Enhancing the Community College Transfer Pathway:
Exploring Aspects of Transfer Receptivity at 4-Year Institutions in Engineering

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Abstract

Community college transfer pathways may play a critical role in realizing broadened participation in engineering; Community colleges serve as an important access-oriented pathway through the postsecondary system in the United States, and also depend on 4-year institutions to streamline vertical transfer. The extent to which 4-year institutions are receptive to community college transfer as a viable pathway to engineering degrees may play a significant role in its efficacy. This dissertation explores a few aspects of transfer receptivity at 4-year institutions to understand how they relate to the efficacy of vertical transfer pathways in engineering disciplines. The first manuscript is a case study of an articulation agreement partnership between one 4-year institution and two public community college partners. The second manuscript examines how transfer policies and institutional characteristics of 4-year institutions in the U.S. relate to the enrollment, graduation and reporting of transfer students in engineering. I use a combination of quantitative and qualitative methodologies across both manuscripts. The results of these studies revealed that: 1) specific challenges for transfer in engineering suggest that adequate examinations of transfer receptivity need be discipline-specific, 2) institutions encounter dissonance when simultaneously managing aims to increase access and prestige, 3) there is a need for shifts in policy and ranking systems that incentivize increases and improvements in vertical transfer, 4) there is a need for more transparency of transfer-related policies and transfer student data, and 5) our understanding of transfer matriculation remains well ahead of graduation outcomes.

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General Audience Abstract

Community college transfer pathways may be critical to increasing the number of women and underrepresented minority engineers. Community colleges serve as an affordable way for students and families to begin their postsecondary education in the United States, but depend on universities to support community college transfer to complete bachelor's degrees. How well universities partner with community colleges in transfer may determine how well it works for students and families. This dissertation explores a few ways that universities encourage or discourage community college transfer as a way to earn a bachelor's degree in engineering. The first study looks closely at a transfer partnership between one university and two community colleges. The second study looks at how transfer policies and characteristics of universities relate to the enrollment, graduation and reporting of engineering transfer students. The results of these studies revealed several important themes. First, there are specific challenges to transfer in engineering. Next, institutions have a hard time increasing access to their institutions for community college students while also increasing their academic ranking and prestige. With this in mind, there is a need to shift policies and ranking systems that encourage institutions to focus more on increasing community college transfer. Next, universities need to be more transparent about their policies and data that influence transfer students. Finally, we know a lot more about how often transfer students successfully transfer to universities than we do about how many students end up graduating from the university and how long it takes them to do so.

Dedication

This work is dedicated to

The students of Community College of Denver, the VT-NETS program, and community college transfer students around the country,
for inspiring me to believe that community college transfer can enable the American dream while simultaneously opening my eyes to the pervasive inequities that exist within the U.S. postsecondary system. Thanks to you, I can be a voice for changing this system.

And also to,

My wife Dana, son Gavin, dog Brinkley, and child to be,
who have supported me throughout this journey and keep me balanced and grounded, reminding me what really matters in the world.

And also to,

My parents Greg and Lori, sister Jordyn, and grandparents Dottie, Clinton, Carole, and Dennis,
who have inspired me to be a lifelong learner and whose selflessness has enabled my entire postsecondary path.

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Attributions

The two manuscripts included in this dissertation are original work where I had primary authorship and research responsibilities. However, each manuscript includes intellectual contributions from research colleagues who will be included as co-authors upon publication. Both manuscripts are informed by and advance prior research on community college transfer pathways in engineering and directly support efforts of the Virginia Tech Network for Engineering Transfer Students (VT-NETS) project led by Bevlee Watford (PI), David Knight (co-PI), and Walter Lee (co-PI). Each of the aforementioned colleagues contributed to Manuscript 1 by assisting with participant recruitment. David Knight and Walter Lee also provided insights and guidance on analysis of data and interpretation of results. The data collected for Manuscript 1 supported the VT-NETS program that aimed to improve transfer programming and services for transfer students at the participating university and partner community colleges.

The data collected for Manuscript 2 also supported VT-NETS as it seeks to advance our understanding of transfer enrollment and graduation in engineering in the United States. David Knight provided insights and guidance on the study's methodology, analysis of data and interpretation of results.

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Chapter One: Overview of Research

1.1 Introduction

The evolution of the public higher education system in the United States has been characterized as a perfect mess; despite haphazard, disconnected, organic development, the result has been the most extensive, diverse, and prestigious collection of postsecondary institutions in the world (Labaree, 2017). Today, at both the federal and state levels, efforts are being made to organize the robust and diverse set of public postsecondary institutions into a coherent and efficient system that will serve the vast and varied needs of the public (Bastedo, 2009). These efforts to organize the U.S. postsecondary system, in conjunction with its natural maturation process, has prompted its formation into an organizational field, or an aggregate group of organizations that produce similar services and products (DiMaggio & Powell, 1983). Greenwood, Raynard, Kodeih, Micelotta, and Lounsbury (2011) assert that the maturation of an organizational field often produces a coherent set of institutional logics, or "overarching sets of principles that prescribe how to interpret organizational reality, what constitutes appropriate behavior, and how to succeed" (Greenwood et al., 2011, p. 318). The institutional logics adopted by an organizational field play a substantial role in how member organizations behave and interact and how the system is organized.

Bastedo (2009) has found that state legislatures and governing boards rely on a clear subset of institutional logics to organize their higher education systems. One widely adopted logic is vertical differentiation, whereby institutions have been organized into distinct levels with each level assigned a particular subset of roles, responsibilities, and types of students they will serve within the system. Differentiation of organizations vertically should reduce duplication and inefficiencies in the state system while also offering a diverse array of institutions from which students can choose that best fit their individual needs and desires (Bastedo, 2009). Many states differentiate across institutions following students' varied levels of academic preparation; institutions are designed to place the most academically advanced students in research universities, honors programs, and liberal arts colleges, whereas "lower performing students will be admitted to community colleges, where they can prove their academic performance and receive instruction that is consistent with their academic preparation" (Bastedo, 2009, pp. 211-212). For example, some scholars suggest that, although states could have accommodated the additional growth in postsecondary enrollments after World War II and the establishments of the Higher Education Act in already established universities, prominent leaders in those institutions advocated for universities to be absolved of teaching lower division coursework to focus on research and scholarship interests (Cohen et al., 2014). As a result, the majority of enrollment growth occurred at community colleges, which reinforced their access role in the postsecondary system (Thelin, 2011). Most states have established three tiers of institutions: 1) research universities and liberal arts colleges that serve the most academically prepared students out of high school, 2) public comprehensive universities that focus on undergraduate and some Master's level instruction with less competitive admissions, and 3) community colleges that are open admissions and serve an access role of the postsecondary system (Thelin, 2011). Vertical differentiation occurs not just within states, but also at a national level, as evidenced by the Carnegie classification system (Carnegie Foundation for the Advancement of Teaching, 2011) and other institutional ranking systems that distinguish institutions hierarchically.

Although vertical differentiation has helped states increase efficiency and reduce duplication of their postsecondary education systems, an unintended consequence of differentiation is the emergence of organizational subfields (i.e., 2-year and 4-year institutions) with divergent institutional logics. Institutional logics exist at the macro-level of the organizational field, in organizational sub-fields, and at the level of individual organizations and they can be divergent across levels and sub-fields (Greenwood et al., 2011). When institutional logics are incompatible, they pose substantial challenges and tensions when attempting to function as a coherent macro-organizational field. One such challenge garnering substantial attention in scholarship, policy, and practice is the integration of these differentiated tiers of the postsecondary system through vertical transfer.

As previously described, 2-year and 4-year institutions serve different functions, purposes, and students in the postsecondary system by design, and thus behave differently (Cohen et al., 2014). Overwhelmingly, community colleges function with access as their primary institutional logic. For example, because any community member is to be granted access to take courses, community colleges offer many evening, weekend, and online courses with few pre- and co-requisite course requirements and are flexible to meet the needs of part-time, adult and non-traditional student schedule needs (Cohen et al., 2014). Further, recognizing the varied levels of academic preparation of their entering students, community colleges have invested heavily in remedial education programs. In contrast, 4-year institutions generally offer courses and course times that meet the needs of traditional full-time college students and offer little or no remedial coursework. Community colleges also are designed to be the most affordable option for students in the postsecondary system and thus are restricted in fiscal resources compared to 4-year institutions. This cost-efficient approach often means that community colleges can offer less academic and non-academic support services and rely more on part-time adjunct faculty to teach courses, whereas 4-year institutions generally have more comprehensive academic and non-academic offerings and have more full-time faculty (Cohen et al., 2014).

Finally, minoritized, low-income and first-generation students are more heavily represented in enrollments at community colleges compared with enrollments in 4-year institutions. Around half of all Black/African American (49%) and Hispanic/Latinx (51%), Native American (55%), and Native Hawaiian-Pacific Islander (45%) students begin their postsecondary educations at a community college; 42%, 30%, 31%, and 42% of students from those groups, respectively, start at 4-year institutions (Community College Research Center, 2019; National Academies of Engineering & National Research Council, 2012). Students from the lowest (61%) and second lowest (55%) income quintiles begin their postsecondary educations at community colleges at higher rates than their peers in the middle (44%), second highest (39%) and highest (20%) quintiles (McFarland, Hussar, Wang, Zhang, Wang, Rathbun, Barmer, Cataldi, & Mann, 2018). By embracing access as the primary institutional logic guiding their behavior, community colleges function differently and serve different students than 4-year institutions.

Unlike 2-year institutions, which seem to be uniformly guided by the access logic, the institutional logics guiding the behavior of 4-year institutions are more varied, with some that may align better with access than others. Institutional prestige is one prominent institutional logic guiding behavior for many 4-year institutions (Dill, 2005; Eckel, 2008; Melguizo & Strober, 2007; Stocum, 2013). For example, research universities generally prioritize research accolades, accrual of external grants, recruitment of highly accomplished faculty, revenue generation, accrual of endowment assets, industry partnerships, and increased selectivity of undergraduate and graduate admissions (Eckel, 2008; Melguizo & Strober, 2007; Stocum, 2013). The majority of these priorities are important factors for 4-year institutions to increase domestic and world college/university rankings (e.g., *U.S. News and World Report*), and subsequently academic prestige amongst peer institutions. Liberal arts institutions place less emphasis on research but still attend closely to accrual of revenues, endowment assets, as well as selective admissions, highlighting importance placed on academic credentials (e.g., SAT scores, class rank, number of AP/IB courses) of entering undergraduate classes (O'meara, 2007; O'Meara & Bloomgarden, 2011). Even regional comprehensive public universities, despite being the second tier of states' differentiated model of higher education institutions, may prioritize some of the same activities, a result of institutional isomorphism of the higher education industry (Eckel, 2008; Wellen, 2005), although to a lesser extent. The prestige logic, particularly when enacted through increased selectivity in undergraduate admissions, is incongruent with the access logic central to 2-year institutions and the transfer vertical transfer pathway. Integrating 2-year and 4-year institutions through vertical transfer is challenged by these contrasting logics, and the extent to which 4-year institutions are receptive to vertical transfer students may be a function of how much (or little) they rely on the prestige logic.

