by a large number of high achieving students enrolling at a community or technical college, most of which are unrated by Barron's.[11] Primarily, students who are lower income and in the middle of the GPA (2.0 – 3.0) and ACT distributions (24 – 28) are those who undermatch using this definition.

Distance from mean GPA and ACT

Approximately 56 percent of students in the sample (N = 74,551) earned high school GPAs that are 0.25 or more points above the mean GPA of the incoming class at the institution they attend.[12] Increasing the cutoff to 0.50 points or more decreases the rate of undermatch to 49 percent (N = 65,232). Twenty-one percent of students (N = 27,956) earned high school GPAs that are greater than or equal to 1 point higher than the mean GPA of the incoming class at the institution at which they enroll.

The majority of these undermatched students are enrolled in community colleges, primarily those in east Tennessee that often serve students who intend to transfer to a local four-year institution (i.e., Pellissippi State Community College in Knoxville, Tennessee and Chattanooga State Community College in Chattanooga, Tennessee) Further, community colleges in Tennessee serve a more diverse study body, which contributes to the large variation in GPAs. Of those who undermatch by 1 GPA point or greater, the majority (more than 80 percent) are

[11] Tennessee Achieves, a regional program and precursor to the statewide Tennessee Promise program that provides free tuition at community and technical colleges may contribute to these enrollment patterns. This policy will be invested more fully in Chapter 5.
[12] Average ACT and GPA, as discussed with regard to this definition, is the four year average (2010-2013) academic qualifications of entering freshmen, as calculated by the Tennessee Higher Education Commission in its annual *Higher Education Factbook.*

nonwhite and Pell eligible – again, it is students of color from lower income households who undermatch at higher rates relative to their white, higher income peers.

Undermatch rates using ACT composite scores yields a similar finding. Approximately 60 percent of students (N = 79,876) attend a college or university at which their ACT composite score is 1.5 points (approximately one-half a standard deviation) above the mean ACT score of their peers. 38 percent of students (N = 50,588) earned an ACT composite score that is 3 points (1 standard deviation) higher than the mean. Again, it is the community colleges, particularly those mentioned above, that have the greater degree of variation in the ACT scores of those who enrolled during this time.[13]

Considering both the GPA and ACT indicators of undermatch, one can use this definition to assert that 21 to 60 percent of recent high school graduates in Tennessee undermatch, depending on the distance from average academic indicators considered. Related to the above-mentioned discussion of whether GPAs or ACT scores are better metrics for measuring undermatch, for this sample, these two indicators yield fairly similar results.

Dillon and Smith (2017)

The difference between students' ability rankings and the institutional quality index is 20 percentile points or greater for approximately 26 percent of the sample (N = 34,613). Using this definition, therefore, these students have undermatched. Similar to the definitions of undermatch discussed above, these students are primarily those who enrolled in a community or technical college, and are predominately nonwhite and lower income.

[13] The distributions of high school GPAs and ACT scores are left-skewed among this sample of first-time freshmen enrollees, bringing down the mean such that a large proportion of students earned GPAs and ACT scores higher than the mean at each institution. This may be due in part to economic conditions during this time: as Tennessee, like the rest of the United States, was emerging from a recession during 2010 and 2011, higher achieving students may have opted for less expensive, less selective institutions than those they were eligible to attend.

Somewhat surprisingly, this definition yields the second lowest estimate of undermatch. This is perhaps because many institutions in Tennessee are lower quality than other institutions nationwide, when considering average student achievement and institutional resources (both those included in this index and those discussed in Chapter 1). Further, students in Tennessee, relative to their peers nationwide, score lower on the ACT – a statewide average of 19, two points lower than the national average of 21 (THEC, 2014). As such, it may be that there is a better match between students and institutions in Tennessee relative to other states, when using Dillon and Smith's definition of undermatch.

Discussion

The five definitions of undermatch applied to one sample of recent high school graduates in Tennessee yield estimates of undermatch ranging from 21 to 69 percent of students, depending on the definition used. These rates are, clearly, very different. The objective of this analysis was to emphasize the need for researchers and policymakers to explicitly define what undermatch is prior to making sweeping conclusions about the prevalence of this phenomenon.

Table 3.2 outlines each definition of undermatch used in this paper, and the corresponding rate of undermatch. The lowest undermatch rates (21 and 26 percent) are the result of definitions accounting for entering students' mean GPAs and more fully for institutional quality as well as student ability, while the highest (69 percent) is due to an extremely broad definition of what it means to undermatch. A difference of 47 percentage points emphasizes the need to define undermatch very explicitly before structuring policies and programs, at the state, local, and institutional levels, to combat this issue.

Irrespective of the definition of undermatch, it is students who are nonwhite and low income who undermatch at rates higher than their white, more affluent peers. This is consistent

with the findings of prior literature, which conclude that these student groups often undermatch due to poor information about the college and financial aid application processes, as well as the costs of college (i.e., Ikenberry & Hartle, 1998; Bowen et al., 2009; Hoxby & Avery, 2003; Roderick et al., 2009; Scott-Clayton, 2012; Smith, et al., 2013).

The state of Tennessee is working to encourage and support high achieving students who are nonwhite and lower income to attend selective colleges and universities throughout the state. UBS Financial Services has partnered with the Tennessee College Access and Success Network (TCASN) to provide college counseling and financial aid to college-bound students identified by their high schools as being "at risk" for undermatching (i.e., those students who are high achieving, nonwhite, and graduates of low performing high schools). Also, the office of Governor Bill Haslam recently launched AdviseTN, a college advising corps that places college counselors in high schools that serve low income and primarily nonwhite students. These advisors will assist students with the college and financial aid search and application processes, as well as help to build a college-going culture in the high schools, to increase each school's college going rate and encourage appropriate academic matches for students.

Additionally, no matter the definition, students who undermatch in Tennessee often attend a community or technical college rather than a four-year institution, perhaps due to lower costs or proximity to home. This finding is particularly timely due to a number of initiatives in Tennessee – particularly the Tennessee Promise, which provides tuition-free community or technical college to recent high school graduates – that incentivize students to attend a two-year or technical college. While the objective of this program is to encourage students who had not intended to do so to enroll in higher education, an unintended consequence may be that higher achieving students choose to enroll in a less-than-four year institution, resulting in undermatch.

Also, beginning in Fall 2015, the Tennessee Education Lottery Scholarship (TELS) award amount increased by 50 percent (from $2,000 to $3,000 for a full time student) for those who enroll in a community college. As the TELS program is a merit-based scholarship, it remains to be seen whether high achieving students will begin attending community colleges at higher rates, as the purchasing power of this scholarship is increased. While one of the stated objectives of both the Tennessee Promise and the TELS programs is to increase student access to higher education, these initiatives may inadvertently increase undermatch throughout the state.

Limitations

This study employs a dataset that includes only students who enroll in higher education (public or private) in Tennessee. While it is only approximately 7 percent of high school graduates who enroll in out-of-state institutions (THEC, 2016) including the enrollment decisions of these students will provide a more robust discussion of undermatch in Tennessee. Tennessee is bordered by eight states, and it is therefore important to explore more fully whether students are crossing the border into neighboring states to attend an institution that is a better academic match. Additionally, earlier versions of this paper included "did not enroll at all" as a definition of undermatch. It is likely that some portion of the students who were flagged as not having enrolled did so out of state. Including data from out-of-state institutions, therefore, reduce bias in the estimates of undermatch presented above.

Further, there are many additional ways in which to define undermatch; this paper is by no means exhaustive in its discussion of only five definitions. There is much opportunity for further exploration of this topic, particularly when considering institutional quality more holistically (i.e., modifying and creating indices in the spirit of Dillon and Smith (2017)) rather than relying solely on students' academic characteristics.

Conclusion

Student undermatch continues to be an issue of concern to educators and policymakers, both in Tennessee and nationwide. It is important that as researchers discuss their findings with these groups, they are clear and explicit about what undermatch means in the context of the work they are presenting. Further, it is imperative that programs and initiatives continue to combat increased rates of undermatch among students who are nonwhite and low income, so these students can access the benefits inherent in attending and graduating from a selective college or university.

The effects of recent higher education initiatives in Tennessee, some of which were discussed above, on undermatch rates remains to be seen. While the intentions of these programs is increase access and affordability, only time will tell if the effects on student decision-making cause high-achieving students to attend lower quality, less selective institutions, leading to increases in undermatch across the state.

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Table 3.1. Descriptive Statistics – Recent High School Graduates in Tennessee (N = 133,127)

	(1) 4-year - Mean	(2) 4-year - SD	(3) 2 year - Mean	(4) 2 year - SD
Race (Mutually Exclusive)				
American Indian	.002		.002	
Asian	.027		.013	
Black	.246		.174	
Hispanic	.032		.027	
White	.626		.732	
Multiracial	.032		.015	
Sex				
Male	.449		.420	
Female	.551		.570	
Pell Eligible	.440		.470	
Enroll in College	.448		.552	
GPA	3.35	.535	3.06	.684
ACT Composite Score	22.30	4.27	19.9	4.44
Barron's Rankings				
Noncompetitive			.558	
Less Competitive	.021			
Competitive	.338			
Very Competitive	.125			
Highly Competitive	.065			
Most Competitive	.001			
	N = 59,697		*N = 73,430*	

Table 3.2. Rates of Undermatch Among Recent High School Graduates, by Definition

Definition	Percent Undermatched
1. Students with ACT≥18 and GPA ≥2.5 who are eligible to attend a 4-year college or university, but attend a less-than-4-year institution.	47
2. Students with ACT≥29 and GPA≥3.7 who are eligible to attend one of the four most selective institutions in Tennessee, but do not.	69
3. Students who attend a college or university that is one or more Barron's category lower than an appropriate academic match.	59
4a. Student's high school GPA is 0.25 points higher than the mean GPA at the institution he attends.	56
4b. Student's high school GPA is 0.5 points higher than the mean GPA at the institution he attends.	49
4c. Student's high school GPA is 1 point higher than the mean GPA at the institution he attends.	21
4d. Student's ACT composite is 1.5 points (.5 standard deviation) higher than the mean ACT score at the institution he attends.	60
4e. Student's ACT composite is 3 points (1 standard deviation) higher than the mean ACT score at the institution he attends.	38
5. Student's ACT percentile differs from his student body-weighted institutional quality percentile by ≥20 points.	26

Table 3.3. Categories for Access to Institution Types, by ACT and High School GPA

Composite ACT	High School GPA					
		<2.0	**2.0-2.4**	**2.5-2.9**	**3.0-3.4**	**3.5-4.3**
	No ACT	2-year	Less selective 4-year	Less selective 4-year	Less selective 4-year	Selective 4-year
	<18	2-year	Less selective 4-year	Less selective 4-year	Less selective 4-year	Selective 4-year
	18-20	Less selective 4-year	Less selective 4-year	Less selective 4-year	Selective 4-year	Selective 4-year
	21-23	Less selective 4-year	Less selective 4-year	Selective 4-year	Selective 4-year	Selective 4-year
	24 +	Less selective 4-year	Selective 4-year	Selective 4-year	Selective 4-year	Selective 4-year

Adapted from Roderick, et al., 2009

Table 3.4. Description of Institution Selectivity Groupings and Ratings

Ratings Grouping Used in This Report	Barron's Ratings	Barron's Definition
Selective 4-year institution	Most Competitive	Admit fewer than 33 percent of applicants. Average freshman: Top 10-20 percent of high school class; GPA of 3.3 or higher; ACT of 29 or higher
	Highly Competitive	Admit 33-50 percent of applicants. Average freshman: Top 20-35 percent of high school class; GPA of 3.0-3.3; ACT of 27 or 28.
	Very Competitive	Admit 50-75 percent of applicants. Average freshman: Top 35-50 percent of high school class; GPA of 2.7-3.0; ACT score of 24, 25, or 26.
Less selective 4-year institution	Competitive	Admit 75-85 percent of applicants. Average freshman: Top 65 percent of high school class; GPA of 2.0-2.7; ACT below 21
	Less Competitive	Admit 85 percent or more of applicants. Average freshman: Top 65 percent of high school class; GPA below a 2.0; ACT below 21
	Noncompetitive	Students must have graduated from an accredited high school with minimum high school requirements. Colleges with higher than a 98 percent admittance rate are automatically in this category.
	Other	Not rated by Barron's
2-year institution	n/a	Not rated by Barron's

Ratings and groupings adapted from Roderick et al., 2009

Chapter 4

Matching the Best and Brightest to the Best Institutions? The Effects of the General Assembly Merit Scholarship (GAMS) Program on Undermatch

Abstract

The Tennessee Education Lottery Scholarship (TELS) program provides merit-based financial aid to high achieving high school graduates in Tennessee. Using student-level data including six cohorts of recent high school graduates provided by the Tennessee Higher Education Commission (THEC) and Tennessee Student Assistance Corporation (TSAC), this paper uses a regression discontinuity design to explore the effects of the General Assembly Merit Scholarship (GAMS), one of three TELS award types, on academic undermatch. Students just over the threshold for GAMS receipt are more likely than their non-GAMS peers to undermatch, perhaps due to the increased buying power of this award at less-selective public institutions across the state. Estimates vary based on the definition of undermatch employed.

Introduction

The effects of statewide merit aid programs on student outcomes have been researched at length, and the three scholarships that comprise the Tennessee Education Lottery Scholarship (TELS) program are no exception (i.e., Pallais, 2009; Bruce & Carruthers, 2014; Tennessee Higher Education Commission [THEC], 2016). While the effects of the TELS program on enrollment, persistence, and degree completion have been previously explored, there is a deficit of knowledge about this program as a contributor to or deterrent of student match. High achieving students may choose to enroll at less-selective institutions than those at which they are eligible to attend due to having received a TELS award (i.e., Cohodes and Goodman, 2014). As such, the likelihood of *undermatch* among these students is increased. Alternatively, students on the margin of attending a two-year institution may instead enroll at a four-year institution as the cost of doing so is reduced (i.e., Dynarski, 2000). While this may result in a student attending a higher quality institution, it is possible he is academically *overmatched* relative to his peers at this institution.

The objective of this chapter is to determine the effect of scholarship receipt on *undermatch* among the highest achieving scholarship recipients, exploring whether treatment effects differ between students who receive a General Assembly Merit Scholarship (GAMS) award versus those who receive a less prestigious, less lucrative Tennessee HOPE scholarship. These awards will be described at length in the Program Description section below. I aim to reconcile the findings of Bruce and Carruthers (2014) and Cohodes and Goodman (2014) in their prior work on the TELS program and the John and Abigail Adams Scholarship Program in Massachusetts, respectively, to determine whether a student's likelihood of undermatch varies by the type of award (and its amount) he or she receives.

Contribution and Research Questions

This chapter contributes to the body of statewide merit aid literature by discussing the GAMS program as a contributor to a student's likelihood of undermatch. I will explore whether students receiving GAMS awards, awarded to the highest achieving high school graduates in the state, are more likely to undermatch than their middle-achieving peers. As such, conclusions drawn from this work will shed light on the effects of this program on the enrollment decisions of Tennessee's "best and brightest" students.

This analysis also updates and expands the work of Bruce and Carruthers (2014) by analyzing a sample of more recent, post-recession high school graduates: the graduating high school classes of 2009-2014. Further, as data provided by the Tennessee Student Assistance Corporation (TSAC) include students are who GAMS *recipients*, rather than those who are GAMS-*eligible*, this study employs a sharp regression discontinuity design, as opposed to the fuzzy regression discontinuity design used by Bruce and Carruthers (2014). Also, due to increases in tuition during this time period, merit aid awards in Tennessee covered approximately 50 percent of tuition and fees at community colleges and public universities (THEC, 2016), a substantial reduction from approximately 75 percent during the time period discussed in Bruce and Carruthers (2014). I will therefore consider whether the reduction in buying power contributes to students' college-going decisions and subsequent match.

In addition, my research paper contributes to ongoing policy conversations among legislators and executive leadership in Tennessee about the function of the statewide merit aid program. As new statewide financial aid programs (i.e., the Tennessee Promise free community and technical college initiative) are universal and are structured to incentivize enrollment at less-

than-four year institutions, it is critical to more fully understand the effects of this program – particularly the GAMS award - on high achieving students' postsecondary enrollment decisions.

I will address the following research questions:

1. Does a student's likelihood of undermatch vary by TELS award (i.e., GAMS versus Tennessee HOPE) received?
2. Does a student's likelihood of undermatch vary by the definition of undermatch employed?

I hypothesize that students with scores just above the ACT threshold for GAMS scholarship eligibility (an ACT composite score of 29) are more likely to undermatch than their peers who fall just short of receiving a GAMS award. This may be due to the award's increased buying power at less-selective institutions across the state. Further, I hypothesize that these "best and brightest" students' likelihood of undermatch will vary based on the definition of undermatch.

Prior Literature

Bruce and Carruthers (2014)

Bruce and Carruthers (2014) employ a fuzzy regression discontinuity design to determine the effect of the TELS program on the enrollment decisions among students on the margin of TELS eligibility. They conclude that while TELS receipt has a negligible effect on students' decisions to enroll in public versus private or in- versus out-of-state institutions, students just above the TELS eligibility threshold are more likely to attend a four-year institution than their peers just below the cut off. As such, eligible students attend four-year institutions with higher graduation rates, increased resources per pupil, and higher Carnegie classifications than the two-year institutions they would have attended (Bruce & Carruthers, 2014). This substitution between

two- and four-year institutions is particularly prominent among low income TELS recipients, who are more sensitive to price than their higher income peers (Bruce & Carruthers, 2014). These findings mirror those of other research investigating statewide merit aid programs (i.e., Dynarski, 2000; Zhang, Hu, Sun, & Pu, 2016).

Cohodes and Goodman (2014)

Cohodes and Goodman (2014) also use a regression discontinuity design to investigate the effects of the Adams Scholarship, a statewide merit aid program in Massachusetts, on the quality of institutions at which recipients enroll. They determine that recipients (students in the top 25 percent of their graduating high school class) attended colleges and universities with considerably lower per pupil funding and graduation rates, relative to their similar-achieving peers attending a non-Adams Scholarship eligible institution. Further, students using Adams Scholarships attended institutions with lower average academic achievement (i.e., mean SAT scores among entering freshmen) increasing the incidence of undermatch among those who take up this scholarship (Cohodes & Goodman, 2014).

Program Description: Tennessee Education Lottery Scholarship

Program history

The Tennessee Education Lottery Scholarship (TELS) program is Tennessee's statewide merit aid program, providing middle-dollar scholarships (packaged after Pell and state need-based grant aid, but prior to institutional aid or community-based scholarships) to high school graduates on the basis of their high school grade point averages (GPAs) and ACT composite scores. Since its implementation in Fall 2004, the TELS program has awarded scholarships to approximately 70,000 students each year, at a cost of over $300 million annually (THEC, 2016). TELS awards can be applied to the cost of attendance at any public or private not-for-profit two-

or four-year institution in Tennessee.[14] The TELS program requires that students file the Free Application for Federal Student Aid (FAFSA) and complete an online scholarship application.

The TELS program was modeled after existing statewide merit aid programs across the southeastern United States; in particular, the Georgia Helping Outstanding Pupils Educationally (HOPE) scholarship program. Governor Phil Bredesen (D-Nashville) and the Tennessee General Assembly established the TELS program in 2002 with four broadly-stated objectives:

1. Provide access to postsecondary education for Tennesseans
2. Improve high school and postsecondary achievement
3. Keep the best and brightest students in Tennessee
4. Provide social and economic benefits to the state (THEC, 2016)

While the Tennessee Education Lottery funds eleven scholarships, three large programs comprise the "TELS Program," and account for over 70 percent of all grant aid dollars disbursed by the state: the Tennessee HOPE scholarship, the General Assembly Merit Scholarship (GAMS), and the Aspire scholarship. When referring to "TELS awards" or the "TELS program" above and throughout this paper, I am referring only to these three scholarship programs.

Each award provides a different dollar amount, and is available to students who meet specific academic and socioeconomic criteria. Receipt and retention criteria are consistent from 2009-2014, the time period of this study (THEC, 2016).

Scholarship types

Tennessee HOPE scholarship. The majority (64 percent) of TELS recipients receive a HOPE award, which during this time provided $4,000 each year to a student enrolling full time

[14] Students enrolling at for-profit institutions operating in Tennessee are not eligible for TELS awards. Students enrolling at technical colleges are eligible for state-funded grant aid that is not merit-based.

at a four-year institution and $2,000 each year for enrolling full time at a community college.[15] To receive a HOPE award, students must earn a composite score of 21 or higher on the ACT *or* a cumulative high school GPA of 3.0 or higher.

General Assembly Merit Scholarship (GAMS). The GAMS award, the objective of which is to keep the "best and brightest" students in-state, requires that students earn a 29 or higher on the ACT *and* a cumulative high school GPA of 3.75 or higher. This award is $5,000 annually for a full time student at a four-year college or university; $2,500 annually for a full time student at a two-year institution.

Aspire award. The Aspire award combines both merit- and need-based aid for students with a family adjusted gross income (AGI) of $36,000 or less. The criteria for receipt are identical to the HOPE award. This award provides $5,500 annually for full time university enrollment and $2,750 annually for full time community college enrollment.

Award receipt. Table 4.1 summarizes award amounts and receipt criteria for each of these three scholarship programs. Students can receive only one scholarship type, and will receive the maximum award for which they are eligible. For example, a student with an ACT composite score of 30 and a high school GPA of 4.0 will receive a GAMS award, while his peer who has an ACT score of 27 and a 4.0 high school GPA will receive a HOPE award. Students who do not meet both the ACT and GPA criteria for a GAMS award will receive a HOPE scholarship, as the HOPE requires an ACT score of 21 *or* a 3.0 high school GPA, whereas the GAMS award requires an ACT score of 29 *and* a 3.75 GPA. If a student is identified as low income (family AGI of $36,000 or less) he will receive an Aspire award, whether he is eligible for a HOPE or GAMS award. This is because the Aspire award amount is higher than both the

[15] All TELS awards are pro-rated based on enrollment intensity. Students are not required to enroll full time to receive a TELS award.

HOPE or GAMS awards. Unless a student chooses to pursue higher education out-of-state or attend a technical college or proprietary institution in Tennessee, there is no reason he would turn down this award.

Data

This study employs student-level data for six cohorts of recent high school graduates in Tennessee: the classes of 2009 through 2014. These data are provided by the Tennessee Higher Education Commission (THEC), the state's public higher education coordinating board, and the Tennessee Student Assistance Corporation (TSAC), Tennessee's financial aid granting agency. Variables provided by THEC include student demographics (e.g., sex, race), academic qualifications (e.g., ACT score, high school GPA), the higher education institution at which a student enrolls, and his enrollment intensity (full- or part-time). Data collected from TSAC include TELS award type and amount disbursed to each student, students' family adjusted gross income (AGI), expected family contribution (EFC), and Pell eligibility.

While students may qualify for HOPE because of their ACT score *or* high school GPA, this paper relies solely on ACT scores to identify students who received HOPE awards. This follows the strategy used by Bruce and Carruthers (2014) and is due to a data quality issue: the Tennessee Department of Education and THEC do not collect high school GPAs; therefore, GPAs provided to TSAC are self-reported, often by students themselves or high school guidance counselors. High school GPAs are missing for 30 percent of students in the sample. This is most often because when a student is determined to be HOPE-eligible based on his ACT score (the "first pass" at eligibility), GPAs are not reported to TSAC. However, more than 80 percent of HOPE recipients qualify due to their ACT score (on its own or in combination with a high school

GPA above 3.0).[16] Using ACT as the forcing variable to identify HOPE recipients, therefore, will still allow for a robust exploration of the effects of HOPE on student match. This data limitation is not relevant to GAMS recipients, as they are required to hit both an ACT and GPA benchmarks to receive the GAMS award.[17]

Sample

The sample for this analysis is comprised of 63,288 high school graduates from the classes of 2009-2014 who received HOPE or GAMS awards. Students in the sample enroll seamlessly into higher education following high school graduation, and are enrolled full time.[18] Sample descriptive statistics are presented in Table 4.2. Students who received Aspire awards are excluded from the sample: though the criteria for receipt are identical to HOPE awards, the Aspire award amount is 37 percent ($1,500) higher than the HOPE award, which may lead to different decision making among recipients. Students who earned a 29 on the ACT but did not meet the high school GPA requirement for GAMS receipt (N = 2,799; approximately three percent of the sample) are eligible for HOPE awards, but are excluded from the sample as ACT is the forcing variable in this analysis.

Approximately 52 percent of HOPE recipients are female, whereas only 43 percent of GAMS recipients are female. Recipients of both scholarships are predominately white: 84.4 percent of HOPE recipients and 88.3 percent of GAMS recipients. GAMS students are higher income than their peers who receive HOPE awards, as 22.2 percent are Pell eligible, relative to

[16] Students who quality for HOPE awards on their high school GPA only (approximately 18 percent of the sample; N = ~32,000) are excluded from this analysis.
[17] GPAs are self-reported or reported by the high school guidance counselors. GPAs of GAMS recipients are audited and high schools are required to provide student transcripts to provide evidence of students' GPAs.
[18] The sample is limited to students enrolled full time to ensure that each HOPE and GAMS recipient receives the same award amount, rather than a prorated amount based on enrollment intensity.

30.5 percent of HOPE recipients. The median ACT score among HOPE (GAMS) students is a 23 (30), and the median high school GPA among those reported is 3.54 (3.96 – all GPAs are reported). The distribution of ACT scores among students in this sample is presented in Figure 4.1.