1.2 Motivation for Studying Transfer Receptivity

Most of the attention in scholarship and practice to improve vertical transfer has focused on the 2-year institution and the role it plays in preparing students for vertical transfer to 4-year institutions (Bahr et al., 2013). For example, Ornelas and Solorzano (2004) provided a framework for community colleges to foster a "transfer sending culture." This idea involved investment by senior administration to prioritize transfer as a goal, creation of programs that promote and facilitate transfer, requiring advising for students to prepare for transfer, expanding faculty involvement in the transfer process, and fostering more proactivity among students so that they seek out information and resources to support transfer (Ornelas & Solorzano, 2004). Their work prompted other scholarship that examined how community colleges could enhance their role in support of vertical transfer (LaSota & Zumeta, 2016; Phillips, 2004; Wyner et al., 2016). However, some scholars have argued that some onus should be shifted to 4-year institutions and the role these organizations play in helping or hindering transfer student success (Bahr et al., 2013; Jain et al., 2011; Wyner et al., 2016). Jain et al. (2011), for example, propose the need to understand *transfer receptivity*, or "an institutional commitment by a four-year college or university to provide the support needed for students to transfer successfully" (pg. 257).

Relying on critical race theory, which emphasizes the need to challenge dominant ideologies of meritocracy, colorblindness, objectivity and race neutrality (Delgado & Stefancic, 2017), Jain et al. (2011) created a model of five elements that are essential for creating a transfer receptive culture. Two of the five elements occur before students transfer to the university: 1) Establish the transfer of students, especially non-traditional, first-generation, low-income, and underrepresented students, as a high institutional priority that ensures stable accessibility, retention, and graduation, and 2) Provide outreach and resources that focus on the specific needs of transfer students while complementing the community college mission of transfer. The other three elements occur post-transfer: 3) Offer financial and academic support through distinct opportunities for nontraditional/reentry transfer students where they are stimulated to achieve at high academic levels, 4) Acknowledge the lived experiences that students bring and the intersectionality between community and family, and 5) Create an appropriate and organic framework from which to assess, evaluate, and enhance transfer receptive programs and initiatives that can lead to further scholarship on transfer students (Jain et al., 2011, pg. 258).

Although some research has focused on prior efforts to improve transfer at the university level, Bahr et al. (2013) suggest that efficacious modifications should be discipline-specific, recognizing the nuances that exist across academic disciplines in facilitating successful transfer. Accordingly, my dissertation focuses on transfer receptivity at the discipline-level – focusing on what institutional characteristics and policies relate to transfer in engineering.

1.3 Motivation for Studying Transfer Receptivity within Engineering Specifically

The transfer pathway in engineering warrants particular attention because of a convergence of national calls to expand and diversify the engineering workforce, a movement encapsulated by scholars and practitioners seeking to broaden participation in engineering (National Academy of Engineering & National Research Council, 2012). The National Academy of Engineering (2012) has underscored the importance of community college pathways to broaden participation in engineering but also acknowledges the current lack of effectiveness of the transfer pathway in engineering. Ogilvie (2014) cites the fragmented nature of scholarship on engineering transfer, although recent large data projects like Cal-PASS, CPEC, MIDFIELD, and P2P have enabled researchers to understand transfer student outcomes in engineering on a large scale, generating some positive momentum for transfer scholarship in engineering. Ogilvie (2014; 2017) summarized recent scholarship focused on engineering transfer and identified four themes: 1) transfer pathways offer potential to diversify the engineering profession, 2) engineering transfer students are heterogeneous and should not be aggregated, 3) most engineering vertical transfer pathways are not 2+2 (i.e., two years at a community college followed by two years at a university), and 4) transfer students face multiple barriers to successful transfer and degree completion in engineering.

Expanding upon this work, I adopt a slightly different approach to organize prior literature on engineering transfer as a way to frame these studies (see Table CH1-1). First, there is a collection of studies that suggest community college pathways offer tremendous opportunity for broadening participation in engineering. Second, there is a group of studies that identify challenges that need be addressed to realize the potential of the community college transfer pathway in engineering. I break each of these two main themes into sub-themes that either advance optimism for the potential of the pathway to broaden participation or acknowledge challenges that need to be addressed to improve transfer pathways.

Table CH1-1

Opportunities & Challenges for CC Pathway to Broaden Participation in Engineering

Themes	Sub-themes	Authors
Opportunities to Broaden Participation in Engineering	1) Who are engineering students in community college pathway?	Knight et al., 2014 Shealy et al., 2013 Sullivan et al., 2012 Terenzini et al., 2014 Yoon et al., 2015
	2) Understanding student motivations for starting at a community college	Brawner & Mobley, 2014 Ogilvie & Knight, 2018
	3) Effective & promising practices that support engineering transfer students	Davis et al., 2017 National Academy of Engineering, 2015 Lichtenstein et al., 2014 Mobley et al., 2012 Perez et al., 2016
Challenges to Realizing Potential of Community College Pathway to BPE	1) Successful transfer students look like FTIC students	Blash et al., 2012 Perez et al., 2016
	2) Limited & mixed results for transfer student academic performance and degree completion in engineering	Cosentino et al., 2014 Gibbons et al., 2011 Laanan et al., 2011 Laugerman, 2012 Laugerman & Shelley, 2013
	3) Extended time-to-degree completion in engineering transfer pathways	Blash et al., 2012 Packard et al., 2012 Yoon et al., 2015
	4) Complexities in vertical transfer pathways to an engineering degree	Ogilvie et al., 2015 Ogilvie et al., 2017 Ohland et al., 2014

1.3.1 Opportunities to Broaden Participation in Engineering

Several areas of scholarship suggest that community colleges can provide a viable pathway for institutions to broaden participation in engineering and for minoritized students to have increased access to engineering degrees. One group of literature has shown higher levels of representation for Black/African American students, Hispanic/Latinx students, and Native American/Alaska Native students within community college engineering students relative to the 4-year sector (Gibbons et al., 2011; Knight et al., 2014; Shealy et al., 2013; Sullivan et al., 2012; Yoon et al., 2015). For example, Knight, Bergom, Burt and Lattuca (2014) drew from a nationally representative dataset of 31 four-year engineering institutions and 15 community colleges and derived a profile of pre-engineering students at community colleges and compared them with first-time-in-college (FTIC) students (i.e., those who matriculated into a 4-year institution). In examining sociodemographic characteristics, they found that Black/African Americans comprised 20% of pre-engineering community college students and Hispanic/Latinx comprised 28%, far exceeding the relatively low (5% and 9%, respectively) levels of representation among students who started their college experiences in engineering at a 4-year institution. Several other studies examining sociodemographic characteristics of engineering pre-transfer students enrolled at community colleges found similar results (e.g., Mobley, Shealy, & Brawner, 2013; Shealy et al., 2013), thus demonstrating the opportunity of the community college pathway for broadening participation in engineering for minoritized populations.

Other studies have sought to understand why engineering students may choose to begin their postsecondary paths in a community college. One study focused on non-traditional students (i.e., older than 24 years old) in their study and found that cost of attendance, proximity of institution to their home, and flexibility in course scheduling were key factors for choosing to start at a community college (Brawner & Mobley, 2014). Ogilvie and Knight (2018) focused their research on Hispanic/Latinx students and found that finances/affordability, nonacademic commitments (e.g., financial support for family, part- or full-time work), and admissions outcomes were primary drivers in decision to start at a community college. Cost emerges as a common theme across studies and student types and remains a prominent reason why low-income and first-generation students steer away from direct-entry pathways to 4-year institutions. For example, public flagship universities, despite being well-positioned to provide its graduates with socio-economic mobility, continue to increase the cost to attend, often prohibiting low and even some middle income students and families access to attend (Mugglestone, Dancy, & Voight, 2019). This research reinforces the notion that community college pathways provide a unique and underutilized means to broaden participation in engineering.

Finally, a collection of papers advance our understanding of effective and promising practices that facilitate successful navigation through the engineering transfer pathway (Bahr et al., 2017; Cortez et al., 2015; Ogilvie & Knight, 2019; National Academy of Engineering, 2015). For example, Bahr et al. (2017) suggest that thoughtful attention should be paid to streamline curricular paths and support students with tutoring and learner-centered pedagogies to realize the opportunities for community colleges to serve as pathways to STEM degrees for minoritized students. Ogilvie and Knight (2019) asked engineering students across four institutions in Texas to reflect on their transitions and post-transfer experiences and found that students had positive perceptions of their transition experiences and their receiving institutions despite facing multiple challenges during the transition. Recently, Cortez et al. (2015) examined a co-enrollment transfer program partnership between a community college and university in Texas. Students in the program are admitted to both the community college and university, have access to a university

ID and all of the same amenities as FTIC students (e.g., library, tutoring, recreational facilities), and take courses that are all guaranteed to transfer to the university. The co-enrollment model has been highly effective at streamlining the vertical transfer process in engineering (Cortez et al., 2015). Finally, the National Academy of Engineering (2015) highlights highly effective practices for engineering transfer at several universities. For example, University of Missouri Science and Technology (UMST) maintains articulation agreements at the university level, reducing nuance in what courses will or will not transfer to certain departments or colleges. UMST also permits transfer students to transfer their grades as well as the credits from their sending institutions to give students credit for their work regardless of the institutional context. Other institutions have institutionalized transfer scholarships, and some have reduced GPA requirements during students' transition semesters to avoid penalizing students who experience transfer shock (National Academy of Engineering, 2015). These studies highlight some effective practices for supporting this pathway.

1.3.2 Challenges for Realizing Potential of Community College Transfer Pathway

Several challenges temper the potential of the community college transfer pathway in engineering. For example, despite higher representation of minoritized enrollments in engineering programs at community colleges, the racial/ethnic demographics of students who successfully transfer to a 4-year institution in engineering are similar to FTIC students (Blash, Karandeff, Purnell, & Schiorring, 2012; Perez, Yoon, Reed, and Lawley, 2016). The authors call attention to the need to improve academic and non-academic services at 2-year institutions to improve student outcomes for minoritized students in the engineering transfer pathway (Perez et al., 2016). Curricular pathways may help explain why minoritized students start the engineering transfer pathway but do not transfer; although a large proportion of minoritized students were enrolled in entry-level courses in math, chemistry and physics at the community college, comparatively fewer progressed to more advanced STEM courses (Bahr et al., 2017). Students beginning at the lowest level in a course sequence in chemistry (e.g., introductory chemistry) or math (e.g., college algebra), for example, were far less likely to advance than students who began one step up from the lowest level (e.g., general chemistry I, trigonometry). Simultaneously, white women and minoritized students of all genders were more likely to begin the sequence at the lowest level compared to their peers in the community college (Bahr et al., 2017).

Other researchers have studied the outcomes for transfer students who do matriculate to the 4-year institution in engineering, with some studies focusing on academic performance (i.e., GPA) (Cosentino et al., 2014; Shealy et al., 2013; Sullivan et al., 2012; Yoon et al., 2015) and others on degree completion (Brawner & Mobley, 2014; Gibbons et al., 2011; Mobley et al., 2013; Yoon et al., 2015). In the case of academic performance, results are mixed with some authors finding evidence that transfer students outperform FTIC students (Mobley et al., 2014), others finding the opposite (Sullivan et al., 2012), and still others finding no difference between the groups (Yoon et al., 2015). Mobley et al. (2014), relying on data from the MIDFIELD database, sought to compare transfer students with FTIC students on course performance in the same set of upper level engineering courses, overcoming the limitation of cumulative GPA which precludes transfer students from using their community college GPA as part of their cumulative GPA calculation. The authors found, in aggregate, no difference between transfer and FTIC students in GPA in those courses (Mobley et al., 2014). Even when disaggregating by institution and discipline, there were some cases where transfer students outperformed FTIC students and others where the opposite was true. More research is needed to understand transfer students' course performance post-transfer in engineering. In comparing degree production of transfer with FTIC students, some authors found that transfer students outperformed FTIC students (Gibbons et al., 2011; Yoon et al., 2015), yet others found the opposite (Mobley et al. 2014; Sullivan et al., 2012). Much like academic performance, more research is needed to understand how the transfer pathway influences engineering degree production, although there are many studies that show promise for the transfer pathway.

The findings of studies that examined time-to-degree completion for transfer students is much clearer, with the majority of research indicating transfer students take longer to graduate in engineering compared to FTIC students (Blash et al., 2012; Packard et al., 2012; Yoon et al., 2015). Even in cases where transfer students graduated more quickly than FTIC students, the time-to-degree extended well beyond the often advertised 2+2 proclamation given to students at the outset of the transfer pathway (Blash et al., 2012). Relying on data from Cal-PASS and CPEC in California, Blash et. al. (2012) found that transfer students averaged 6.5 years to complete an engineering degree, regardless of how many credits students completed at the community college prior to transfer. The longer it takes for transfer students to complete a degree in engineering, the more it will cost students, both in real costs and opportunity costs, decreasing the utility and feasibility of the pathway.

Finally, a collection of research has examined the various pathways students take to an engineering degree (Ogilvie et al., 2015; Ohland et al., 2014). In ideal form, students in the transfer pathway would begin at a community college that has clearly articulated pathways for coursework to a university partner, completing both an Associate's and Bachelor's Degree in engineering. Unfortunately, students' pathways to an engineering degree are not so clear with students often attending four or more different 2-year and 4-year institutions, some of which have no agreements on which courses will or will not transfer between them (Ohland et al., 2014). Students may experience swirl, transitioning back and forth between community colleges and 4-year institutions en route to an engineering degree. Thus, although the community college pathway presents an exciting opportunity for broadening participation in engineering, it does not come without its challenges, evidenced by these studies on engineering transfer.

1.4 Study Overview

My dissertation is organized into two studies that, in combination, will advance understanding of engineering transfer receptivity of 4-year institutions. First, I conducted a case study analysis of an articulation agreement between one university and two partner community colleges to understand how advisors, administrators, and faculty manage its implementation. More specifically, I explored how these institutional actors, serving as institutions' street-level bureaucrats (Lipsky, 2010), balance implementation of the articulation agreement with a college-level enrollment management policy, which, incongruent in purpose, collide for transfer students. By illuminating how the collision of disparate policies can be experienced negatively by transfer students in unintended ways, 4-year engineering programs may identify similar policy intersections on their own campuses that may be adjusted to enhance their transfer receptivity.

Second, I developed a new data set that brings together institutional data related to engineering transfer student enrollment and graduation in engineering. Such a data source presently does not exist and will be an invaluable resource for other researchers, practitioners and administrators interested in engineering transfer. Moreover, I explored patterns in these newly derived transfer student metrics, exploring common factors, such as statewide guaranteed transfer of associate's degrees, statewide reverse transfer, articulation agreement GPA requirements, institutional characteristics, and institutional resources, that may relate to an institution being *transfer receptive* (Jain et al., 2011) within engineering.

Table CH1-2 provides a summary of each manuscript including the research questions, data source, participants and contribution of the study.

Table CH1-2.

Summary of Dissertation Manuscripts

MS	Research Questions	Data Source	Participants	Contribution
1	1) How do academic advisors, administrators, and faculty describe having to implement colliding policies? 2) How do colliding policies influence the coursework transfer process for vertical transfer in engineering?	Interviews, Policy Documents, Institutional Data	Faculty and staff who engage with transfer students in an advising capacity at either the university or community colleges	An understanding of how articulation agreements are implemented and intersect with other institutional policies
2	1) What types of publicly available data are utilized by 4-year institutions to assess and evaluate transfer student matriculation and graduation in engineering programs? 2) How do engineering transfer student enrollment and graduation rates vary across 4-year institutions? 3) What institutional characteristics and policies relate to engineering transfer enrollments and graduations across 4-year institutions?	A composite of data from IPEDS, ASEE, and institutional data collected from institutional research websites and institutional research offices	Institutions with undergraduate engineering programs that enrolled 1000 or more undergraduate students in engineering in 2017.	A composite dataset of transfer student access and graduation outcomes with an analysis of a set of variables or factors related to transfer receptivity

1.5 Researcher Reflexivity

My interests in making the U.S. postsecondary education system more accessible, particularly for minoritized, low-income, and first-generation students, are a result of several years of experience as a higher education practitioner. During my time as a community college professional, I was exposed to the vast systematic inequities in our postsecondary education system which prompted my decision to pursue a Ph.D. so that I may become better positioned to contribute to understanding and improving an inequitable education system. As is the case in most states, minoritized, low-income, and first-generation students were over-represented at the "lower tier" community colleges and vastly underrepresented at "elite tier" institutions in the state in which I worked. Myths perpetuated about how community college transfer students were not prepared for the academic "rigor" of coursework at their receiving institutions. All too often students who had transferred to a university would return to our campus seeking support and services that were ineffective or did not exist at the universities. Some students described how they were the only minoritized student in their classes at the university and sought support from centers that serve Black/African American, Hispanic/Latinx, Asian/Pacific Islander and Native American/Alaska Native students. However, students found those services to be both tokenized and tokenizing, housed at the periphery of campus with miniscule budgets to support their efforts. Students often limited themselves to attend regional public comprehensive universities when applying for transfer, even if they were academically competitive for "higher tier" institutions, citing the prohibitive costs of tuition and fees and lack of "people that look like me" at public flagship and private institutions in the state. In summary, my pathway to a Ph.D. and to focus on this topic in particular can be characterized as a practice to research approach.

Seeking a way to contextualize these inequities from a research perspective as a Ph.D. student, I was introduced to several critical perspectives that both directly and indirectly inform these manuscripts. For example, Paulo Freire, in his text *Pedagogy of the Oppressed* (Freire, 2018), explains how institutional policies and structures systematically dehumanize and oppress minoritized members in a community. I have since used that text to engage in critical self-reflection about my positionalities, how they impact my own practices as a higher education professional and researcher, and what actions I can take to engage in praxis and develop critical consciousness. Engaging in reflexivity through Freire's frame of dialogic and antidialogic practice was a transformative experience for me, helped to contextualize my professional experiences at the community college, and grounds my research agenda as a whole.

As a community college practitioner I often found that power played a substantive role in my interactions with university practitioners. For example, conversations to improve transfer student experiences were typically unidirectional, with 4-year institution practitioners making recommendations for how to change, adjust or shift a practice, policy, or support service at the community college to align more clearly with the university. The power dynamic of these interactions was imbalanced and favored the academic prestige of universities. Often the result of these negotiations was perpetuation of the status quo of the university system, imposing change on the community college system and students. Informed by these experiences of imbalanced power, in all of my research I seek to improve the system from the perspective of a community college student and practitioner.

Unsurprisingly, then, I naturally gravitated towards scholarship informed by critical perspectives, including the transfer receptivity framework (Jain et al., 2011) and equity-mindedness (Bensimon et al., 2016; Dowd & Bensimon, 2015; Griffin, 2013). Jain et al. (2011) examined the community college transfer function through the critical race theory frame, which acknowledges the ways that systems privilege dominant ideologies and perspectives (Delgado & Stefancic, 2017). This approach counteracts the power imbalance between 2-year and 4-year institutions and implores 4-year institutions to observe transfer as "a dual commitment between both the sending and receiving institution" (p. 252). Similarly, equity-mindedness refers to a perspective adopted by practitioners who willingly call attention to personal and institutional practices that systematically privilege certain groups of students and seek out ways to make them more equitable (Bensimon et al., 2016). Both perspectives are critically based and assume that the current system is inequitable and perpetuated by existing power structures both within and between 2-year and 4-year institutions.

To summarize, my research is grounded in and framed by experiences I had as a professional at a community college. Observances of systematic inequities that students encountered during vertical transfer as well as my own experiences of unequal power in negotiations with practitioners at 4-year institutions to adjust and improve the transfer function led to my gravitation toward critical theories. Finally, by exploring transfer receptivity in engineering, I aim to expand work guided by critical race theory and advance perspectives that remedy power imbalances between 2-year and 4-year institutions in designing an effective vertical transfer system. Consequently, I acknowledge that my experiences as a community college practitioner and reliance on critical perspectives will inform my interpretation of findings. In particular, my interpretation of findings may overemphasize the roles that power, prestige, and institutional ranking play in maintaining transfer partnerships and in promoting or limiting access for minoritized, low-income and first-generation students and community college transfer students. For example, the approach of this study may overemphasize the importance of transfer pathways to improve equitable access in engineering and under-acknowledge other ways institutions are increasing access for FTIC students. I also acknowledge that my experiences as a white man of privilege, despite my epistemological and axiological stance, come with implicit bias and may have led to me insufficiently applying a critical lens. Additionally, my focus on transfer pathways and engineering might minimize other issues of power, such as co-curricular experiences. I encourage readers to consider these implicit biases and positionalities when interpreting findings for both studies.

1.6 Implications for Research and Practice

These manuscripts can advance our understanding of how the community college transfer pathway can be improved in engineering, as viewed through the lens of *transfer receptivity* of 4-year institutions. If transfer pathways within engineering can work better, a primary implication of this project will work toward increasing access and successful degree completion for minoritized students in engineering, recognizing that improvements are necessary to make it a viable, timely, and affordable pathway (Bahr et al., 2017; Ogilvie, 2014). Each manuscript makes unique contributions to our understanding of the transfer pathway within engineering.

Manuscript 1 provides an in-depth analysis of one articulation agreement for engineering between a university and two community college partners. The benefits of this depth of analysis are to examine how articulation agreements are implemented, how they impact the transfer of coursework process, and the challenges that influence their efficacy. By examining articulation policy in this way, I uncovered how other institutional policies intersect with the articulation agreement in ways that influenced its effectiveness in streamlining the transfer process. Designing articulation policies in a vacuum without consideration for other competing university policies may render them less effective. Because articulation policies are among the most frequently cited tool to improve transfer, we need to understand how they actually work in practice, not simply how they are designed to work. My research illuminated the complexities of intersecting policies and what that might mean for engineering transfer students.

Manuscript 2 advanced understanding the transfer pathway by identifying institutions that enroll and graduate high numbers of transfer students in engineering—those institutions could be characterized as being *transfer receptive*. I also looked across those institutions for shared characteristics that may be useful in generating and maintaining a transfer receptive culture. For example, is transfer in engineering more prevalent in public or private institutions? Do land-grant institutions enroll more transfer students in engineering than other public institutions without that designation? Do those institutions all exist in states with common course numbering systems regulated by the state? Does admissions selectivity relate to the extent of transfer in engineering at an institution? Does the minimum GPA required for admissions consideration into the college of engineering impact the number of transfer students entering into engineering? By highlighting institutions that successfully admit and support transfer in engineering to degree completion, I hope to identify institutional characteristics and policies that may support engineering transfer receptivity. Following my dissertation research, follow-on qualitative research could also be conducted at select institutions that enroll and graduate high numbers of transfer students in engineering to explore more specific programmatic and cultural efforts that may support them in being transfer receptive.