Methodology

This study employs a sharp regression discontinuity design to determine the effect of GAMS and HOPE receipt on undermatch, using the two definitions of undermatch discussed in the Definitions section below. Because the data provided by the Tennessee Student Assistance Corporation reflects award *receipt*, a sharp design is appropriate, and the treatment effects calculated are treatment-on-the-treated (TOT) estimates. This is because the ACT cutoff score (29) perfectly predicts assignment to treatment (GAMS receipt) in this sample, and will allow me to evaluate the effect of GAMS receipt on students who take up the scholarship, rather than those who are eligible based on their ACT scores and high school GPAs.

To explore the effects of the GAMS program, it is improbable that state leadership in Tennessee would ever allow for a randomized controlled trial. Because GAMS is a state-funded financial aid program, it would be difficult to justify (politically) why some eligible students receive this award while others do not. The next best option for this analysis, therefore, is a regression discontinuity design that exploits the scholarship eligibility discontinuity at an ACT score of 29. Further, the design is a sharp regression discontinuity as there is perfect compliance between scholarship eligibility and scholarship receipt in this sample. This is because, as a state-sponsored financial aid program, financial aid officers do not have any authority to use professional judgement when making GAMS awards to students. Figure 4.2 depicts the

likelihood of receiving a GAMS award, by ACT score. It is clear from this figure that GAMS awards are disbursed only to those students who are academically eligible.

To confirm whether a regression discontinuity design is valid, I conduct a McCrary (2008) density test to ensure that there is no evidence of sorting at the cut score. If students were able to manipulate their GAMS receipt (treatment status) there may be a cluster of observations right above or right below the ACT cutoff. Figure 4.3 depicts results of the McCrary test, which indicate that this type of sorting did not occur.

Estimation

Equation (1) provides a description of the parametric regression (a linear probability model) used to estimate the probability of undermatch among those receiving a GAMS award:

$$UM_{it} = B_0 + B_1 X_1 + B_2(GAMS) + e \qquad (1)$$

where UM_{it} is student *i*'s probability of undermatch in year *t*, X_1 is a vector of student characteristics (e.g., sex, race, Pell eligibility), *GAMS* is a binary indicator (0/1) measuring whether the student is a GAMS recipient or not, and *e* is the error term. This identification strategy relies on the discontinuity that exists at an ACT score of 29, at which point students in the sample are eligible for a GAMS award. Student-level control variables found to be relevant to undermatch in prior literature investigating this issue (e.g., race, Pell eligibility) are included to improve the model's precision. The same is true in Equation (2) below.

Regression discontinuity designs are commonly operationalized in two ways: 1) focusing on the discontinuity itself to depict the treatment effect as the relationship between treatment and outcomes (Hahn, Todd, & van der Klaauw, 2001) or 2) assuming random assignment ("local randomization") around the discontinuity, in which case the treatment effects are the difference in means on each side of the cutoff (Lee & Card, 2008). Whereas the former relies on accurately

specifying the model's functional form, the latter relies on determining the correct bandwidth and bin widths such that estimates are accurate (Hahn, et al., 2001, Lee & Card, 2008). The local average treatment effects (LATE) yielded from the second strategy are particularly relevant to state-level policymaking in Tennessee. This is because each year, numerous state representatives introduce legislation to change the ACT cutoffs for HOPE and GAMS receipt by a few points. As such, the LATE estimates of the GAMS program's influence on undermatch, though they are not widely generalizable, are quite useful.

I use both parametric (Equation (1)) and nonparametric strategies to estimate the effect of GAMS receipt on students' likelihood of undermatch. Equation (2) below presents the nonparametric (linear probability model) estimating equation:

$$UM_{it} = B_0 + B_1X_1 + B_2(GAMS) + f(ACT) + e \qquad (2)$$

where UM_{it} is a student's probability of undermatch in year *t*, X_1 is a vector of student characteristics (i.e., sex, race, Pell eligibility), *GAMS* is a binary indicator (0/1) for whether the student is a GAMS recipient, *f*(*ACT*) is a function of the assignment variable (ACT composite score) and *e* is the error term.

To account for any nonlinearity in the relationship between GAMS receipt and undermatch, polynomial and interaction terms are included when estimating Equation (2). Results from the inclusion of these terms are presented in Tables 4.3 and 4.4. Measures of fit (i.e., F-test and AIC values) are used to determine the optimal model specification, which for this analysis is a quadratic function (lowest AIC; F-test p-value < 0.05; referent is linear model).

To confirm the estimates of undermatch produced using the quadratic function identified above, a bandwidth is selected in which to conduct a local linear regression around the cut score. Whereas a narrow bandwidth will yield less biased estimates of the effect of GAMS on

undermatch, these estimates introduce higher variance than those predicted using a larger bandwidth, due to a smaller number of observations closer to the ACT cut off (Jacob, Zhu, Somers, & Bloom, 2012). Estimates calculated using larger bandwidths have less variance, but may also be biased. Determining the appropriate bandwidth, therefore, is often a tradeoff between bias and variance. A range of bandwidths is presented in Table 4.5. The preferred bandwidth is 4, which is calculated using the "plug in" procedure (i.e., Imbens & Kalyanaraman, 2012). This is comparable to the bandwidth used by Bruce and Carruthers (2014) in their exploration of the TELS program in 2014.

Definitions of undermatch

Two of the undermatch definitions discussed in Chapter 3 are used to investigate the effects of GAMS receipt on undermatch. As this paper's sample is comprised of Tennessee's "best and brightest" high school graduates, the first definition of undermatch mirrors that of Bowen and colleagues (2009) in Crossing the Finish Line. GAMS recipients who do not attend one of the four most selective higher education institutions in the state – Rhodes College, Sewanee, the University of the South, the University of Tennessee at Knoxville, and Vanderbilt University - are classified as undermatched.

The second definition is that used by Dillon and Smith (2017) to more fully account for institutional resources and college quality. I calculate students' ACT score percentile and replicate Dillon and Smith's four-factor index of college quality, using mean ACT composite scores, admission rates, faculty salaries and faculty-student ratios to measure institutional quality.[19] When the difference between the ACT and college quality percentiles is 20 or greater, the student is labeled as having undermatched.

[19] Dillon and Smith construct a six-factor index for institutions (less-selective four-year and most two-year institutions) that do not report standardized test scores. As all institutions receiving

These two definitions are the most relevant when exploring the enrollment behavior of these high achieving students. Very few GAMS recipients enroll in community colleges (THEC, 2016), so the Roderick et al. (2009) definition (enrolling in a two-year when eligible to enroll in a four-year institution) does not provide valuable new information. Further, there is not much variation in Barron's selectivity categories among institutions across Tennessee, particularly when considering the institutions attended by high achieving students. And, as will be discussed at length in the Conclusion, distance from an institution's incoming class's average ACT or GPA would yield astronomical estimates of undermatch, as the academic achievement of GAMS recipients is well above the institution averages.

Results

Four most selective institutions

GAMS recipients in this sample are .11 probability points[20] more likely than their peers who receive Tennessee HOPE scholarships to undermatch, when undermatch is defined as failing to attend one of the four most selective higher education institutions in the state. This parametric estimate is presented in Table 4.3, and is consistent with the nonparametric estimates displayed in Table 4.5.

While considering only the four most selective institutions in the state is a very narrow definition of undermatch (as discussed in Chapter 3) it speaks to both institutional capacity and affordability. With the exception of the University of Tennessee at Knoxville, the total first year enrollment at the other three highly selective institutions is smaller than the number of students receiving a GAMS award each year. As such, if every GAMS recipient attended Rhodes College, Sewanee, the University of the South or Vanderbilt University, there would not be enough spots

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TELS dollars are required to report mean ACT scores to THEC, this data is available for all institutions in the sample. For this reason, I replicate the four-factor index.

[20] All estimates are presented as estimated probability points ("p-hats").

in the total freshman class for them to do so. Also, as the sticker tuition price at the three private institutions in this choice set is three to five times that of the University of Tennessee at Knoxville (THEC, 2016) and even more compared to other less-selective public colleges and universities, high achieving students may choose to take their GAMS dollars to an institution at which the buying power is greater.

Subgroup treatment effects

Sex. Using this definition, male students who receive GAMS awards are .05 probability points more likely than female GAMS recipients to undermatch. While the magnitude of this difference is not as substantial as the differences between racial and income groups presented below, this difference between male and female GAMS recipients is statistically significant ($p < .01$).

Race. Nonwhite GAMS recipients are .20 probability points more likely to undermatch by not attending one of the four most selective institutions in the state compared to their white peers who receive GAMS awards. This finding is consistent with the literature explored in Chapter 2 regarding the increased likelihood of nonwhite students undermatching compared to their white peers. Though these scholarship recipients are very high achieving, this finding is consistent with the hypothesis that nonwhite students frequently struggle with the college search and application processes, leading to a large increase in the likelihood of undermatch relative to their white peers.

Pell.: Pell-eligible GAMS recipients are .25 probability points more likely than their non-Pell peers who receive GAMS to undermatch. This is similar to the finding above with respect to nonwhite students, and is aligned with prior research on this topic. As Pell-eligible students may

hesitate to attend a very selective, very expensive institution due to concerns about affordability, they instead attend less selective, more affordable institutions, resulting in undermatch.

Robustness check. To examine the robustness of these findings and to further confirm the model specification, I drop observations in the tails of the ACT distribution to determine whether estimates of undermatch change substantially. The robustness check for this definition of undermatch is presented in Table 4.6. The estimates presented in this table confirm that a quadratic functional form is best fitting, and that the results are robust to removing extreme observations.

Dillon and Smith (2017)

GAMS recipients are .23 probability points more likely than their peers who receive Tennessee HOPE scholarships to undermatch, when undermatch is defined using a more complete measure of institutional quality. Dillon and Smith's (2017) definition of undermatch accounts not only for students' academic abilities relative to their peers, but considers institutional resources as well. This parametric estimate is presented in Table 4.4, and is consistent with the nonparametric estimates displayed in Table 4.5.

GAMS award recipients who undermatch when using this definition are more likely to attend institutions that are not as well-resourced as those they are eligible to attend. As above, this may be because students attend less-selective, less expensive institutions at which their GAMS award will cover a greater proportion of the cost of attendance. As discussed throughout this dissertation, attending lower quality, less-selective institutions has implications for academic achievement, persistence, and graduation, and reflects the varied quality of private and public colleges and universities across the state.

Subgroup treatment effects

Sex. Using this definition of undermatch, male GAMS recipients are .07 probability points more likely than female GAMS recipients to undermatch. This is comparable to the estimate above using a different undermatch definition; however, this difference is significant only at a 90 percent confidence level.

Race. Nonwhite GAMS recipients are .34 probability points more likely to undermatch than GAMS recipients who are white. Again, this is consistent with the findings of prior literature exploring the prevalence undermatch among student subgroups. However, while the direction is the same, this estimate is more than double the magnitude of the effect of GAMS on nonwhite students described above. This further emphasizes that being very clear about the definition of undermatch used is critical when drawing conclusions about this phenomenon.

Pell. Pell eligible GAMS recipients are .36 probability points more likely than non-Pell eligible GAMS recipients undermatch using this definition. As above, this is similar to the findings of prior research on this topic, and may reflect students' hesitation to apply to or enroll at institutions they perceive to be too expensive.

Robustness check. Again, to examine the robustness of these findings and to further confirm the model specification, I drop observations in the tails of the ACT distribution to determine whether estimates of undermatch change substantially. The robustness check for this definition of undermatch is presented in Table 4.6. As with the previous definition of undermatch, the estimates presented in this table confirm that a quadratic functional form is best fitting, and that the results are robust to removing these observations.

Limitations

The biggest limitation to this study is that conclusions about students' probability of undermatch are limited to those immediately around the GAMS cutoff – an ACT score of 29.

This is a consequence of employing a regression discontinuity design. A strategy to generalize conclusions about undermatch to inframarginal students away from the cutoff is proposed by Angrist and Rokkanen (2015). This method requires conditioning on covariates other than the running variable (i.e., students' grades, distance to a two- or four-year institution) to reduce or eliminate the relationship between the outcome of interest (undermatch) and the running variable (ACT score). Doing so (and relying on the conditional independence assumption) helps to address omitted variable bias, such that findings are more generalizable to the entire sample (Angrist & Rokkanen, 2015).

Also, the GAMS program serves a relatively small number of students, relative to other merit-based financial aid programs in Tennessee. As such, this chapter employs a comparatively smaller sample than had recipients of all other types of scholarships been included. Further, this chapter does not include an indicator for an *offer* of a GAMS award, to examine the decisions of high achieving students who did not accept the award and instead chose to enroll out-of-state.

As Tennessee currently provides substantial financial incentives for students to attend community and technical colleges, the enrollment decisions of these high-flying high school graduates are not a high policy priority. It remains important, however, to explore whether these awards are encouraging students to stay in-state and enroll in a well-matched institution.

Conclusion

When discussing the Tennessee Education Lottery Scholarship (TELS) program, students who receive these awards are often lumped into one category of "TELS recipients." Doing so masks any variation in the effect of the three distinct award types (each of which has different criteria for receipt and a different award amount) on students' enrollment decisions. The objective of this paper is to determine the effect of one scholarship type – the General Assembly

Merit Scholarship – on the highest achieving students' likelihood of undermatch. Though higher education policy in Tennessee (and elsewhere) is currently focused on inducing students on the margin of college attendance to enroll via a free community college program (which will be explored in Chapter 5), it remains important to investigate where the highest achieving high school graduates are matriculating throughout the state. Given the economic and social returns to attending a selective college or university (as outlined in Chapters 2 and 3) it is critical to understand more fully whether a difference of $1,000 ($4,000 for HOPE; $5,000 for GAMS) has a substantial effect on these students' college-going decisions.

Further, the two definitions of undermatch used in this study yield quite different main effects, reinforcing that it is imperative that researchers are clear about the definition of undermatch used when drawing conclusions about this issue, and acknowledge that findings apply only to those students around the cutoff value. The definition must be appropriate for one's research questions and the characteristics of the sample of interest. For example, when the analysis is focused on GAMS recipients, using the definition of undermatch discussed in Chapter 3 that relies on distance from entering students' average ACT score would have yielded astronomical rates of undermatch, as the mean ACT composite score at all institutions in Tennessee except for Vanderbilt University is *below* 29, the cut off for GAMS receipt. This is just one example of why clarity and transparency with regard to how undermatch is conceptualized is critical to informed discussion about this topic.

Finally, when considering the enrollment behavior of certain subgroups of students, it is clear that the findings of prior literature are applicable to this study as well: students who are nonwhite and low income are much more likely to undermatch than their white, middle income peers, no matter how undermatch is defined. This consistent finding should inform the way

policymakers, educators and community members think about this issue and structure interventions to encourage better match.

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Table 4.1. Criteria for TELS award receipt, 2009-2014

	HOPE	Aspire	GAMS
Annual award amount (full time, 4-year)	$4,000	$5,500	$5,000
Annual award amount (full time, 2-year)	$2,000	$2,750	$2,500
Minimum high school GPA	3	3	3.75
Minimum ACT composite	*or* 21	*or* 21	*and* 29
Family adjusted gross income (AGI)	N/A	≤ $36,000	N/A

Table 4.2. Sample descriptive statistics, by TELS award type

	Full sample	HOPE	GAMS
% Female	50.3	51.5	43.4
Race			
% White	84.9	84.4	88.3
% Black	5.6	6.3	1.5
% Hispanic	2.2	2.3	1.9
% Pell eligible	29.9	30.5	22.2
Median ACT	24	23	30
Median high school GPA	3.60	3.54	3.96
Total N (students)	**63,288**	**53,888**	**9,400**

Figure 4.1. ACT Composite Score Distribution

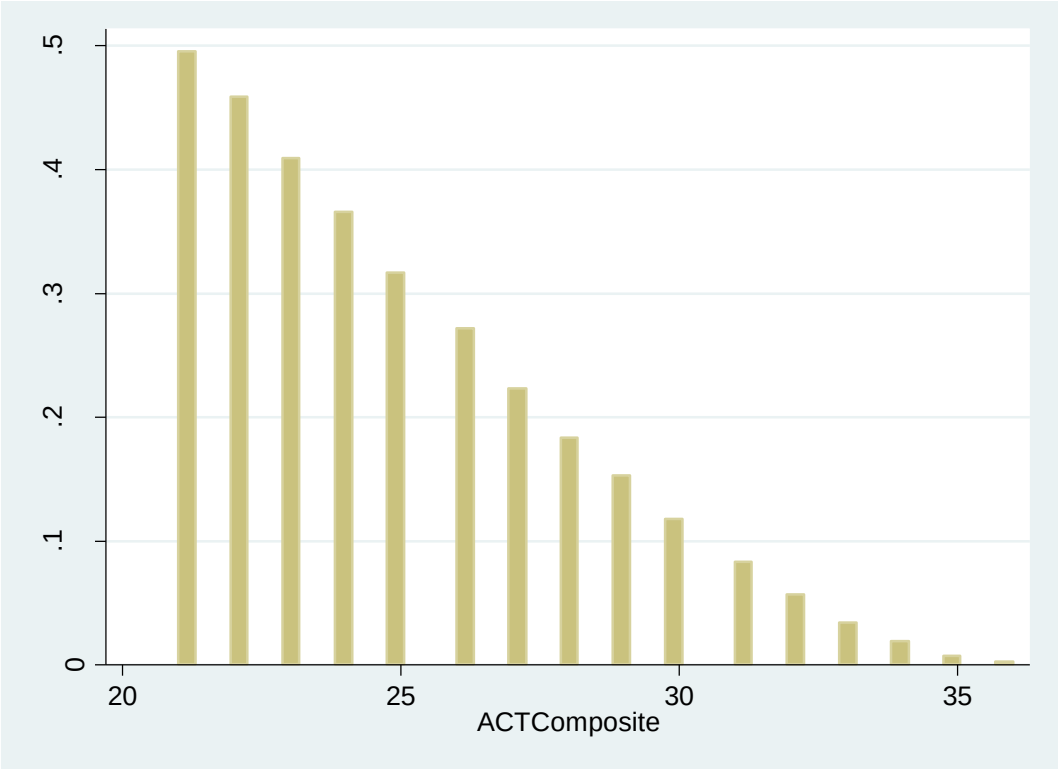

Figure 4.2. Likelihood of GAMS receipt, by ACT score

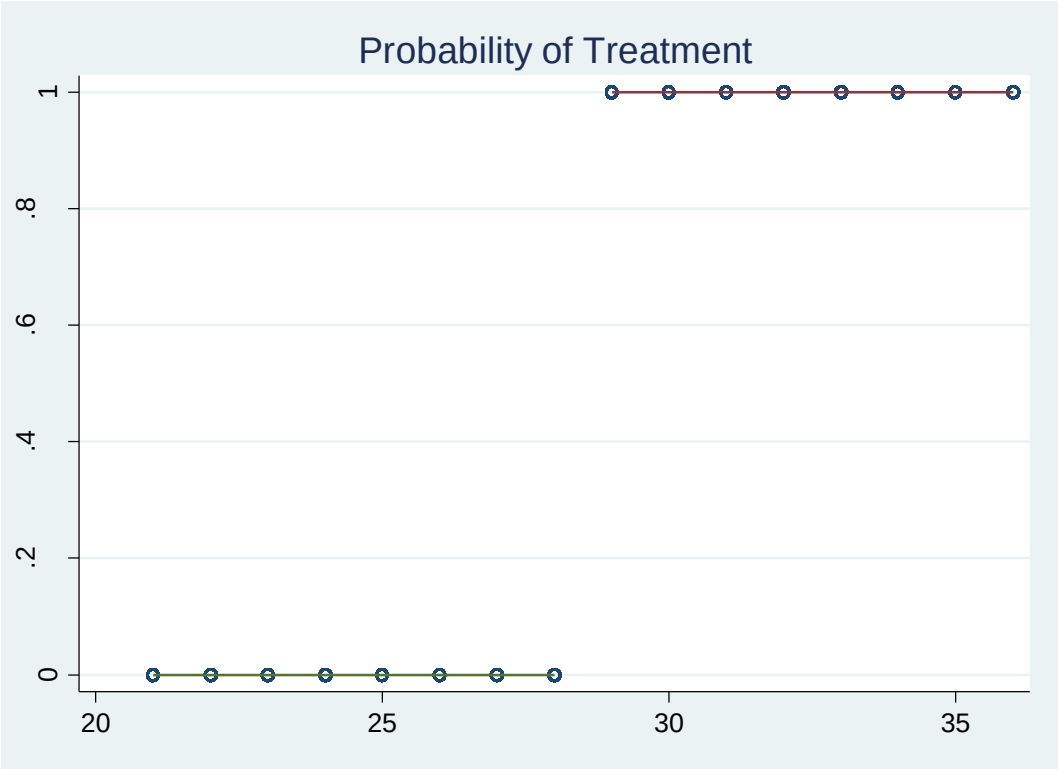

Figure 4.3. Sorting at the ACT discontinuity (McCrary density test)

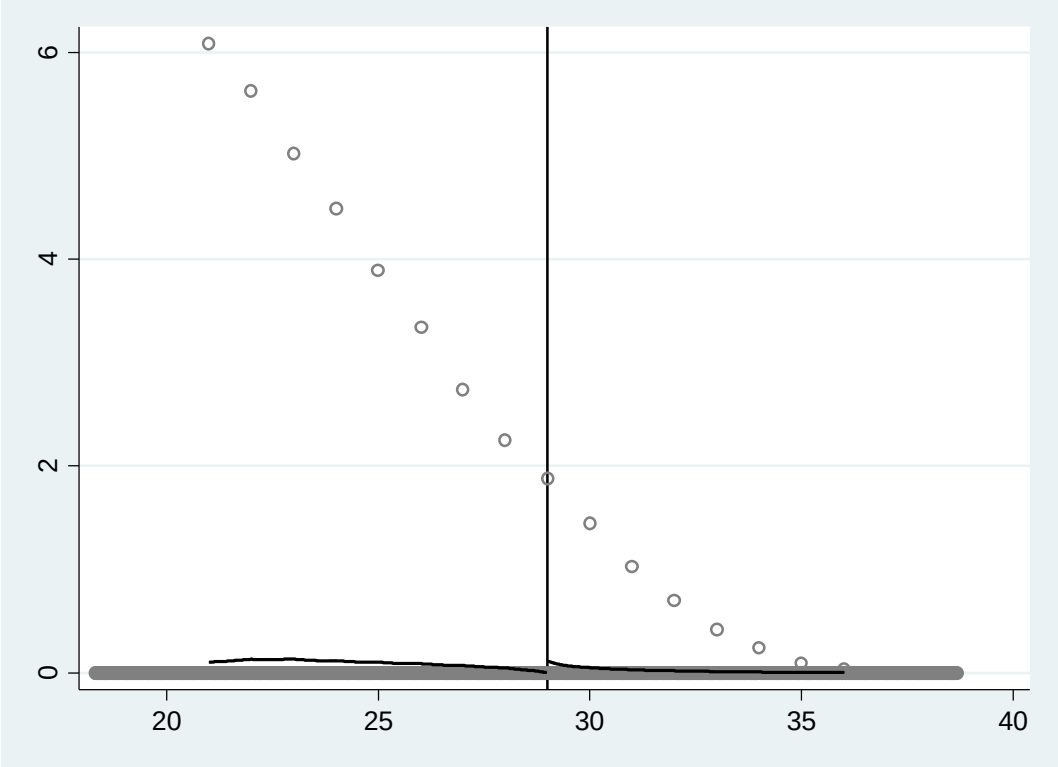

Table 4.3. OLS and Parametric effects of GAMS receipt on likelihood of undermatch: Attending Top 4 Institutions in Tennessee

	Linear, No covariates	Linear	Quadratic	Cubic
GAMS	0.13***	0.14***	0.11**	0.12**
	(0.037)	(0.017)	(0.013)	(0.013)
ACT	0.19***	0.19***	0.20***	0.20***
	(0.04)	(0.004)	(0.02)	(0.063)
ACT*GAMS	0.09***	0.09***	0.13***	0.15***
	(0.032)	(0.014)	(0.041)	(0.093)
ACT2			0.02**	0.02**
			(0.002)	(0.015)
ACT2*GAMS			0.10**	0.10**
			(0.007)	(0.035)
ACT3				0.00
				(0.001)
ACT3*GAMS				-0.01
				(0.075)
Female		0.08*	0.05*	0.05*
		(0.048)	(0.045)	(0.045)
Pell		0.27**	0.20**	0.20**
		(0.003)	(0.005)	(0.001)
Nonwhite		0.29**	0.25**	0.25**
		(0.002)	(0.004)	(0.004)
Constant		0.57	0.52	0.5
AIC	83101	83055	83017	83010
F test (p-value)	0.05	0.05	0.02	0.27
N students	63,288	63,288	63,288	63,288

*p<.10 ** p<.05 ***p<.01

Standard errors in parentheses

Linear model is referent

Table 4.4. OLS and Parametric effects of GAMS receipt on likelihood of undermatch: Dillon and Smith (2017)

	Linear, No covariates	Linear	Quadratic	Cubic
GAMS	0.22***	0.21***	0.23***	0.24***
	(0.24)	(0.044)	(0.011)	(0.096)
ACT	0.08***	0.08***	0.15***	0.17***
	(0.017)	(0.005)	(0.024)	(0.076)
ACT*GAMS	0.07***	0.06***	0.14***	0.18*
	(0.033)	(0.015)	(0.049)	(0.109)
ACT2			0.12***	0.14***
			(0.002)	(0.018)
ACT2*GAMS			0.15***	0.17**
			(0.009)	(0.04)
ACT3				0.01
				(0.057)
ACT3*GAMS				0.001
				(0.068)
Female		0.05**	0.07**	0.07**
		(0.008)	(0.003)	(0.003)
Nonwhite		0.29**	0.34**	0.35**
		(0.007)	(0.003)	(0.003)
Pell		0.28**	0.36**	0.37**
		(0.005)	(0.003)	(0.003)
Constant		0.226	0.249	0.337
AIC	57556	57506	57026	57397
F test (p-value)	0.01	0.01	0.29	0.33
N students	63,288	63,288	63,288	63,288