Finally, Manuscript 2 will benefit the fields of higher education and engineering education at large. Data collection on engineering transfer students has not been done in a systematic way across institutions. Developing a new data set will provide two benefits for future research: 1) other researchers can use the data set for analysis of transfer outcomes in engineering, and 2) combining this new data set with other existing data may identify gaps in the national datasets on transfer students as well as a starting point for recommended variables to be included in future data collection efforts by IPEDS on transfer students.

Chapter 2: Exploring impacts of policy intersections for transfer student access: Perspectives from street-level bureaucrats

2.1 Introduction

In the United States, 4-year postsecondary institutions must manage a wealth of competing interests and priorities, particularly in science, technology, engineering, and math (STEM). A complex, often-opposing set of forces is meeting national calls to broaden access for underserved, low-income and first-generation students while simultaneously enhancing financial stability and institutional rank and prestige in an increasingly competitive higher education marketplace. Community college transfer pathways offer one potential lever for institutions to increase access for underserved populations and are often bolstered through articulation agreements (LaSota & Zumeta, 2016). Simultaneously, 4-year institutions rely on comprehensive enrollment management practices to maintain financial stability and rank, despite the challenges they pose for equity and access (Hossler, 2004). In this paper, we explore how institutions balance these competing priorities, as enacted through implementation of articulation and enrollment management policies, and describe how the collision of these policies pose challenges for students and individuals who are responsible for implementing each policy.

Several concurrent movements compel postsecondary institutions to expand access. First, calls persist for the postsecondary education system to prepare a sufficient and diverse STEM workforce in the United States (Tsui, 2007). Second, the exponential rise in tuition and fees—and subsequent student loan debts encumbered by students and families to attain a postsecondary credential—have resulted in public outcry for reform the postsecondary education system to be more financially accessible (Heller, 2001). Third, a societal focus on equity and inclusion, coupled with recent admissions scandals at elite universities (Jaschik, 2019a), has called attention to postsecondary institutions' efforts (or lack thereof) to diversify and make campuses more inclusive. This challenge is particularly notable in areas such as STEM, where enrollments of minoritized students fall well behind those of White and Asian students (*Digest of Education Statistics, 2018*, 2019). The community college transfer pathway is one policy mechanism that 4-year institutions use to increase access. Community colleges have long served as a low-cost pathway for students and families and enroll a disproportionately high percentage of underrepresented minorities (URM; using a term from the National Science Foundation), low-income, and first-generation students in the U.S. higher education system (Roksa & Keith, 2008), particularly within engineering (Terenzini et al., 2014).

Community college transfer pathways are increasingly formalized through articulation agreements at the state, system, and institutional levels (Hodara et al., 2017). However, the efficacy of these policies in increasing transfer is inconclusive and varies across states and institutions (Anderson et al., 2006; Eaton, 1994; Giani, 2019; Kopko & Crosta, 2016; Roksa, 2006; Roksa, 2007). The effectiveness of articulation agreements in STEM contexts is particularly constrained by rigidity in how credits transfer between institutions, highly sequenced coursework, disagreement between faculty members about the content of foundational STEM courses, and perceptual concerns over "rigor" of pre-requisite coursework, particularly in math courses. These factors collectively lead to credit loss, ambiguous advising support structures, and credit creep (Dowd, 2012; Hodara et al., 2017; Ignash & Townsend, 2001; LaSota & Zumeta, 2016; Moore et al., 2009; Morris, 2016). This challenge is most prevalent for students who seek transfer to highly selective institutions (Hoffman et al., 2010). We know little about how these policies intersect and/or interact with other competing policies at 4-year institutions with different aims, like enrollment management.

4-year universities and colleges have institutionalized enrollment management policies and practices that enable recruitment, retention, and graduation of the students who best fit the mission and goals of the institution, and thus increase financial stability, institutional prestige, and rank (Humphrey, 2006; Natale & Doran, 2012; Snowden, 2010). Competitive admissions into academic programs is one of the most common forms of enrollment management (Hossler, 1984; Hossler & Bontrager, 2014; Natale & Doran, 2012). Among the key metrics for increasing institutional rank in postsecondary ranking systems, such as in the U.S. News and World Report, is the admission rate of new undergraduate students. Although some institutions focus on this metric institution-wide, others highlight specific academic programs with highly competitive entry to increase the program's, and simultaneously the institution's, academic social identity and rank among its peers. The arms race for academic program prestige is particularly pronounced in STEM disciplines. Enrollment management policies and practices, like those of competitive admissions, are counter-intuitive to policies and practices that increase access, like articulation agreements. Implemented in concert, the result is a collision of policy efforts; as an institution seeks progress in one area, its efforts may actually be detrimental to progress made for another, despite astute care during design and implementation of each policy independently.

In this paper, we examine what happens when articulation agreements and enrollment management policies collide for transfer students through the lenses of specific advisors, administrators, and faculty who hold the responsibility for advising students on academic matters. Serving as institutions' "street-level bureaucrat" (Lipsky, 2010; Meyers & Vorsanger, 2007; Prottas, 1978; Taylor, 2007), these particular institutional actors must play a substantial role as implementers of policies. These actors also understand the system in which the policies operate, akin to having the perspective of hundreds of transfer students who have navigated and experienced the policies directly. Although street-level bureaucrats may not have a hand in crafting policies, these stakeholders must help enact them and interface with students affected by them, which can become challenging when colliding policies work against one another in objectives. The guiding questions for this inquiry are:

- How do academic advisors, administrators, and faculty describe having to implement colliding policies?
- How do colliding policies influence the coursework transfer process for vertical transfer in engineering?

Employing a case study methodology, we engaged faculty and advisors who are responsible for advising engineering transfer students on academic matters in semi-structured interviews at a university and two partner community colleges to understand how they navigate the implementation of contrasting policies as well as the implications of the policy collision on transfer students in engineering. We complement findings from interviews with analysis of policy documents and quantitative analysis of transfer students' course-taking post-transfer.

2.2 Literature Review and Theoretical Underpinning

To understand the transfer of coursework process, we first summarize literature regarding articulation agreement policies and their impacts on community college and university transfer partnerships. Next, we detail previous scholarship on university enrollment management policies and practices. Finally, we discuss the role of street-level bureaucrats in policy implementation.

2.2.1 Articulation Agreements

Although articulation agreements between institutions have existed since the early 1900's (O'Meara et al., 2007), state involvement has grown substantially in the past 30 years to streamline transfer of coursework processes through the implementation of statewide agreements

(Kisker et al., 2011; LaSota & Zumeta, 2016; Montague, 2012; O'Meara et al., 2007; Zinser & Hanssen, 2006). Research on articulation policy has focused primarily on their design, implementation, intended outcomes, and efficacy (Montague, 2012; O'Meara et al., 2007). Research on efficacy has found mixed results, with some studies indicating transfer students: 1) perform on par with FTIC students in terms of grade-point average (Garcia Falconetti, 2009); 2) have better graduation outcomes if they transfer through an articulation agreement (Kopko & Crosta, 2016); and 3) are more likely to transfer vertically if they live in a state with a blanket articulation policy across all public institutions (LaSota & Zumeta, 2016). Other research has shown that articulation agreements had no effect on increasing the prevalence of transfer (Roksa & Keith, 2008) or successful completion of bachelor's degrees after transfer (Garcia Falconetti, 2009; Huffman, 2012). Considered collectively, there is ample evidence that suggests that the effectiveness of articulation policies depends heavily on state or institutional contexts. This finding suggests that the structure and design of the policies may differ across contexts and should be examined more closely to understand the actual influences of those policies.

Roksa and Keith (2008) took a broad approach and examined policies across all 50 U.S. states to understand the intended outcomes of state articulation policy. They found the majority of articulation policies made no mention of increasing the prevalence of transfer and instead focused on the preservation of credits for students who do transfer. Similarly, other scholars have attempted to characterize articulation policy across states, systems, and institutional levels. For example, Kisker, Wagoner and Cohen (2011) conducted a detailed analysis of policies across four states (Ohio, Arizona, New Jersey & Washington) and found seven common curricular/policy elements to support transfer: 1) common general education package, 2) common lower-division pre-major and early-major pathways, 3) credit applicability, 4) students granted junior status upon transfer, 5) guaranteed and/or priority university admission, 6) associate/bachelor's degree credit limits, and 7) acceptance policy for upper-division courses. These conclusions support Roksa and Keith's (2008) findings that most articulation policies are designed to preserve credits across institutions, as only the fifth element, guaranteed and/or priority university admission, seems to emphasize prevalence of transfer.

Other scholars have sought to understand what barriers impede the influence of articulation policy on transfer, both in terms of preservation of credits and increasing prevalence of transfer. Hodara, Martinez-Wenzl, Stevens, and Mazzeo (2017) developed a cohesiveness continuum for articulation policy, ranging from tightly coupled 2+2 arrangements (system-wide) to loosely coupled arrangements between institutions for specific programs (institution-driven), to understand how different policy designs influence preservation of transfer credits and prevalence of transfer. They found that system-wide policies provided the clearest transfer pathways to credit equivalency and timely degree progress, whereas institution-level arrangements were cumbersome and lacked clarity. Across all articulation policy designs, however, they found that student uncertainty of major as well as limited advising capacity, particularly at the community college, negatively influenced policy outcomes. This finding suggests that lack of on-the-ground resources may inhibit the effectiveness of articulation policy, regardless of its purpose and design.

Finally, Montague (2012) detailed challenges of managing articulation agreements, particularly broad-stroke policies, which often fall short because of prejudices held between 2- and 4-year faculty, the multi-purpose nature of community college courses (e.g., transfer pre-requisite, core requirement for a terminal degree, certificate course), and student major uncertainty. Thus, articulation policy may fall short of bolstering transfer student outcomes because it may become derailed by other institutional actors, structures, and policies that exert influence during implementation. The nature of this derailment needs to be better understood. Our research fills a few notable gaps in articulation policy literature. First, to better understand how these policies are actually interpreted and implemented, we engage with street-level bureaucrats who are charged with implementing articulation policy. Second, a benefit of a close-up street-level perspective within a specific context is the ability to examine how 4-year institutions balance implementation of articulation policy alongside other institutional interests that may act as a conflict, such as enrollment management. Such a focused approach within a single context complements prior larger-scale studies of articulation agreements and provides a unique, more nuanced understanding of policy implementation.

2.2.2 Enrollment Management

An emerging finding in our exploration of articulation agreements is their interaction with enrollment management policies. With the emergence of a competitive academic marketplace, institutions have adopted strategic enrollment management practices and policies to maintain financial stability and academic rank. Snowden (2010) finds that enrollment management practices and policies have become institutionalized and professionalized within 4-year institutional structures, and are powerful influencers on organizational decision making and spending priorities. The main goal of enrollment management is to develop a unique identity and brand through student enrollment and marketing (Hossler & Bontrager, 2014), and enrollment management practices exist across many parts of an institution including recruitment, admissions, financial aid, selective enrollment, marketing and branding (Natale & Doran, 2012). Humphrey (2006) found that in addition to enrollment management being critical for maintaining financial stability, the policy also bolsters institutions' ability to grow endowments, enhance academic reputation, and increase in academic rank.