*p<.10 ** p<.05 ***p<.01

Standard errors in parentheses

Linear model is referent

Table 4.5. Nonparametric effects of GAMS receipt on likelihood of undermatch, by definition of undermatch

Top 4 institutions		
Bandwidth	Treatment effect	Standard error
2	0.10	0.009
4	0.11	0.035
6	0.19	0.023
Dillon and Smith (2017)		
Bandwidth	Treatment effect	Standard error
2	0.20	0.009
4	0.23	0.042
6	0.27	0.025

Table 4.6. Robustness checks to confirm quadratic model specification

	Top 4 Institutions		Dillon and Smith (2017)	
	Estimate	**Std Error**	**Estimate**	**Std Error**
All ACT scores				
Main effect	0.110**	0.013	0.230***	0.011
Sex	0.050*	0.045	0.070***	0.003
Race (nonwhite)	0.200**	0.005	0.340***	0.003
Pell eligible	0.250**	0.004	0.360***	0.003
ACT 23-34				
Main effect	0.105**	0.015	0.220***	0.013
Sex	0.053**	0.045	0.070**	0.003
Race (nonwhite)	0.224**	0.007	0.340***	0.005
Pell eligible	0.272**	0.005	0.357***	0.004
ACT 25-32				
Main effect	0.099**	0.023	0.205**	0.018
Sex	0.052**	0.047	0.068**	0.004
Race (nonwhite)	0.209***	0.009	0.325**	0.007
Pell eligible	0.267***	0.006	0.348**	0.005
ACT 27-30				
Main effect	0.098**	0.019	0.204***	0.016
Sex	0.052**	0.049	0.060**	0.007
Race (nonwhite)	0.202***	0.014	0.301***	0.011
Pell eligible	0.255***	0.009	0.320***	0.009

*p<.10 ** p<.05 ***p<.01

Standard errors in parentheses

Linear model is referent

Chapter 5

Free at What Cost? The Effects of Tennessee Achieves on Undermatch

Abstract

Tennessee Achieves, an initiative providing last-dollar tuition and fees at community and technical colleges in Tennessee, has seen great success enrolling recent high school graduates in less-than-four year institutions. What is less clear is whether this program leads to undermatch among students who could have attended more selective four-year colleges or universities. Using data provided by the Tennessee Higher Education Commission, I use difference-in-differences and propensity score matching methodologies to explore the effect of this program on undermatch. I conclude that students with access to Tennessee Achieves in three of the largest treated counties are more likely to undermatch than their peers in counties without access to this program, irrespective of the definition of undermatch. Students' probabilities of undermatch vary by treated county, reflecting diverse local higher education contexts throughout the state.

Introduction

Tuition-free college initiatives are becoming increasingly popular policy proposals at the state and national levels (i.e., American Association of Community Colleges, 2016; Weeden & Hultin, 2015). As interest in these programs grows, it is important to note that a handful of communities (i.e., Kalamazoo, Michigan and Knox County, Tennessee) have had such programs in place for close to a decade. As such, much of what is known about the effect of tuition-free college plans on enrollment, persistence, and completion is due to investigations of the Kalamazoo Promise and Knox Achieves, two of the most well-established free college initiatives (i.e., Andrews, DesJardins, & Ranchhod, 2010; Bartik, Hershbein, & Lachowska, 2015; Carruthers & Fox, 2016). What is less clear is the effect of free college initiatives on student match: is "free college" incentivizing students to enroll at less selective institutions than the best among those they are academically eligible to attend?

Tennessee has been at the forefront of the statewide tuition-free college movement, as Governor Bill Haslam introduced the statewide Tennessee Promise program in early 2014. Beginning in Fall 2015, the Tennessee Promise offers tuition-free community and technical college to all recent high school graduates in Tennessee. The implementation of the Tennessee Promise is a classic example of policy diffusion (i.e., Berry & Berry, 1999): this free college initiative grew from one county (Knox Achieves) to 27 counties (renamed Tennessee Achieves) and is now available to students in all of Tennessee's 95 counties (renamed Tennessee Promise).

Because of the rapidity of this expansion, there remains much to learn about the effects of free community and technical college on young Tennesseans' postsecondary enrollment decisions. The objective of this chapter is to determine whether Tennessee Achieves led to increases in undermatch in the three largest of the 27 treated counties between 2009 and 2014.

Because Tennessee Achieves provided a financial incentive for students to attend community and technical colleges rather than four-year institutions, exposure to this program may have caused high achieving students to downshift to two-year institutions. This chapter builds upon the work of Carruthers and Fox (2016) who investigated the influence of Knox Achieves, the free community and technical college program available only to students in Knox County, Tennessee, on students' high school graduation outcomes and postsecondary enrollment.

Carruthers and Fox (2016)

Carruthers and Fox (2016) employ difference-in-differences and propensity score matching to determine the effect of Knox Achieves on students' likelihood of high school graduation and college-going decisions. They determine that students exposed to Knox Achieves (i.e., enrolled in high school in Knox County, where the program was available) were more likely to graduate from high school and enroll seamlessly in higher education, relative to neighboring counties without the program. Students who participated in (i.e., enrolled in a community or technical college as a Knox Achieves student) Knox Achieves were more likely than their non-treated peers in neighboring counties to enroll seamlessly into higher education following high school graduation, and were slightly less likely to enroll at four-year institutions (Carruthers & Fox, 2016). Increases in postsecondary enrollment were most statistically significant among low-income (Pell eligible) students (Carruthers & Fox, 2016).

Contribution and research questions

I contribute to the limited body of literature exploring free college programs by investigating the effect of Tennessee Achieves on undermatch: does this program lead high achieving students to attend less selective, lower quality postsecondary institutions? A greater understanding of how these programs affect students' college-going decisions is critical, as free

college programs are being proposed and piloted across the United States. I will explore whether undermatch varies by the definition of undermatch employed and by location, as the three treated counties are located in the East, Middle, and West regions of Tennessee.

Further, I will extend the work of Carruthers and Fox (2016) by including three more recent cohorts of high school graduates (the graduating classes of 2012-2014) and by expanding the analysis to focus on the three largest of the 27 Tennessee Achieves counties: Davidson, Knox, and Shelby counties. These counties are the center of the three largest metropolitan statistical areas in Tennessee (Nashville, Knoxville, and Memphis, respectively), which comprise approximately one-third of high school age (age 15-19) students in Tennessee, and served the largest number of Tennessee Achieves students from 2009 through 2014 (American Community Survey, 2014; Tennessee Achieves, 2016).

Finally, I will contribute to ongoing policy discussions in Tennessee and nationwide about the benefits and consequences – intended and unintended – of free college programs. While much of the evidence informing the development of these programs is descriptive at best, a more rigorous study will give more depth to the claims made by proponents and detractors of such programs.

I explore the following research questions:

1. Are students with access to Tennessee Achieves in Davidson, Knox, and Shelby counties more likely to undermatch than their peers in neighboring, untreated counties?
2. Does the effect of Tennessee Achieves on students' probability of undermatch vary based on the definition of undermatch employed?
3. Does the effect of Tennessee Achieves on students' probability of undermatch vary by treated county, as the counties are located in distinct regions of the state?

I hypothesize that those students with access to and who take up Tennessee Achieves are more likely to undermatch than their untreated peers, provided that the definition of undermatch is that they attend a two-year rather a four-year institution. If the definition of undermatch is one that more robustly accounts for institutional quality (i.e., Dillon and Smith, 2017), I hypothesize that Tennessee Achieves students are no more likely to undermatch than their untreated peers. This is because many will attend community and technical colleges that are comparable on many dimensions to some lower quality four-year institutions. Finally, I hypothesize that the probability of undermatch among treated students in Davidson and Shelby counties (Nashville and Memphis metropolitan areas, respectively) will be comparable, while students in Knox County (Knoxville) will have an increased probability of undermatch. This is due to the quality (i.e., available resources, graduation rates) of community and technical colleges in this region, as well as the maturity of the program in Knox County (THEC, 2016).

Program description: Tennessee Achieves

Beginning in Fall 2010,[21] Tennessee Achieves provided donor-funded last dollar scholarships to recent high school graduates. There were no academic or financial criteria for receipt of this aid, only a geographic constraint: students must graduate from a public or private high school in a treated county to be eligible. There is no evidence that students and their families relocated or enrolled in high schools across a county border to gain access to this program (Tennessee Achieves, 2016). A Tennessee Achieves scholarship could be applied to tuition and mandatory fees at any of the 13 community or 27 technical colleges in the state, though over 85 percent of students attended a campus in their home county (THEC, 2016). On average, these last-dollar awards were approximately $900 annually. Award amounts varied very

[21] Students living in Knox County were exposed to Knox Achieves beginning in 2009. Expansion to additional counties began in 2010, when the program was rebranded as Tennessee Achieves. Knox County is included in this study's sample.

little by the institution at which the awards were applied to tuition and fees (Carruthers & Fox, 2016; THEC, 2016).

To receive this aid, high school seniors were required to apply for the program via an online application, file the Free Application for Federal Student Aid (FAFSA), meet twice with a volunteer mentor (assigned by Tennessee Achieves) and complete eight hours of community service. If a student did not complete any of these steps, or did not do so by the program-imposed deadlines, he was no longer eligible for this scholarship. Students were required to enroll in a community or technical college seamlessly following high school graduation and to enroll full time. To retain the award once enrolled, students must earn a grade point average of 2.0 or higher, remain enrolled full time, and complete eight hours of community service each term, including summer.[22]

Prior to the statewide expansion of this program, Tennessee Achieves served over 10,000 students with a privately funded annual budget (including scholarship awards) of approximately $3 million (Tennessee Achieves, 2016). Approximately 65 percent of Tennessee Achieves students were first-generation college-goers, and 70 percent were Pell eligible, reflecting the program's initial goal of enrolling students who are traditionally underrepresented in higher education in Tennessee and nationwide (THEC, 2016; Tennessee Achieves, 2016).

Data

Student-level administrative data for eight cohorts of high school graduates (graduating high school classes of 2007-2014; pre- and post-Tennessee Achieves implementation) is provided by the Tennessee Higher Education Commission (THEC), Tennessee's public higher education coordinating board. Variables provided by THEC include student demographic (e.g.,

[22] The criteria for receipt and retention of Tennessee Achieves scholarships are identical to those of the statewide Tennessee Promise program.

sex, race), socioeconomic (e.g., Pell grant eligibility), and academic (e.g., ACT composite score) characteristics, county of residence, and the first institution at which a student enrolls following high school graduation. This dataset also includes dichotomous variables (0/1) to indicate whether a student participated in Tennessee Achieves, whether he graduated from a high school in a county in which Tennessee Achieves was available, and whether he graduated from high school before or after the program's implementation in his home county. County-level controls variables (e.g., unemployment rate at the time of Tennessee Achieves implementation, educational attainment, number of less-than-four-year institutions) in treated and control counties are provided by the Bureau of Labor Statistics, the American Community Survey, and THEC, respectively.

Sample

The sample for this analysis is comprised of high school graduates from the three largest counties with access to Tennessee Achieves (Davidson, Knox, and Shelby) and their neighboring counties in which the program was not available. Figure 5.1 presents a map of the three treated counties (shaded in dark gray) and the fifteen control counties (shaded in light gray) that surround them. Table 5.1 provides this information in tabular form and includes the year of program implementation and years of data included in the sample.[23]

Table 5.2 presents sample descriptive statistics for students in treated and untreated counties. The sample is limited to traditional-aged students who enroll in higher education immediately following high school; approximately 70 percent of postsecondary enrollees in Tennessee (THEC, 2016). There is substantial variation in Tennessee Achieves student

[23] Tennessee Achieves was implemented in the counties serving as controls for Knox County in 2012. For this reason, only three years of Tennessee Achieves data for Knox County are included, though the program was in place for six years prior to the statewide expansion. Tennessee Achieves expanded into Blount County in 2010; as such, it is excluded as a control county.

characteristics, which reflects the distinct demographic and socioeconomic traits of Tennessee's three regions. These differences are evident in the control counties as well. The majority of Tennessee Achieves students in Davidson County are female; in Knox and Shelby counties, approximately half of the treated students are female. In Shelby County, which is predominately African American, almost two-thirds of Tennessee Achieves students are black, compared to only 15.6 percent in Knox County, which is a disproportionately white county. A much larger proportion of Tennessee Achieves students in Davidson and Shelby counties are low income (Pell eligible) as compared to their treated peers in Knox County. Average ACT Composite scores are similar across treated and control counties. Given the large differences in student characteristics in each Tennessee Achieves county, it is important to emphasize that each of the three counties are investigated separately and are compared only to their untreated neighbors. This strategy will be discussed at length in the Methodology section below.