The most prevalent enrollment management efforts discussed in the literature include tuition discounting, spending on recruitment and marketing, and selective enrollment (Hossler & Bontrager, 2014). Tuition discounting involves a shift to merit-based aid practices whereby institutions offer attractive aid packages to the students with the most competitive admissions application package (Hossler, 2004; Natale & Doran, 2012). Institutions also may increase spending on recruitment of highly qualified students, marketing, and branding (Natale & Doran, 2012). The impacts of increased spending on enrollment management has negative implications for equitable access for underserved students and has been explored by several scholars (Natale & Doran, 2012; Hossler & Bontrager, 2014). Finally, institutions can increase prestige and academic social rank through increased selectivity of enrollment, both into the institution and into specific academic programs (Frank, 2004; Hossler, 2004; Natale & Doran, 2012). Some elite universities have low acceptance rates institution-wide, whereas other 4-year institutions instead only have certain academic programs or colleges that are highly ranked or wield prestige in the professional marketplace for their graduates. In this latter case, colleges within a university may use enrollment management policies to restrict enrollment flow into specific degree programs. This scenario is the case in our study, as the college of engineering utilizes an enrollment management policy to restrict enrollments into degree-granting engineering majors based on academic performance.

Although enrollment management supports institutions' efforts to enhance their brand and academic identity, other scholars have highlighted the subsequent detriment to college access (Hossler, 2004). Tuition discounting, for example, involves a shift away from need-based aid packaging to merit-based aid funding, thereby supporting students who already have the means to afford college (Hossler, 2004). Investments in recruiting high-scoring students siphon money from efforts to increase diversity of enrollments on campus (Natale & Doran, 2012). And increasing the selectivity of academic programs, much like systems to distribute merit-based aid, typically relies on students' performance on standardized tests, course performance, and completion of certain courses to determine eligibility. Underserved, low-income, and first-generation students are more likely to underperform on these entry metrics compared to high- and middle-income white students, thereby perpetuating inequities in the postsecondary education system (Carnevale & Strohl, 2013).

In thinking across seemingly contrasting policies, an institution will be forced to decide how to balance investments between enrollment management practices and its efforts for supporting equitable access through policies like articulation agreements. Because street-level bureaucrats serve on the front lines as policy implementers, they play a particularly critical role in representing the institution to students in how it chooses to balance competing needs and policy interests. In cases where policies intersect or overlap, as is the case in our study with articulation and enrollment management policies, front line faculty and advisors are forced to make on-the-ground decisions about how to apply each policy.

2.2.3 Policy Implementation and Street-Level Bureaucracy

Individuals involved in the first three phases of policy-making (i.e., agenda setting, policy formulation, and policy adoption) rarely are involved directly in implementation, a job often carried out by administrators on the ground (Dunn, 2015, p. 43). We consider this fourth phase of the policy-making process in our study, particularly with respect to articulation policies coming into conflict with enrollment management policies at the implementation phase. To describe the role that front-line administrators have in carrying out policies and procedures, Lipsky (1969) coined the term "street-level bureaucrat," which is the theoretical lens that grounds our analysis. Prottas (1978) further explored the unique positioning of street-level bureaucrats as boundary actors between an organization and its clients, suggesting that they accrue power and control as the only member with simultaneous access to information of the organization and client. Hudson (1989) suggested that street-level bureaucracy has been underutilized as a theory to explain policy implementation and how street-level bureaucrats make decisions during implementation.

In one of a few examples where street-level bureaucracy is used to explain how policies are implemented, Loyens and Maesschalck (2010) linked the theory of street-level bureaucracy with ethical decision making. They found that street-level bureaucrats often face role strain during policy implementation, where they must balance their role as employee of the organization and also act in support of the client. Despite developing routines for decision making based on client characteristics, Loyens and Maesschalck (2010) found that street-level bureaucrats were often left with inescapable dilemmas of competing needs that were impossible to reconcile and, as a result, were coerced to act with discretion.

In examining the behaviors of street-level bureaucrats, several authors have found that the implemented policy often deviates from prescribed or intended policy, a phenomenon coined as street-level divergence (Brodkin, 2003; Lipsky, 1980; Maynard-Moody & Musheno, 2000). For example, caseworkers in Chicago welfare offices distorted implementation of a federal caseworker policy by adjusting the content of casework meetings. Brodkin (2003) describes how doing so allowed caseworkers to meet federal quotas to continue receiving funding. Although perverse external accountability demands are one cause for street-level divergence, it can also result from policy ambiguity, changes in organizational practice, or multiple stakeholders being impacted from complex decisions about implementation (Brodkin, 2003; Gofen, 2013; Hill, 2005; Lipsky, 1980). The complexity of meeting divergent stakeholder demands plays a significant role in the emergence of street-level divergence during policy implementation.

Gofen (2013) expanded prior work on street-level divergence by examining policy implementation within contexts of teachers, nurses, and social workers. He found that divergence could be categorized in three ways: 1) transparent versus concealed divergence, 2) self-serving versus other-serving divergence, and 3) individual versus collective divergence. In the first case, street-level bureaucrats chose to label explicitly their divergence from stated policy to stakeholders, particularly to clients, or to adjust policy during implementation without disclosing their adjustments to the policy. In the second instance, street-level bureaucrats acted either within their self-interest and adjusted policy to make it easier to operate in support of competing stakeholder needs, or made adjustments that best suited the needs of the clients they served. Third, Gofen (2013) found that divergence could occur either on the individual level with certain street-level bureaucrats shifting policy at implementation, or it could occur across a collection of colleagues working to enact adjustments together. These findings provide a framework to examine how street-level divergence occurs within organizations and how that divergence can influence policy implementation.

In our study, we extend prior research on policy implementation by examining how street-level bureaucrats manage implementation of two converging policies. Prior research points to the complexities that street-level bureaucrats encounter in trying to meet the needs of multiple competing stakeholders. However, there is little research on the influence of managing multiple policies that are dissonant in purpose but impact the same clients, a notable contribution of this study. Another contribution of this study is that, to our knowledge, street-level bureaucracy and divergence have not been examined within the postsecondary education context. We seek to understand how street-level bureaucracy can be used to explore actions of academic faculty and advisors who implement policies on the ground for postsecondary institutions.

2.3 Data and Methods

We explore the collision of policies through semi-structured interviews with faculty and academic advisors in a case study of a partnership between the College of Engineering at a mid-Atlantic research university and two community colleges located within the same state. A case study approach can answer "how" and "why" questions, and when context is relevant to and challenging to discern from the phenomenon under study (Baxter & Jack, 2008). Thus, our use of case study methodology allowed us to conduct an in-depth analysis of how institutional actors enact and implement policies within a specific articulation agreement context. Interview participants included faculty and advisors at each institution who are responsible for engaging with engineering transfer students in a professional advising capacity. In effort to triangulate our findings from interviews with participants, we also collected data from policy documents, institutional webpages that contained information about each policy, and institutional course-taking data for transfer students. We describe each of these research processes in the following sections. In-depth descriptions of the institutional and college contexts as well as the policy contexts follow the Data and Methods section.

2.3.1 Data Collection and Participants

We engaged faculty and advisors in semi-structured interviews to explore their experiences managing implementation of colliding policies in engineering. We complement interview data by analyzing documents that detail the articulation agreement and enrollment management policies and analyzing university course-taking data of transfer students.

2.3.1.1 Interview Data

All College of Engineering (COE) faculty and academic advisors who engaged with transfer students in an advising capacity at the 4-year university were invited to participate. This population included professional advisors, administrative professional faculty who advised transfer students, administrators who coordinated transfer within the COE, and community college faculty who also were responsible for advising transfer students. We conducted a total of 26 interviews, 21 with university academic advisors and administrators across 12 of the 14 (86%) university engineering departments, and five with community college faculty responsible for advising engineering transfer students at two community colleges. All of the participants at the university were within academic affairs in the COE. The professional role and title of department advisors at the university varied, with some classified as administrative, others as administrative/professional faculty, and others as faculty who had specific responsibilities around student advising (separate from teaching responsibilities). We use the following methodology to distinguish the professional roles of participants throughout the paper: community college engineering faculty who also advise students are listed as “faculty”; staff within the COE are labeled as “administrators,” except for the transitional advisor; and the transitional advisor within the COE and all other participants serving as advisors within engineering disciplines are labeled as “advisors.” We use “participants” when referring to the entire participant pool. More details about the professional roles of participants and the organizational structure of the university are provided in the institutional and college contexts.

Although indirectly involved in implementation of colliding policies at the university, incorporating the perspectives of community college faculty was critical for understanding implications of the collision on the outcomes of the articulation agreement between the university and the community college partners. We acknowledge that the community college perspective is underrepresented relative to the numbers of university perspectives in the participant pool. The participating community colleges had far fewer faculty who worked with prospective engineering transfer students; the participants included in this study account for most of the faculty advisors in engineering across the two community colleges. Based on interviews with these faculty, we determined that advising generalists at the community college would not have sufficient understanding of engineering pathways to merit inclusion in our sample.

The interview protocol was approved through the Institutional Review Board, and all participants provided informed consent. Interview questions were adapted from a previous study on transfer students (Ogilvie & Knight, 2018, 2019) and customized by a team with relevant professional experience and research expertise with transfer students, community colleges, and transfer of coursework processes. Interviews explored five primary areas of the transfer of coursework process: 1) how students receive information on transfer of coursework prior to transfer, 2) the role of academic faculty/advisors in the course transfer process, 3) the application of transfer articulation agreements in practice, 4) perceptions of academic preparedness of incoming transfer students, and 5) how transfer of courses and variation across academic programs influence transfer student success. The full interview protocol is provided in Appendix A. The use of semi-structured interviews provided consistency through a prescribed set of questions addressed to all participants while also allowing flexibility to engage in robust discussion (Corbin et al., 2014). Interviews lasted 45-60 minutes and were audio-recorded and transcribed for coding and analysis. All interviews were conducted in person with one interviewer and one participant.

2.3.1.2 Policy Documents & Institutional Data

A characteristic of case studies is the use of multiple data sources to gain a more comprehensive understanding of the context under study (Stake, 2006; Yin, 2009). We complemented interview data with policy documents. Collecting and analyzing the articulation agreement and enrollment management policy information corroborated findings from interviews about the purpose or intentions of each policy. This information was posted on university and community college webpages.

Finally, to corroborate interview and document data, we analyzed institutional data on student course taking post-transfer. In doing so we were able to understand what courses students took at the university post-transfer and understand, tangentially, how each policy and their collision may influence students' course taking patterns. A data access agreement was established with the university's data steward to access student-level course-taking data at the institution. This quantitative dataset included records of all courses taken by engineering transfer students between Fall 2009 and Fall 2016 semesters at the university (n = 2,208 students). By using multiple types of data, we were able to triangulate findings from interviews on how these policies influenced students' course-taking immediately following transfer.

2.3.2 Data Analysis and Quality

Data analysis was conducted in three phases. First, we used thematic analysis (Corbin et al., 2014) of transcribed interviews to explore how faculty and advisors implement colliding policies and how that management process influences the transfer of coursework process. The first round of thematic analysis involved descriptive coding (Saldaña, 2015) by a member of the research team using NVivo coding software. To validate the quality of the initial codes generated through thematic analysis, a second research team member selected a random subset of transcribed interviews and generated descriptive codes, which were then used to refine the initial codes generated by the first research team member. The research team then engaged in peer auditing, looking across themes to identify codes relevant to the research questions addressed in this study.

Three descriptive codes were most salient and were selected for a secondary round of focused coding: *Articulation Agreements*, *Enrollment Management Policy*, and general discussion of *Other Policy*. Seeking a more nuanced understanding of these codes, the research team engaged in a second cycle of coding which included a blend of focused and evaluation coding (Saldaña, 2015). The combination of focused and evaluation coding enabled us to capture a more detailed understanding of participants' on-the-ground experiences with each policy, including their perceptions of the effectiveness and impacts of the policies on the transfer process. Table MS1-1 provides a summary of frequency counts of the occurrence of the focused codes with a count of sources (i.e., participants) for each code. Finally, the research team consolidated findings from descriptive, focused and evaluative codes and identified themes related to each policy and their intersection.

To triangulate descriptions from the participant interviews, we generated a protocol to conduct a document analysis of the articulation agreement and enrollment management policy. The protocol involved a systematic and iterative review of each policy examining the following elements: 1) purpose, 2) requirements, and 3) benefits and/or intended outcomes. Lastly, we conducted a descriptive analysis of entering transfer students in engineering including student demographics. We also examined the types of courses in which transfer students enrolled during their first two semesters post-transfer.

Table MS1-1

Frequency Counts of Focused and Evaluation Code Mentions and Sources

Descriptive Code	Focused & Evaluation (+/-) Code	# of Sources	# of Mentions
Articulation Agreement	AlignmentofCourses_-	21	153
	Partnerships	17	92
	Perception_+	20	82
	AlignmentofCourses_+	20	79
	RigorofCourses_-	18	68
	GeneralInformation	18	52
	CurriculumCommitteeProcess	16	47
	Perception_-	15	47
	ASDegree_TechnicalCourseOverload_-	14	34
	StudentParticipationLevels	9	30
	RigorofCourses_+	10	24
	NonVCCSTransfer	4	13
	ConfusingLegalese	2	6
	OnlineCourses	2	6
	PoorTimingforAdmissions	2	4
	Remedial_Nontransferable	1	3
	NoAgreementAvailable_OutofState	2	2
Enrollment Management Policy	Advising	16	124
	ImplicationsforStudents_-	19	109
	Process	10	71
	Justification	10	42
	Requirements	11	39
	ImplicationsforStudents_+	13	34
Other Policy	ClemencyRules_-	4	9
	ExceedCreditLimit	3	8
	FallAdmissionsOnly_-	1	3
	CourseWithdrawals	1	2
	DeansOfficeImplementation	1	2

All courses taken by a transfer student in their first two semesters post-transfer were collated into three groups: 1) elective courses, 2) foundational pre-engineering non-major courses, and 3) discipline in-major courses. We then compared percentages of enrollment by transfer students in each group during their first two semesters post-transfer, which helped us to triangulate the impacts of colliding policies on transfer student's course enrollments. We also examined transfer students' performance (i.e., GPA) in courses during their first semester post-transfer to understand the scope of students impacted by the collision of policies.

2.4 Institutional and College Contexts

The university of focus in our study is a historically white, predominantly white, 'more selective, very high research activity,' land grant institution. Classified as a 'lower transfer-in' university, around 17% of all new enrollments annually are transfer students, with a lower percentage (14%) of transfer students entering engineering. Engineering is the most prestigious college at the institution and houses the largest percentage of undergraduate enrollments. However, entry into many of the engineering disciplines is competitive. The institution has 14 engineering departments that enroll around 8,000 total undergraduate students annually. The college admits around 300 transfer students annually, the majority of whom come from the state's community college system. For the Fall 2019 entering class of new engineering transfer students (n = 344), 15% were women, 2% were veterans, and 27% were first-generation. Further, 16% were from minoritized race/ethnicity backgrounds, excluding Asian (30%). Asian students are not included in this aggregate racial group as they are overrepresented in science and engineering relative to their population representation (National Science Board, 1987; Burke & Mattis, 2010). We recognize that important distinctions exist amongst different racial and ethnic sub-groups of Asian students and that not all Asian students are overrepresented—however, the aggregation of data reported at the institutional level does not enable a more nuanced and critically-minded construction of the minoritized variable (Museus & Kiang, 2010).

We focus this paper on the college of engineering for three reasons. First, national calls persist to increase the number and diversity of graduates in engineering, which subsequently led the institution to invest substantial amounts of money toward the efforts of these colleges. Second, engineering is historically difficult for students to navigate as a transfer pathway because of sequential and credit-heavy nature of the curriculum, and so the field serves as a useful case study that has known barriers to transfer success. Third, the grant that supported this research sought to bolster this engineering transfer pathway, and this policy analysis is a way to improve that system.

The advising structure students encounter during the transfer process is multi-layered with several hand-offs between departments at both the community colleges and the university. By design, new students at the community college are first assigned a generalist advisor out of a centralized advising office at each community college. Upon declaring a major, students are then assigned a faculty advisor within the engineering department at each community college. This faculty member interacts with students by teaching courses in the discipline and also serves as students' academic advisor through the transfer process – all five community college faculty advisors in this study are referred to as "faculty" throughout this paper. As students begin their transitions to the university, they interact with a staff member in the administrative office of the COE. Among other roles, this person serves as the recruiter for community college transfer students from the state system – this and other COE staff participating in our study are labeled as "administrators." Once students are admitted to the institution and pay their matriculation fee, they are assigned to a professional transitional advisor housed within the administrative office of the COE or to a professional academic advisor within the general engineering program. These advisors also advise FTIC students during their first year at the university. Once students fulfill the requirements set forth by the enrollment management policy, students are then handed off to an academic advisor within a degree-granting discipline based on their major. At the 4-year institution, the professional academic advisors hold the titles administrative/professional faculty or Professor of Practice. We use the term “advisors” in this paper to refer to this final collection of participants because the institution considers advising responsibilities as separate from teaching.

2.5 Policy Context

The establishment of articulation agreements between the university and its state community college partners are linked with negotiations between the university and the state around a range of issues related to autonomy (Leslie & Berdahl, 2008). The creation of articulated pathways for engineering was not state-mandated and was built by the college of engineering in collaboration with the state’s community college system. The historical context around crafting the articulation policy at the university is not formally documented. Based on current practices at the institution regarding formalization of policy, creation of the articulation agreement may not have involved all departments within the COE and may have involved a voting process by members on a committee. Currently, administrators in the COE central office represent the university in formal negotiation of the transfer articulation agreement with the SCCS. The articulation agreement between the COE and the state community college system (SCCS) outlines a prescribed set of courses, minimum grade-point average (i.e., 3.2), and completion requirement of an Associate of Science (AS) degree for guaranteed admission into the university’s COE. The policy aims to facilitate a seamless transition for students from the community college to the university, a goal outlined in the official document detailing the agreement:

> The University’s COE and SCCS, recognizing the need to facilitate the transfer of students from the community college to [University] resolve to adopt a Guaranteed

> Admissions Agreement (GAA). [University] provides special opportunities to help [community college] students experience a smooth transition.

By meeting the requirements set forth in the agreement, the primary benefits for students are guaranteed admission into the college of engineering at the university, access to a community college and university contact who can direct students to departmental faculty and advisors who can help students understand requirements for various majors at the university, completion of the university's general education course requirements, and access to scholarships specifically for GAA and SCCS students. This articulation agreement is best characterized as an institution-level (institution-driven) agreement (Hodara et al., 2017); a detailed description of these types of articulation agreements is provided in the literature review.

After gaining admission to the university through the agreement, students are admitted into general engineering, a non-degree-granting program. To enter a degree-granting major within the COE (e.g., mechanical engineering or civil engineering), students must meet the requirements of the enrollment management (EM) policy. The EM policy was formalized between 2010 and 2012, a period of growth for the university and is believed to have served as a mechanism for "equitable" distribution of incoming students into engineering programs. The EM policy is best characterized as a policy that restricts enrollment flows into disciplines (Hossler & Bontrager, 2014). Based on findings from interviews, the process of creating and institutionalizing the policy was informal and driven by an ad hoc committee. Thus, like the articulation agreement, the process of formalizing the EM policy is not formally documented. The EM policy was created more than a decade after the articulation agreement and thus may have involved a largely different group of actors, offices, and departments in its creation. Currently, formal decision-making authority for the EM policy is shared across degree-granting engineering disciplines and is enforced by the general engineering department. The decision makers for the EM policy are not necessarily the same institutional actors that manage the articulation agreement in the COE.

The EM policy requires that transfer students complete 12 GPA-bearing credits at the university at a minimum grade-point average (3.0) to gain admission into the degree granting major of their choice. Students need to meet a minimum GPA of 2.0 for eligibility for any degree-granting program. Unlike the articulation agreement, the official document outlining the enrollment management policy does not include language explicitly specifying the purpose or intentions of the policy. The webpage containing the admissions process for the College of Engineering includes the following language:

> Once accepted to the College of Engineering, first-year and transfer students are admitted to the general engineering major, housed in the [General Engineering Department], where a major focus is allowing students the opportunity to explore the 14 degree-granting majors available at [University].

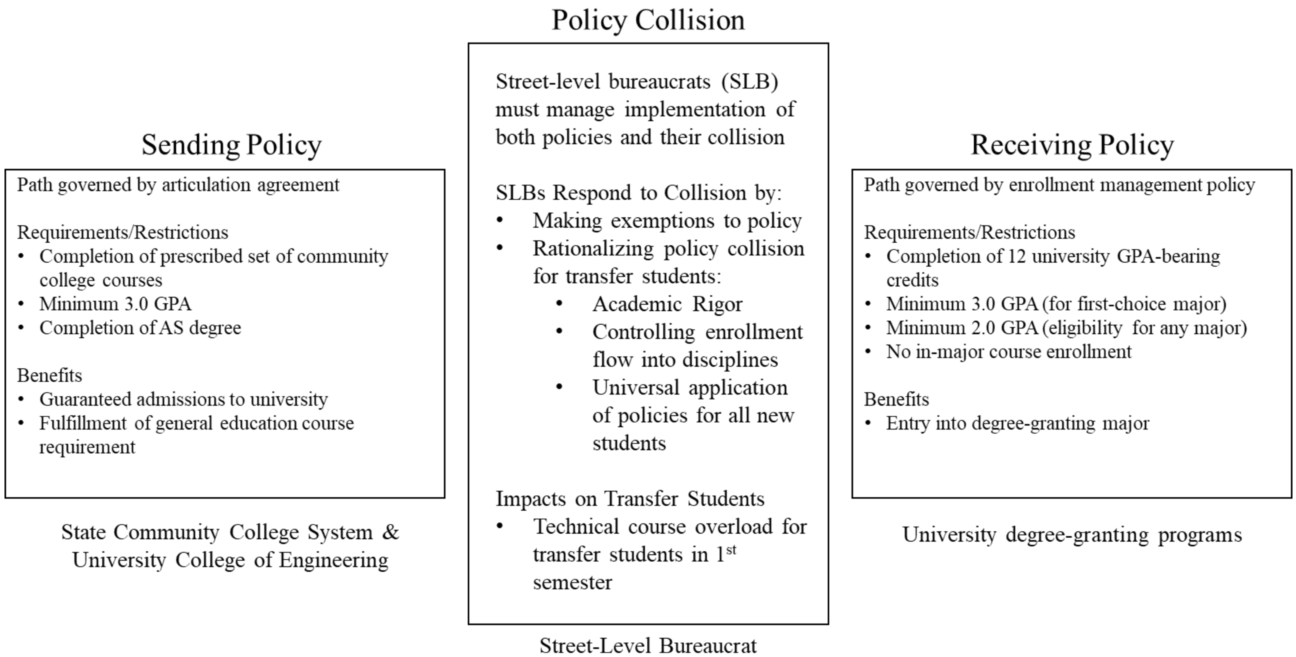
Understood in isolation, each policy serves a purpose. The articulation agreement explicitly expands access into engineering programs for transfer students through the community college path. The agreement outlines a set of requirements that, if met, result in students' guaranteed admission, completion of the general education course requirements, and access to scholarship opportunities specifically allocated for transfer students. The enrollment management policy, instead, funnels all new students, including transfer students, into a general engineering department to allow students to explore major options and to require students to take university courses and meet a GPA requirement before applying for a degree granting major. Although less explicit in purpose and function than the articulation agreement, the enrollment management policy acts to control enrollment flows into disciplines.