County-level characteristics are used as controls in the difference-in-differences model, and are presented in Table 5.3. County unemployment rates are as of the September prior to the implementation of Tennessee Achieves (2008, 2010, and 2013 for Knox, Shelby, and Davidson counties and their control counties, respectively) as this is when high school seniors begin the college application process. In treated counties, unemployment was lower than in many of the control counties, ranging from 3.9 to 5.9 percent; in counties without access to Tennessee Achieves, the unemployment rate ranged from 3.4 to 8.0 percent. With the exception of Williamson County, which is the most affluent and highly educated county in the state, educational attainment (defined as the proportion of adults with an Associate's degree or higher) ranges from approximately 25 to 45 percent, with treated counties on the high end of this range. Each Tennessee Achieves county has two two-year institutions (a community college and a

technical college) in the county; five control counties have one or two two-year institutions within county lines.

Methodology

Difference-in-differences

To determine the effect of the availability of Tennessee Achieves on students' probabilities of undermatch, I first estimate a county-level difference-in-differences (DID) regression. As Tennessee Achieves was implemented at the county level, this method will compare the probability of undermatch in the three largest counties with access to Tennessee Achieves ("treated counties") to that of their adjacent neighboring counties without exposure to the program ("control counties"). Only those counties that border the treated county are included as controls. This is done to reflect region-specific differences throughout the state, including local higher education opportunities, local labor markets and workforce and industry needs, and the quality of local K-12 education systems.

An important consideration when conducting a difference-in-differences regression is the parallel trends assumption: in the absence of intervention (i.e., Tennessee Achieves) the average change in the outcome (i.e., rate of undermatch) in treated and untreated counties would have been the same. While this assumption is untestable, it is important to state that trends in higher education enrollment in Tennessee in the years immediately preceding Tennessee Achieves implementation are consistent across all of Tennessee's 95 counties. For example, the county-level college-going rates are consistent, and enrollment at all 13 community colleges across the state decreased as the economy in Tennessee improved. Further, there were no substantial changes to state-funded financial aid during this time (THEC, 2016.)

The data used to estimate the DID regression include high school graduates before and after the implementation of Tennessee Achieves (the graduating classes of 2007-2014) for three treated counties and their untreated neighbors. Equation (1) presents the DID linear probability model:

$$Y_{ct} = B_0 + B_1(TNA_c) + B_2(PRE_c) + B_3(X_{ct}) + B_4(TNA_c * YEAR_c) + B_5(TNA_c * YEAR_c * NON_i) + B_6(TNA_c * YEAR_c * PELL_i) + B_7(Z_i) + e_{ct} \quad (1)$$

where Y_{ct} is an indicator of undermatch in county *c* in year *t*, TNA_c is a dichotomous variable (0/1) reflecting the presence of Tennessee Achieves in county *c*, PRE_c is a dichotomous variable (0/1) representing pre-or post-Tennessee Achieves implementation in county *c*, X_{ct} is a vector of county-level characteristics in year *t* (e.g., unemployment, educational attainment, the number of less-than-four-year institutions in the county), and TNA_c*$YEAR_c$ is the interaction of the presence of Tennessee Achieves and the year pre- and post-treatment. B_4, the coefficient on this interaction term, is the initial parameter of interest, as it is the main effect of the availability of Tennessee Achieves on undermatch. (TNA_c*$YEAR_c$* NON_i) and (TNA_c*$YEAR_c$* $Pell_i$) are additional interaction terms to determine the effect of the availability of Tennessee Achieves on undermatch among nonwhite and lower income (Pell eligible) students, respectively. B_5 and B_6 are these subgroup estimates. Z_i is a vector of student characteristics, including sex, race, ACT score, Pell eligibility, and a dichotomous variable (0/1) indicating whether a community college is located within 10 miles of the student's high school. These covariates are included as they have been found in prior literature to relate to students' probabilities of undermatch. Finally, e_{ct} is the error term.

Propensity score matching

Propensity score matching is used to explore the effect of Tennessee Achieves on the probability of undermatch among treated students. Each Tennessee Achieves student is matched with an untreated student in a neighboring control county who has the same propensity to participate in Tennessee Achieves had it been available.[24] Students in treated counties are matched with those in untreated counties to account somewhat for self-selection into the program. Students with access to Tennessee Achieves who take up the program may differ on a number of unobserved characteristics (i.e., motivation, organization) from those who have access but do not participate. As such, students are not matched within-county in an attempt to mitigate this issue.

Propensity scores are calculated using observed characteristics including year of high school graduation, county of residence, sex, race, Pell-eligibility and ACT scores within the sample of treated students. Students in untreated counties are then matched with those in treated counties, based on their propensities to participate in Tennessee Achieves. The set of covariates used to calculate the propensity scores meets the conditional independence assumption necessary when conducting propensity score analyses.

The conditional independence assumption (CIA) states that when holding constant covariates such as those listed above, assignment to treatment (Tennessee Achieves) is independent of the outcome of interest (undermatch). Further, each of these covariates is unaffected by the treatment[25] and are measured prior to treatment. These covariates, particularly county of residence and year of high school graduation, fully determine access to the program;

[24] Treated students in the three treated counties are matched only with untreated students who live in a county neighboring their own. For example, a treated student in Shelby County is matched only with an untreated student in Tipton or Fayette counties, both of which neighbor Shelby County.

[25] All covariates that do influence assignment to treatment – county of residence, year of high school graduation, and requirements met to allow take up of the program – are observed in this dataset.

the only variability in participation is whether a student decides to take up the program or not, which provides the rationale for not matching within-county (Caliendo & Kopeinig, 2008; Guo & Fraser, 2010).

I use nearest neighbor matching with replacement to match treated students with those in neighboring counties without access to Tennessee Achieves, following the methodology employed by Carruthers and Fox (2016) in their investigation of Knox Achieves.[26] Untreated students are matched within a 0.05 percentage point window of the treated student's propensity.[27] Nearest neighbor matching is most appropriate for this analysis as it is the most straightforward method of propensity score matching (Caliendo & Kopeinig, 2008) and, as mentioned above, best accounts for self-selection into Tennessee Achieves, which is perhaps the largest source of omitted variable bias in this analysis (Carruthers & Fox, 2016).

The linear probability model used to calculate the propensity score is:

$$Y_{it} = B_0 + B_1(YEAR_i) + B_2(COUNTY_i) + B_3(X_{it}) + e_{it} \qquad (2)$$

where Y_{it} is a binary indicator for a student's participation in Tennessee Achieves in year *t*, $YEAR_i$ is the student's year of high school graduation, $COUNTY_i$ is the student's county of residence, X_{it} is a vector of student characteristics on which he is matched (e.g., sex, race, Pell eligibility, ACT score, high school's distance from a community college), and e_{it} is the error term. The result of this model provides the propensity score for all - treated and untreated - students in the sample. Treated and control students are balanced (distribution does not vary by treatment status) on the aforementioned demographic and academic covariates ($p > .05$; variance ratios data range from 0.88 for Pell eligibility to 1.32 for ACT scores).

[26] Students are matched using the *teffects* command in Stata, as *teffects* calculates adjusted, robust standard errors when conducting propensity score analyses.
[27] Matching students without replacement, using a narrower caliper (0.02 and 0.01) and using kernel matching yield similar results for the full sample and for student subgroups.

After matching Tennessee Achieves students to their non-treated peers with the same propensity to participate in Tennessee Achieves, I calculate the average treatment effect on the treated (ATET) of participating in Tennessee Achieves on students' probability of undermatch. The ATET is the difference in the probability of undermatch between matched pairs. These treatment effects are discussed in the Results section below.

Definitions of undermatch

This paper employs two of the five definitions of undermatch discussed in Chapter 3 of this dissertation. The first definition of undermatch is perhaps the most intuitive: Tennessee Achieves students who are academically eligible to attend a four-year institution in Tennessee (having earned an ACT composite score of 18 or higher) but instead attend a community or technical college are labeled as undermatched. As attending a two- versus four-year institution is the margin on which many students undermatch (i.e., Goodman, Hurwitz, & Smith, 2016), this is relevant not only to the structure of the Tennessee Achieves (now Tennessee Promise) program, which drives the cost of tuition and fees at a community or technical college to zero, but to broader discussions about free college programs and student match.

The second definition of undermatch is used by Dillon and Smith (2017) to account more fully for institutional quality, rather than simply considering students' academic abilities to determine appropriate match. As community and technical colleges in Tennessee enroll a freshmen class that is similar in composition to some less selective four-year institutions and have similar per-pupil resources (see Chapter 1), using this definition will determine whether Tennessee Achieves students attend a community or technical college that is of lower quality than a four-year institution at which they were academically eligible to enroll.

Results

Difference-in-differences

Results of the difference-in-differences regression are presented in Table 5.4. These estimates of undermatch are, by definition, lower than those produced using propensity score matching (presented below). This is because the difference-in-differences estimates are based on the availability of Tennessee Achieves (intent to treat), not take up of Tennessee Achieves (treatment on the treated).

Using the first definition of undermatch (attending a two-year institution when academically eligible to attend a four-year), students with access to Tennessee Achieves by virtue of graduating from a high school in Davidson, Knox, or Shelby counties in the years in which the program was available are 0.061 probability points[28] more likely than their peers in neighboring counties to undermatch. This is logical, as the structure of Tennessee Achieves incentivizes students to enroll in a community or technical college. This estimate is significant at the 0.01 level, demonstrating that *access* to a free college program has a statistically significant effect on students' decisions to enroll in two-year institutions when they are academically eligible to attend a four-year institution. This finding is relevant to ongoing policy discussions about the expansion of such programs in other states, as merely having access to a tuition-free community or technical college program leads to a statistically significant change in students enrollment decisions.

The second definition of undermatch, which more thoroughly accounts for institutional quality, yields an estimate of 0.019 probability points: treated students are 1.9 percentage points more likely than their peers in counties without access to Tennessee Achieves to undermatch. While the magnitude of this estimate is smaller than that discussed above, it is also statistically

[28] All estimates of the effect of Tennessee Achieves on undermatch are predicted probabilities ("p-hats").

significant at the 0.01 level. As such, undermatch behavior between treated and untreated students can be said to differ significantly when considering the quality of the institutions in which they enroll.

Subgroup treatment effects

Sex. When undermatch is defined as attending a two-year institution when a student is academically eligible to attend a four-year college or university, male students with access to Tennessee Achieves are 8.9 percentage points more likely than their female peers to undermatch. Similarly, when using Dillon and Smith's definition of undermatch to more fully account for institutional quality, male students in Davidson, Knox, and Shelby counties are 9.0 percentage points more likely than their female peers to undermatch. Both of these estimates are statistically significant, and are in line with prior findings about the differences in undermatch between male and female students.

Race. Nonwhite students with access to Tennessee Achieves are 0.078 probability points more likely than their white peers to undermatch by attending a two-year institution. This result is consistent with findings of prior literature. Using Dillon and Smith's definition, nonwhite students with access to Tennessee Achieves are 0.019 percentage points more likely than their white peers to undermatch. These estimates are statistically significant at the 0.01 and 0.05 levels, respectively.

Pell. Similar to the findings relative to race, Pell eligible students in Tennessee Achieves counties are .091 probability points more likely than their middle/upper income peers to undermatch, when undermatch is defined as substituting a two-year for a four-year institution. This may be due to the financial incentive to attend a two-year institution, as Tennessee Achieves drives the cost of tuition and fees to zero, or the desire to attend a local institution close

to home. Pell-eligible students with access to Tennessee Achieves are 11.1 percentage points more likely to undermatch than their non-Pell eligible peers when more fully accounting for institutional quality, per the Dillon and Smith definition.

Propensity Score Matching

Table 5.5 presents the average treatment effects on the treated (ATET) of Tennessee Achieves on students' probability of undermatch. As discussed above, students in treated counties were matched only to students in untreated counties that neighbor their county of residence.

Treated students' probability of undermatch varies by county of residence and the definition of undermatch applied. Using the first definition of undermatch, Tennessee Achieves students in each of the three treated counties are between .148 and .298 probability points more likely than their untreated peers to undermatch by attending a two-year institution when they are academically eligible to attend a four-year college or university. That the three counties have such dissimilar estimates is not surprising. The concept of tuition-free community college is much more well-established in Knox County (predicted probability = .298) as compared to the other two counties, and Pellissippi State Community College, located in Knox County, is arguably the best community college in the state (i.e., highest average ACT score of entering class, highest graduation rate, and highest rate of transfer to a four-year institution) (THEC, 2016). For these reasons, it makes sense that the effect of Tennessee Achieves on the rate of undermatch in Knox County is higher than the other two treated counties.

Using Dillon and Smith's (2017) definition of undermatch, Tennessee Achieves students in the three treated counties are between .112 (Davidson) and .171 (Shelby) probability points more likely than their untreated peers to undermatch. These differences in students' probability

of undermatch may be reflective of the variation in institutional quality that exists across the state. Institutions in middle and east Tennessee (i.e., Davidson and Knox counties) are, on the whole, of higher quality than institutions in west Tennessee, where Shelby County is located (THEC, 2016). As such, students who take up Tennessee Achieves in Davidson and Knox counties are not trading off as much quality as their peers in Shelby County when attending a community or technical college. Assuming that the average student wants to attend a postsecondary institution that is less than three hours (the time it takes to travel from Memphis to Nashville, and from Nashville to Knoxville) from home, a student's choice set in Davidson and Knox counties include institutions – both less-than-four and four-year institutions - with higher average ACT scores, additional financial and student support resources, lower student-faculty ratios, and higher graduation rates than those in Shelby County (THEC, 2016). A Rosenbaum bounds test confirms that there is no hidden bias in these estimates due to unobserved confounders (gamma = 1, 2, 3; $p < .05$).

Subgroup treatment effects

Sex. If undermatch is defined as attending a two-year institution rather than a four-year college or university, male Tennessee Achieves students between 0.8 and 1.7 percentage points more likely than their untreated male peers to undermatch. Similarly, when using Dillon and Smith's definition of undermatch, male students are between 0.6 and 0.8 percentage points more likely than their untreated male peers to undermatch. These estimates are quite small in magnitude, and are not statistically significant at conventional levels.

Race. Nonwhite Tennessee Achieves students are more likely to undermatch than their untreated nonwhite peers in all three Tennessee Achieves counties, using both definitions of undermatch. Average treatment effects on treated students range from 3.7 percentage points in

Shelby County, where college goers are predominately African American, and 2.1 percentage points in Davidson County, where there is much greater racial diversity. The aforementioned estimates, however, were calculated using Dillon and Smith's definition of undermatch and the two- versus four-year definition, respectively, again emphasizing how different estimates may be when applying unique definitions of undermatch. These estimates are statistically significant at the .01 level.

Pell. When undermatch is defined as attending a two-year in place of a four-year institution, Tennessee Achieves students who are Pell-eligible are between 2.4 and 3.3 percentage points more likely than their untreated Pell-eligible peers to undermatch. When using Dillon and Smith's definition of undermatch, Pell-eligible students who participate in Tennessee Achieves are between 2.4 to 3.1 percentage points more likely than their untreated Pell-eligible peers to undermatch. The likelihood of undermatch among these lower income students is highest in Davidson County, which is the most income-diverse of the three treated counties.

Distance to community college. Tennessee Achieves participants who graduated from a high school within 10 miles of a community college are more likely to undermatch than their untreated peers who live close to a community college. This is true in all three treated counties and when using either definition of undermatch. When undermatch is defined as attended a two-year rather than a four-year institution, Tennessee Achieves students living near community colleges are between .067 and .081 probability points more likely than their peers to undermatch, depending on their county of residence. Similarly, using Dillon and Smith's definition, Tennessee Achieves students living within 10 miles of a community college are between .049 and .076 probability points more likely than their untreated peers to undermatch. Each of these

estimates is statistically significant, and are in line with findings of prior literature exploring the effects of proximity to different institution types on students' enrollment decisions.

Directions for future research

An issue inherent to discussions of free community college programs is the *quality* of community colleges at which students may attend tuition-free. As seen above, access to a high quality community college (i.e., Pellissippi State Community College in Knox County) has a substantial influence on students' enrollment decisions, especially when the tuition cost of enrolling at the local community college in driven to zero. As tuition-free community college initiatives continue to be popular policy proposals throughout the country, much still needs to be done to improve community colleges' processes (i.e., academic and student support services) and student outcomes (i.e., transfer and graduation rates) to address the "community college penalty" (i.e., Reynolds, 2012) if students are being incentivized to attend a two-year rather than a four-year institution. Additionally, as such programs may alter the composition of students enrolling at two- or four-year institutions, measures of quality and selectivity that rely on students' academic characteristics (i.e., high school GPA, ACT scores) have the potential to shift substantially.

Further, the *structure* of free college programs will have differential effects on student match. As Tennessee Achieves (now Tennessee Promise) provides a financial incentive for students to enroll at two-year institutions, their likelihood of undermatch by substituting two-year for four-year institutions is increased. However, the Kalamazoo Promise, for example, provides tuition and fees at *any* public institution in Michigan, including the state's most selective public universities: the University of Michigan and Michigan State University. As such, student match may be improved, as students with access to the Kalamazoo Promise will apply to

and attend more selective institutions with greater frequency (Andrews, et al., 2010; Bartik, et al., 2015). As the number of free college proposals grows, and input is solicited from researchers and policymakers, it is imperative the effects of different free college program structures on student match are investigated thoroughly.

Limitations

A limitation to this chapter is that it examines the effect on Tennessee Achieves on students' probability of undermatch in only three of the 27 participating counties. While this is useful to policy discussions and captures that majority of students participating in Tennessee Achieves, a future paper exploring undermatch in all 27 counties will shed light on additional variation (i.e., quality of K-12 school system, urban versus rural counties, etc.) that exists in students' college-going decisions across the state. The challenge in doing so, however, will be determining the most appropriate control counties, as counties contiguous to treated counties will often themselves be treated.

Another limitation to this chapter is the different lengths of time for which each of these counties participated in Tennessee Achieves. More mature counties, by virtue of being more mature, had more observations in the dataset, potentially increasing the statistical power of estimates of the effect of this program on undermatch. To mitigate this, future research can perhaps begin at a certain point in time and move forward; when exploring Tennessee Promise, future research can simply control for a county's participation in Tennessee Achieves prior to the statewide expansion of this initiative.

Conclusion

As tuition-free college initiatives remain popular policy proposals, there is much to learn about the effects of such programs on students' college-going decisions (i.e., how search and

choice change), and eventually, their persistence and degree attainment. This paper explores the effect of one such program – Tennessee Achieves – on students' enrollment choices. Specifically, I investigate whether access to and take up of this program leads to increases in students' probability of undermatch.

The findings support the aforementioned hypotheses. When undermatch is defined as a student attending a two-year institution when he is academically eligible to attend a four-year, both intent-to-treat (ITT) and average treatment effect on the treated (ATET) demonstrate that Tennessee Achieves students are more likely than their peers to undermatch. Exposure to Tennessee Achieves resulted in an increase of 6.1 percentage points in the likelihood of students who are eligible to attend four year institutions enrolling at two-year institutions. This ITT estimate is important for policymakers to consider when proposing free college policies, as this is the estimated effect of the program on undermatch, irrespective of actual program take up. The probability of undermatch among treated students in the three treated counties ranges approximately 14.8 to 29.8 percentage points, with rates varying slightly between the three counties. Lower income and nonwhite students have increased probabilities of undermatch, relative to their untreated peers.

When the definition of undermatch more fully captures institutional quality, not only students' academic abilities, students who take up Tennessee Achieves are between 11.2 and 17.1 percentage points more likely to undermatch than their untreated peers. This is counter to the hypothesis above, and is likely due to the substantial differences in student body composition and resources available at two- versus four-year institutions in Tennessee.

This variation in rates of undermatch emphasizes the point made in Chapter 3: the definition of undermatch matters to conclusions drawn about this phenomenon, and different

definitions will yield different results. It is important, therefore, that researchers and policymakers are very clear about how they are defining undermatch when discussing this issue.

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Figure 5.1. Tennessee Achieves and neighboring (untreated) counties

Table 5.1. Tennessee Achieves implementation and neighboring (untreated) counties

TNA county	Implementation year	N years in sample	Control counties
Davidson	2014	1	Cheatham, Robertson, Rutherford, Sumner, Williamson, Wilson
Knox	2009	3*	Anderson, Grainger, Jefferson, Loudon, Roane, Sevier, Union
Shelby	2011	4	Fayette, Tipton

Note: Tennessee Achieves was introduced in Anderson, Grainger, Jefferson, Loudon, Roane, Sevier and Union counties in 2012. As such, these are appropriate control counties for only three cohorts of high school graduates from Knox County.

Table 5.2. Sample descriptive statistics – post-Tennessee Achieves implementation, by county

	Davidson County			Knox County			Shelby County		
	All	*TNA*	*Controls*	*All*	*TNA*	*Controls*	*All*	*TNA*	*Controls*
% female	53.7	58.9	53.2	51.6	49.8	54.2	53.3	47.8	58.7
% nonwhite (black & Hispanic)	37.8	42.4	32.7	13.1	15.6	11.2	59.6	65.4	57.9
% Pell eligible	40.2	77.9	36.8	52.3	45.1	54.4	64.4	69.2	59.7
% enroll 2-year	34.9	100	29.3	69.5	100	61.0	68.2	100	38.1
Avg. ACT	21.8	16.9	22.6	20.9	19.9	21.5	17.8	16.9	21.1
TNA Implementation Year		2014			2009			2011	
N students	4,004	417	3,587	4,316	1,244	3,072	3,547	1,976	1,571

Note: Tennessee Achieves students are program participants.
Sample limited to students enrolling immediately following high school.

Table 5.3. County-level unemployment, attainment, and presence of two-year institutions

County	Implementation year	% unemployed *	% adults with AA or higher	N 2-year institutions in county
Davidson	2014	5.9	42.5	2
Cheatham		6.4	26.0	0
Robertson		6.5	24.0	0
Rutherford		6.0	36.6	1
Sumner		6.1	31.3	1
Williamson		5.2	60.0	0
Wilson		6.2	34.8	0
Knox	2009	5.3	43.1	2
Anderson		6.2	29.6	0
Grainger		8.0	17.9	1
Jefferson		6.7	21.7	0
Loudon		5.8	32.8	0
Roane		6.0	25.1	2
Sevier		5.8	22.4	0
Union		6.2	13.9	0
Shelby	2011	3.9	36.0	2
Fayette		6.2	28.4	0
Tipton		3.4	22.6	1

Note: Percent unemployed in September *prior* to Tennessee Achieves implementation year.

Table 5.4. Difference-in-differences: Effect of Tennessee Achieves on undermatch

	1	2
Definition of undermatch	2 vs. 4 year	Dillon & Smith
Post-treatment	-0.01	0.014***
	(0.022)	(0.024)
Treated county	0.125***	0.253***
	(0.035)	(0.041)
Post * Treated	**0.061*** **	**0.019*** **
	(0.028)	(0.032)
Education attainment	-0.070***	-0.020***
	(0.001)	(0.001)
Unemployment rate	0.044***	0.029***
	(0.008)	(0.008)
N 2-year institutions	0.032***	0.080***
	(0.015)	(0.017)
< 10 miles to CC	0.057***	0.041***
	(0.002)	(0.001)
Female * Post * Treated	**-0.089*** **	**-0.09** **
	(0.018)	(0.021)
Nonwhite * Post * Treated	**0.078*** **	**0.019** **
	(0.018)	(0.021)
Pell * Post * Treated	**0.091*** **	**0.111** **
	(0.016)	(0.026)
Observations	110,147	110,147
R2	0.032	0.009
Chi2	4388.4	1198.2

Note: Sample limited to students enrolling immediately following high school.

Clustered (county by year) standard errors in parentheses.

*** $p < .01$

** $p < .05$

Table 5.5. Propensity score matching results: Tennessee Achieves participation and probability of undermatch

	Average Treatment Effect on the Treated (ATET)		
Definition	**Davidson**	**Knox**	**Shelby**
2- versus 4-year institution	0.177***	0.298***	0.148***
	(0.007)	(0.007)	(0.008)
Female	-0.017	-0.012	-0.009
	(0.027)	(0.014)	(0.021)
Nonwhite	0.021**	0.031**	0.031***
	(0.027)	(0.021)	(0.011)
Pell eligible	0.024**	0.033**	0.024***
	(0.015)	(0.047)	(0.009)
< 10 miles to CC	0.067***	0.081***	0.077***
	(0.001)	(0.004)	(0.002)
Dillon & Smith (2017)	0.112***	0.144***	0.171***
	(0.021)	(0.008)	(0.018)
Female	-0.006	0.000	-0.008
	(0.041)	(0.032)	(0.038)
Nonwhite	0.029**	0.027***	0.037***
	(0.002)	(0.011)	(0.003)
Pell eligible	0.031**	0.024***	0.024***
	(0.004)	(0.009)	(0.007)
< 10 miles to CC	0.049***	0.076***	0.069***
	(0.003)	(0.006)	(0.010)
N students	866	2,494	3,966
Treated students on support	416	1,244	1,976
Untreated students on support	450	1,250	1,990

Note: Sample limited to students enrolling immediately following high school. Treated students matched only to untreated students in neighboring counties. Standard errors in parentheses. Estimates based on nearest neighbor matching.