2.6 Results

Exploring the collision of an articulation agreement and an enrollment management policy sheds light on the systematic complexities that occur for faculty and advisors responsible for implementing and enforcing both policies, as well as the implications on students who confront those colliding policies. We find that the articulation agreement functions as a *sending policy* designed to support transfer students as they transition to a university in engineering, whereas the enrollment management policy functions as a *receiving policy* to coordinate enrollment flows into disciplines. Although both policies are distinct in purpose and are not designed with intersection in mind, these policies collide for transfer students and for the street-level bureaucrats charged with implementation. We find that street-level-bureaucrats, as implementers of both policies, simultaneously must facilitate the gateway for access for transfer students as outlined through the articulation agreement and serve as the gatekeeper to restrict access and preserve prestige through enforcement of the enrollment management policy. The following sections detail several themes that emerge from the collision of these policies (Figure MS1-1).

Figure MS1-1

Policy Collision of Sending and Receiving Policies



2.6.1 Managing Policies as They Collide

Our analysis of interviews with street-level bureaucrats identified multiple themes. First, faculty and advisors modify parts of policies so that they work in better alignment during implementation. Next, we discuss rationalization processes that emerge as advisors, faculty and administrators grapple with dissonance caused by the policy collision. Finally, we detail how the collision of policies negates some of the benefits included in the design of the articulation policy.

2.6.1.1 Exemptions: Street-Level Divergence in Response to Dissonant Policies

During the policy collision period, the majority of university advisors and administrators interviewed (16 of 21; 76%) described making modifications to parts of the enrollment management policy, often referred to by participants as "exemptions." Specifically, university advisors and administrators enact modifications to the policy during implementation so that it comes into better alignment with the articulation agreement. By design, transfer students who complete their associate's degree in engineering before transfer often have completed most or all of their foundational core coursework (e.g., math, physics, chemistry). Also, by virtue of the articulation agreement, these students have satisfied the general education requirement for the university. Thus, when students arrive to the university via the articulation policy, they should be positioned to take courses within a degree-granting department because they have completed pre-requisite courses. However, the EM policy restricts any student from taking a course within a degree-granting major or discipline until they have completed 12 credits at the university with a minimum 3.0 GPA. Consequently, transfer students encounter an EM policy that does not allow enrollment into in-major courses during their first semester. University advisors and administrators, acting as street-level bureaucrats, are left to make decisions about how to enforce the EM policy while simultaneously upholding the benefits of the articulation agreement policy.

In response, advisors and administrators have enacted exemptions to the course-taking restriction portion of the EM policy for transfer students. This type of exception is not made for FTIC students who also must abide by the EM policy during their first year at the university. One advisor details the exemption made exclusively for transfer students:

> That's a policy that we do have internally that no one knows about except for transfer students and advisors who work with transfer students in our college . . . we do not allow a first-year student to take discipline-specific courses that are major restricted until they're in the major, but we do allow new transfers to take discipline-specific courses before being officially admitted.

Without this unofficial exemption, an advisor often is challenged to find courses for students to take in their first semester after transfer, which can hinder students' timely progress to degree. An advisor highlights how the exemption has removed a barrier for transfer students: "I think because of the work we've done with the departments to gain access into the major level classes, I really don't think it's a hindrance to most students." The adjustment of the policy is temporary and is reinstituted for transfer students immediately after their first semester:

> If you don't get into [specific engineering major] at the end of fall, then you can't take that [engineering major] spring class because you're not in the major. That's part of our

> enrollment management . . . we are busting at the seams. We cannot continue to allow non-majors in our classes, but we do make that flexible for our first time enrolled transfer student.

The collision of the benefits outlined for students who transfer using the articulation agreement is not well aligned with the EM policy restriction that precludes students from taking upper level courses prior to being admitted into a degree granting major. As participants grapple with competing policies, they exhibit agency and engage in street-level divergence (Lipsky, 1980) by modifying the EM policy to align with the benefits of the articulation agreement.

The override process is quite common; in examining students' course-taking data during their first semester at the university (Fall 2009–Fall 2016), we find that 42% of courses (n=12,663 courses) taken by transfer students in their first semester at the university are within a degree-granting engineering major department that would have required an exemption by an advisor. By design, transfer students are no longer exempt from the major restriction portion of the EM policy after their first semester when it is perceived by faculty and advisors that the policies no longer interfere with one another. There is some evidence, however, that the exemption may be extended beyond the first semester for some transfer students who do not meet the minimum GPA or credit completion requirements set in the EM policy to matriculate to a degree-granting major. 32% of courses taken by students who remained in General Engineering into their second term (34% of transfer students) are in-major courses that would require an extension of the exemption to the policy. These findings do not align with findings from interviews; advisors made no mention of extending the exemption that allows in-major course taking for transfer students who remained in General Engineering beyond their first semester. It could be that advisors were reticent to share examples where they extended the exemption for students beyond the 1^{st} semester because doing so runs counter to the prestige logic of the EM policy to restrict enrollments only for the most academically prepared students. Alternatively, it could be that advisors did not share their entire experience in interviews. Regardless, this discrepancy is notable and worth further investigation.

2.6.1.2 Policy Justifications: Making Sense When Policies Don't Make Sense

To reconcile dissonance between and communicate the purposes for the articulation agreement and enrollment management policies to students, participants engaged in a rationalization process, generating varied policy justifications that may or may not mirror the original intents. Advisors described feeling stuck between the two policies during implementation and, particularly when confronted with frustration from students, were compelled to justify why transfer students were subject to misaligned policies. We discuss three frequently used justifications generated by participants in this rationalization process: 1) academic rigor of university engineering, 2) distribution of enrollment flows into disciplines, and 3) equitable policy implementation for all students.

2.6.1.2.1 Academic rigor of university engineering

Several university advisors and administrators pointed to "academic rigor" as the justification for incorporating transfer students into the EM policy. This rationale was pervasive, emerging in conversations with 16 of the 21 (76%) university participants across nine departments. Despite the articulation policy guaranteeing university admission for transfer students, students must also meet the separate GPA requirement (3.0) in their first semester at the university for guaranteed entry into a degree-granting major of their choice. When asked by students why there are two separate GPA requirements, university advisors and administrators often attribute the requirement to the desire to ensure students are prepared to withstand the university's academic rigor: "the committee on enrollment management made a decision . . . that indicated that they wanted an actual university GPA before they would allow a student to go into a major. My assumption it's to show proof that a student can withstand the university rigor when they transfer." Another advisor suggested that the policy helps the university mitigate concerns about how community college coursework prepares students to be successful at the university:

> Then the 12 hours came about because we really thought these transfer students, they have a 3.5 at their institution, but we don't know how their institution rigor compares really to [University]. We want them to have a solid number of hours here. That's what we'll make our evaluation on if they're competitive for their major they're wanting to go into.

One advisor felt the justification of rigor for enrollment management policy was a university-wide theme, although most stringent in engineering:

> You have to prove to us that you can do [University] work. Right or wrong, that's kind of the direction that we've gone. I don't know that that's engineering specifically. I think that is across the university. However, we have the most stringent enrollment management plan.

Although widely prevalent, justifying the enrollment management policy based on the argument of rigor was not a unanimous belief. One advisor held a contrasting view, expressing concern for the potential implications that using "rigor" as a justification may have for incoming transfer students:

> I've heard colleagues say things like, 'Yeah, you have to take 12 credits to prove to us that you can be successful in engineering.' I think that is what is concerning because I can see how [students] perceived [it] that way and then if we have folks actually saying those words, then that's trouble too.

Although not explicitly stated in its purpose, advisors and administrators at the university commonly expressed their belief that academic rigor was the primary function of the enrollment management policy. Other participants have expressed concern with how making sense of policies in this way, and communicating that justification to students can influence transfer students' perceptions of their transition experiences to the university in terms of entering an unwelcoming environment.

2.6.1.2.2 Controlling Enrollment Flows into Disciplines

Another justification that emerged from participants' rationalization process was the need for the college to control enrollment flows into departments. This justification was less prevalent than the rigor rationale, but still emerged in interviews with seven (33%) university participants across six departments. One advisor explains:

> What the college was seeing was there were certain majors . . . at that time, it was [Department A] and [Department B], that the demand for those was just overwhelming. At that time, there weren't really any restrictions on the number of students that could go in. Let's say [Department C], not a lot of students really knew about that. They didn't have a lot of applications, and everyone was going into these two or three. It was really causing a resource burden. When it comes around time to ask for faculty, [Department A] and [Department B] are saying we have more students, we need more faculty.

Based on this perspective, the policy was intended to shift enrollment flows to align better with college resources, structures, and efficiency as opposed to responding to student demand:

> [Large departments] continued to get more, and then the smaller departments that don't have as many students are continuing to get less. In essence, we're hurting those departments while we're just continuing to feed these other ones. We're not using our resources strategically at that point. We're just putting them in where we have demand.

This justification was pervasive across several disciplines within the college. One administrator cited the strategic push by the college to encourage students to enroll in smaller departments: "The College having so many of the university's students. How to manage that number. How to allow ... not unbounded growth in the college and have departments have the number of students that they can reasonably teach." Another advisor similarly highlights the criticality of the policy to help smaller, less sought-after departments increase their enrollment demand:

> We're big, we have a big faculty, so we can teach a lot of students. [Department] is not as big they can't teach as many students and plus, who wants to go to [Department]? Not very many people. I mean that's just the reality of it. Or [Department] is another one for example. It's a smaller unit than we are. I think that the GPA, and the credit issue is a big picture enrollment management process. And the college, I suspect, is still trying to figure that out.

How institutions grapple with meeting student demand and efficient allocation of resources is an important conversation and emerges as a different justification when these policies collide.

2.6.1.2.3 Equitable Policy: Universal application to all students

A final policy justification that emerged from the rationalization process of university advisors and administrators was the need to apply policies equitably to transfer students and FTIC students. This justification was least frequent of the three rationales, emerging in interviews with six participants at the university (23%) across two departments. An advisor shares a perspective on why transfer students should also abide by EM policy guidelines:

> When that went into place, it meant that all students did come into [general engineering], because if we direct admitted transfer students, then we had a harder time controlling the number of students that went into each discipline. We had to put them into the enrollment management plan as well.