*** $p < .01$

** $p < .05$

Chapter 6

Conclusion

Through this dissertation, I explore the effects of two state-sponsored financial aid programs on postsecondary undermatch, as well as the importance of being explicit about definitions of undermatch when discussing this issue. In Chapter 3, I apply five unique definitions of undermatch to one sample of students. I determine that estimates of undermatch among recent high school graduates in Tennessee range from 21 to 69 percent, depending on the definition applied. These dramatically different results lead to varied conclusions about how prevalent undermatch is in this state. In Chapter 4, I investigate undermatch among students who receive the General Assembly Merit Scholarship (GAMS), a merit scholarship awarded to the highest achieving students in the state. These students, particularly those who are nonwhite and low income, have an increased likelihood of undermatch relative to their peers who receive different scholarship aid. As above, the effects of the GAMS program on students' probabilities of undermatch rely on the definition of undermatch applied. In Chapter 5, I determine that students who took up the Tennessee Achieves tuition-free community and technical college program (prior to its statewide expansion and rebranding as Tennessee Promise) have an increased probability of undermatching, compared to their non-treated peers, should undermatch be defined as attending a two-year institution when they were academically eligible to attend a four-year institution. Students' probabilities of undermatch vary between racial and socioeconomic subgroups.

Below, I discuss how the findings of each of these three studies contribute to the body of undermatch literature; fit within the theoretical frameworks presented in Chapter 2; and can be used to develop public policy in Tennessee and throughout the United States. I conclude with a discussion of opportunities for future research.

Contribution to literature

These three papers contribute to the body of undermatch literature in a number of ways. Chapter 3, which implements five unique definitions of undermatch to estimate the prevalence of undermatch in Tennessee, emphasizes that in order for research and conversations about undermatch to be comparable and useful, researchers must be very transparent about how they define what undermatch actually is. As some of the most often-cited studies of undermatch (i.e., Bowen, et al., 2009; Roderick, et al., 2008, 2009) employ very different methodologies and definitions to answer distinct research questions, the results of these studies are not comparable, and sometimes present a conflicting narrative about how widespread undermatch is among those entering higher education in the United States.

Chapters 4 and 5 related to the findings of many prior studies of undermatch, particularly with respect to the enrollment behavior of nonwhite and lower income students (i.e., Fry, 2002; Alon & Tienda, 2005; Bowen, et al., 2009; Roderick, et al., 2008, 2009; Smith et al., 2013; Dillon & Smith, 2017; Rodriguez, forthcoming). The findings presented in these two chapters, which investigate the effects of the General Assembly Merit Scholarship and Tennessee Achieves programs, respectively, provide further evidence that students of color and those who are lower income (Pell-eligible) who are GAMS recipients or took up Tennessee Achieves have an increased probability of undermatch, relative to their white or middle/upper income peers, irrespective of the definition of undermatch applied.

It is worth noting that the majority of college-goers (63 percent) in Tennessee are white, as are the majority of GAMS recipients (70 percent) and Tennessee Achieves (74 percent) participants (Tennessee Higher Education Commission, 2016). As such, researchers and policymakers in Tennessee must be keenly aware of the enrollment decisions of typically underrepresented students entering higher education, and, more specifically, GAMS and Tennessee Achieves (now Tennessee Promise) recipients. These students have much to gain from enrolling in a selective institution (i.e., Dale & Krueger, 2002, 2014) and must be supported to ensure that they enroll at colleges and universities that are the best match for them.

Theoretical frameworks

Human capital theory

As outlined in Chapter 2, human capital theory is very relevant to studies of undermatch. Becker (1993) asserts that it is not only the *quantity* of education in which a student invests, but also the *quality* that influences his lifetime earnings. Students who attend higher education institutions that are less selective and of lower quality than those they are academically eligible to attend, therefore, may not be optimally investing in their own human capital. While these students may be acting rationally in the short term (i.e., maximizing their utility by attending an institution that is lower cost, has desired programs of study, is closer to home, etc.) they may do themselves a long-term economic disservice by attending a less selective college or university.

An important next step in this research is to explore the degree completion and workforce outcomes of undermatched students in Tennessee, particularly those who received GAMS awards or were Tennessee Achieves (or Tennessee Promise) students. Tennessee has a robust P-20W data system that allows researchers to track students through higher education into the workforce. To expand upon the findings presented in this dissertation, these data can be used to determine whether students who

undermatched are underemployed or are earning low wages upon entering the workforce, as compared to their peers who attended more selective institutions at which they were well-matched (or overmatched).

College choice models

This set of papers reinforces a number of conclusions from the college choice theory and literature presented in Chapter 2. Considering Hossler and Gallagher's (1987) three-stage model of college choice, students' search process (the second stage of this model) often leads to undermatch, as many students are not seeking information about higher education institutions at which they would be well-matched. Instead, they are gathering information about and applying to colleges and universities that are close to home, institutions with which they are familiar, or at which they know peers and high school classmates (Roderick et al., 2008, 2009). Or, students who receive GAMS awards, for example, may be limiting their search to institutions that are in-state, such that they may use their merit aid awards. To prevent undermatch due to misinformation or lacking information, students must be supported by counselors, teachers, and other school and community personnel to seek information – how to apply for both admission and financial aid, for example - about institutions at which they would be well-matched.

This need for support is particularly relevant in Tennessee, as the Tennessee Achieves program has now expanded statewide. Tennessee Promise, the now-statewide free community and technical college program, is very heavily promoted, which may adversely affect students' information-seeking about the higher education option most appropriate for them.[29] While the intention of these media campaigns is to attract students for whom higher education seems out of reach into community and technical colleges across the state (THEC, 2016), an unforeseen consequence may be that students who would be well-matched at a four-year (selective) college

[29] There was much media coverage and publicity when Tennessee Achieves expanded to each of the 27 counties as well, but nothing like the online, radio, television and print campaigns that have accompanied the rollout of the Tennessee Promise program over the past two years.

or university are suspending their college searches and choosing to enroll in a less-than-four year institution as a Tennessee Promise student. Perna's (2006) theory of college choice is applicable to this discussion as well. This is a clear example of how the state policy context (Perna's fourth layer) is effecting the information about college-going provided to students in their schools and communities (Perna's second layer), potentially leading to less well-matched enrollment decisions.

Implications for policy

Undermatch in Tennessee

High achieving students with an increased likelihood of undermatch (i.e., nonwhite and lower income students) should be identified as early as possible, and be supported through their college search and application processes. The Tennessee College Access and Success Network, a nonprofit organization that promotes college access across the state, has recently partnered with UBS Financial Services to intervene in low performing high schools in Tennessee to do just that. High performing students in these schools will have access to mentors, nudges (i.e., text messaging), and additional resources (i.e., college visits to selective institutions) to ensure that their college search process includes institutions at which they would be well-matched. This collaboration is interesting, as it addresses undermatch directly, as opposed to treating undermatch as a symptom or unintended consequence of another initiative. If this program succeeds in reducing undermatch among treated students, there is much opportunity to expand this intervention to additional schools statewide to impact as many additional high achieving, nonwhite and/or low income students as possible.

Further, improvements to college counseling and advising will substantially decrease students' probabilities of undermatching. As college counselors are often stretched thin or are

responsible for students at multiple high schools, the state of Tennessee has established AdviseTN ("Advise Tennessee"), a corps of college counselors placed in forty of the most underserved high schools across the state. These counselors are charged with helping students with the college search and application processes as early as their sophomore years, and, among other responsibilities, helping students to seek information and make postsecondary choices that are appropriately aligned with their academic abilities. While AdviseTN is state-funded, and these college counselors are technically state employees, they have been trained and explicitly instructed to do a thorough college search with their students – not simply suggest that all students take advantage of the Tennessee Promise and enroll in a less-than-four-year institution. As this program is still in its infancy, there will be great opportunity for robust research about the outcomes and enrollment decisions of treated students in the next few years.

Finally, with regard to interactions with legislators and executive leadership in Tennessee, it is imperative that higher education advocates and researchers are very clear about what they mean when talking about undermatch. As demonstrated in Chapter 3, undermatch can be defined in a number of ways, each yielding a very different estimate that tells a dissimilar story about the prevalence of this issue. As such, transparency and clarity about what undermatch means will lead to much greater political support when combatting this issue across Tennessee.

GAMS program

Though the majority of higher education policymakers in Tennessee are currently focused on the role of the community and technical colleges as a vehicle for college access across the state (i.e., the Tennessee Promise and Tennessee Reconnect programs), it is critical that they are also aware of the college search and enrollment decisions of the state's highest achieving students. Based on the findings of Chapter 4 of this dissertation, it is clear that these

students, particularly those who are nonwhite or lower income, lack the support and information necessary to attend highly selective, academically appropriate institutions.

These high achieving students require support throughout the college search process, just as their lower achieving peers do (i.e., Roderick et al., 2008, 2009). It is critical, therefore, that college and guidance counselors are prepared to provide information and support, just as they would to those students on the margin of enrolling in higher education at all. As discussed above, this is a role that AdviseTN advisors will play; not promoting only state-sponsored programs, but working with high achieving students to determine the institutions that are the best fit – public, private, in-state or out-of-state.

Tennessee Achieves (Tennessee Promise)

As mentioned above, high school guidance and college counselors must be strategic about the students to whom they advocate participating in Tennessee Promise. Tennessee Promise should not be encouraged uniformly across all student subgroups: those who would be better-matched at a four-year institution should be encouraged and supported to seek information about and apply to these institutions. Students on the margin of not attending college at all should be the first order priority for these counselors and mentors/community members when making recommendations about Tennessee Promise.

Additionally, it is critical that students who enroll in community or technical colleges as Tennessee Promise students are able to transfer seamlessly into a four-year institution, should they so choose. This is particularly true for students who took advantage of tuition-free community or technical college when they were academically eligible to have attended a four-year institution. While the state of Tennessee has established structured Transfer Pathways, subject-specific articulation agreements between community colleges and four-year public

universities, they are not always honored and/or implemented with fidelity. This fact, coupled with an upcoming change in public higher education governance in Tennessee, emphasizes the need for explicit policies around transfer, and accountability measures to ensure that these policies are being executed as intended.

Directions for future research

Transfer behavior among undermatched students

It is imperative that policymakers and education researchers in Tennessee understand transfer behavior in this state, particularly in light of the Tennessee Promise program. Students who undermatch by attending a community or technical college as a result of this program may transfer to a four-year college or university upon completing (or before) a technical certificate or an Associate's degree. It is important to understand the point in time at which these transfers occur, as well as students' time to a Bachelor's degree – do they experience the "community college penalty" because they began their higher education experience at a community or technical college? Further, students who undermatch by attending less selective, lower quality four-year colleges and universities may transfer to more selective four-year institutions, both in- and out-of-state. By using both the THEC Student Information System and data provided by the National Student Clearinghouse to investigate the timing and direction of these transfers, policymakers in Tennessee will better understand the ways in which undermatch influences student outcomes.

Workforce outcomes

As one of the most often-cited arguments for addressing undermatch is the economic return (i.e., lifetime earnings) to attending a selective postsecondary institution, an important next step in higher education research in Tennessee is to explore the workforce outcomes of

undermatched students. Workforce outcomes – including the field in which a student is employed, whether the student is underemployed, and his wages/salary – will likely differ by the definition of undermatch applied, which in itself could be an interesting study. As mentioned above, Tennessee has a robust P-20W data system that allows researchers to determine the workforce outcomes of those who graduated from both public and private higher education institutions in Tennessee, to begin to determine their post-higher education economic well-being.

Changes to financial aid programs

With the announcement of the Tennessee Promise is 2014, many existing state-funded financial aid programs were modified to fund this ambitious statewide tuition-free college program. Tennessee Education Lottery Scholarship awards (including the GAMS award), for example, were repackaged such that students did not receive the same amount of aid each year. Students enrolled at four-year institutions received $500 less during their first two years and an additional $500 during their Junior and Senior years. While the total award amount over four years was unchanged, the disbursement of the funds differed. It is important that higher education researchers begin to examine the effects of these changes, particularly as related to undermatch. Students for whom $500 is a nontrivial amount of scholarship aid (i.e., low income students) are those who are more likely to undermatch. Therefore, it is important to determine how this change in the packaging of TELS awards (among other state aid programs) influences students' enrollment decisions, especially for those students who belong to subgroups with historically high rates of undermatch.

Conclusion

Tennessee has over the past few years been at the forefront of many important higher education innovations. For this reason, it is a very exciting place to work as a higher education

researcher, and there is ample opportunity to explore the effects of these innovative statewide programs on student outcomes. It is critical, however, that these initiatives are investigated and evaluated with regard to student match: how are these innovations affecting students' enrollment decisions, particularly among high achieving students? This dissertation – which explores the importance of clear definitions of undermatch and determines the effects of two state-sponsored financial aid programs on undermatch – is only the tip of the iceberg. Additional research must be done to determine the most appropriate ways to ensure that students in Tennessee have access to the higher education institutions at which they are best-matched, where they will be most successful, and that will prepare them for ample opportunities in the workforce.

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