In this case, controlling enrollment flows for FTIC students into engineering disciplines also meant that the policy should be applied equally across all incoming students. A few other advisors surmised that admitting transfer students directly into major could lead to frustration and complaining from FTIC students and their parents, feeling as though FTIC students were not being treated equally for competitive entry into disciplines. One advisor elaborates on this perspective: “When we went to this enrollment management plan in engineering about three or four years ago and stakes were so much higher for getting into the major that you wanted . . . [transfer students] still have to get in like a freshman would have to get in.” Under the assumptions of this rationale, excluding transfer students from the EM policy is seen as an unfair application of the policy, providing transfer students advantages not afforded to FTIC students who must abide by the requirements of the policy.

It is important, however, for institutions to consider the implications of including transfer students in enrollment management processes when, as one university advisor noted: “Most transfer students I feel like know what they want to do right when they come. Or they wouldn't have spent two years at community college trying to figure it out.” Another important consideration for the inclusion of transfer students in EM policies is how it is perceived by community college faculty and on the students they are supporting through the transfer process. As one community college faculty reflects on their experience informing students about the impending collision of policies:

> When I advise students and I tell them that they're going to go and they're going to get in to general engineering, it is a disappointment . . . the student feels like they did all this work, and they graduated, and they have a 4.0, but they're not going to get into their discipline. I think that's tough. I think it's a perceived negative for them because I don't think it actually, if they're a great student, really impacts them there. But it's perceived that way.

The use of justifications to explain incongruent policies, particularly when communicated with transfer students, may influence their experience during transfer.

2.6.2 Impacts of Colliding Policies on Students

To address our second research question, we sought to understand how colliding policies influenced the transfer of coursework process. An important theme that emerged in conversations with 14 of the 26 (54%) study participants was the unintended consequences of technical course overload for transfer students in their first semester after transfer. By transferring to the university through the articulation agreement, one of the primary benefits for students is satisfying the general education course requirement at the university. When examining the articulation agreement in isolation, this arrangement seems to be a desirable and enticing benefit for transfer students and guarantees the transfer of a portion of credits required for completion of a bachelor's degree. However, faculty and advisors discussed how this benefit can actually end up harming students, particularly in their first semester after transfer, as students' schedules are overloaded with technical, upper-level major courses. An advisor details how an engineering program's curriculum (i.e., check sheet) is designed to help students balance difficult technical courses with non-program elective courses each semester and the implications for transfer students who lose access to the balanced curriculum by design:

> I worry a little bit about the burnout ... the reason we have the check sheet the way it is is because it's very balanced. . . you have the [Gen Ed Required Courses] littered throughout . . . You have a balance of [program] classes and non-[program] classes . . . But if you're coming in and you've eliminated everything but the [program] classes that first year when you just start, it can be just kind of a killer. Just a motivational killer sort of thing.

Designed as an incentive for community college students to transfer via an articulation policy, students who have completed the general education course requirement are left with "nothing to take except for really, really hard classes that they're just not quite ready for." Table MS1-2 shows the distribution of general education courses and compares courses allotted in the first two years of a program versus the latter two years; in aggregate, program plans are designed to have more general education courses in the latter two years as a way to balance the academic course load. On average across disciplines, academic plans include three credits more of general education in the latter two years than the first two years. This design helps students balance their workload in the junior and senior years as they contend with challenging upper-level major courses as well as a senior design project. Thus, although the intent of the articulation policy general education requirement waiver is to benefit transfer students, it acts in contrast to how classes are sequenced in academic plans across engineering disciplines for FTIC students.

The check sheets do not account for courses that transfer students actually take after transferring to the university. Consequently, we examined the classes in which transfer students actually enrolled their first semester after transfer and compared them with courses taken by FTIC students in their first year, the semester FTIC students are subject to the EM policy. Transfer students enrolled in more major courses and fewer elective courses than FTIC students (Table 3).

Table MS1-2

Distribution of General Education Courses in Academic Plans by Discipline

Engineering Degree	Gen. Ed. Electives (First 2 years)	Gen. Ed. Electives (Last 2 years)
Aerospace	7	6
Biological Systems	7	9
Chemical	6	10
Civil	6	7
Computer	4	12
Computer Science	9	9
Construction Management	4	3
Electrical	6	10
Engineering Science & Mechanics	6	7
Industrial Systems	6	10
Materials Science	4	9
Mechanical	4	12
Mining	7	9
Ocean	7	6
Average	5.93	8.50

Table MS1-3

Comparing 1st Semester Transfer and 1st Year FTIC Enrollments by Course Type

Course Subject Type	% of 1st Semester Transfer Enrollments	% of 1st Year FTIC Enrollments
All Electives	11.30%	15.10%
All STEM Electives	2.60%	2.20%
All Major	86.10%	82.70%
Total Course Enrollments	10939	49889

Further complicating the issue for transfer students is that in their first semester, along with enrolling in a higher number of difficult technical courses, on average, transfer students also had to meet the GPA (3.0) and credit completion (12) requirements of the enrollment management policy to gain entry to a degree-granting major. Only 63% of transfer students in our dataset met the minimum GPA requirement in their first semester for entry into their first choice major, with a median GPA of 3.19. An advisor reflects on frustration expressed by transfer students who feel the classes they are taking in their first semester after transfer are harder when compared with FTIC students who must meet the requirement of the enrollment management policy after their first year of courses at the university:

> [Transfer students] say things like they don't get any 'frou-frou' classes, or whatever, which I get. That's absolutely a challenge that I see. And we try and acknowledge that without adding fuel to their fire. We try and acknowledge that at orientation by emphasizing the importance of having a balanced schedule. So you don't need to take 18 credits of junior level whatever engineering major. Let's balance out other degree requirements, that might help.

This expressed concern of transfer students may be warranted, as the average weighted GPA of FTIC students in their 1st year courses is 3.12, which includes some general education courses. However, when examining the academic performance of FTIC students in the same set of courses that transfer students take during their first semester, transfer students (3.01 average) actually outperform FTIC students (2.97 average) in those same courses. Thus, institutional data support the perception that the enrollment management policy implicates FTIC and transfer students in different ways.

Knowing students must complete 12 credits at a 3.0 GPA to enter into a degree granting program, another advisor modified their recommended courses for students, particularly in the first semester after transfer, to help students successfully transition to the university. The advisor describes that, although students could take a set of courses to advance more quickly toward degree completion after transfer and not enroll in general education courses, it may not be a best practice for their success:

> Sometimes, we also have to be careful about the number of discipline-specific courses that we're recommending to transfers because we also don't want to overwhelm them even though they can do something; it's a matter of should they be doing something. But I also think we have to be careful about the types of courses that we're putting our transfer students in right out of the gate. I think that we do need to take those things into consideration as advisors in our college and not throw them in all 4000 level classes in a specific discipline and allow them that semester of transition.

Another advisor shares a contrasting perspective and suggests that students advised to take courses to meet the requirements of the enrollment management policy “get penalized for that because they're not being advised to take classes that count towards their progression. It's going to take them longer and longer to graduate.” The advising students received about how to best navigate coursework in their first semester at the university varied across advisors; variance in advising impacts students differently. For example, students who were advised to ensure that they meet the GPA minimum specified in the EM policy may have been advised to take a few general education courses to balance their course load. The benefits in the short-term (i.e., matriculation into degree-granting major) may come at the expense of falling behind in progress to degree in major courses. Conversely, another advisor may suggest that a student prioritize the long-term degree progress and, as such, is advised to take an overload of technical courses in their first term. The student’s performance in those courses will influence their ability to get into their major and will do so in more difficult courses than other transfer students. Certainly such decisions for how to advise students are not an easy task and requires discretion.

Although there is variation in how faculty and advisors choose to manage students’ technical course loads in their first semester, the impact of colliding policies is evident. One advisor expresses pessimism about the design of the articulation agreement for transfer students and expresses concern over how its current design hinders students' ability to be successful in coursework after they transfer:

> That's where it comes into a question of the associate's degree is great to have on their record, and I know that the community colleges want it for graduation statistics, but it actually in a lot of times hurts the students if they come in with a full associate's, because there's just not anything here for them to take, whereas if you only do one year there, we can actually insert some classes into your first year here.

It seems that, particularly within this engineering context, the potential consequences of granting students' fulfillment of general education coursework as part of an articulation agreement in combination with enrollment management policy requirements may place students in challenging situations.

2.7 Discussion

We organize the discussion around four themes that emerged from our results. First, we compare and contrast our main finding, the collision of policies, with other education policy literature, focusing specifically on policy (in)coherence (Honig & Hatch, 2004) in the K-12 sector. Second, we contextualize how street-level bureaucrats manage the policy implementation process, focusing particularly on instances when implementation diverges from policy design. Third, we seek to understand the emergence of participants' rationalizations for policy by connecting our findings to prior literature on enrollment management policies and practices. Finally, we connect our results to prior research on transfer shock and design of articulation policies.

The primary finding of this study is that advisors, administrators, and faculty, acting as street-level bureaucrats, face challenges in implementing two policies that collide for transfer students. Prior research in K-12 education policy points to similar challenges faced by front line workers in public schools who, in managing multiple competing external demands, encounter policy incoherence, or a lack of alignment of coordinated policies to meet educational goals (Fuhrman, 1993; Hatch, 2002; Honig, 2006; Knapp et al., 1998). Policy incoherence has been linked with school mismanagement, strained coordination and productivity, teacher turnover, and overall poor performance of schools (Fuhrman, 1999; Honig & Hatch, 2004). Ideally, K-12 schools, in collaboration with school district central offices, would “work together to craft or continually negotiate the fit between external demands and schools’ own goals and strategies” (Honig & Hatch, 2004, p. 16) to achieve policy coherence, a coordination of policies that support achievement of educational goals.

Policy coherence, in some ways, informs our findings of policy collision. First, policy coherence positions external demands as distinct from a school’s internal goals and strategies. In our case, to achieve more fiscal autonomy from state control (Leslie & Berdahl, 2008), the university was compelled by the state to formalize articulation policy, even if transfer was not a priority for the institution. In this way, establishing and managing the articulation agreement pathway for transfer students became an external demand that the institution was forced to manage in conjunction with enrollment management practices and policies. Honig & Hatch (2004) conceptualize “crafting coherence” as a dynamic process of managing external and internal demands through policy and suggest that schools use goals and strategies to either bridge or buffer external demands. Bridging activities strategically engage external demands to advance internal goals, whereas buffering activities selectively limit the influence and incorporation of external demands (Honig & Hatch, 2004). If we adopt the perspective that the articulation agreement for transfer students moved forward because of external demands from the state, inclusion of transfer students in the EM policy could have been a buffering activity by the university, thereby limiting the influence of the external demand on internal enrollment goals.

However, drawing these conclusions could also overstate transfer and articulation as purely an external demand for the university.

Policy collision also differs from policy coherence in several ways. First, policy coherence is primarily concerned with the relationship between schools and school district central offices, which often act as the centralized governing body for a collection of schools. In our case, articulation policies are formalized agreements between 4-year institutions and 2-year institutions that are distinct and have limited or no shared governing structure, at least within the state context of this study. Consequently, transfer articulation in this context is not a mandate and is not imposed, regulated, or enforced. Additionally, the establishment of transfer articulation also may be an internal priority for the institution or for the college. In this way, policy collision would be a result of two competing internal goals of the institution, dissimilar from policy coherence, which is a result of conflicting external and internal priorities. Prior research on policy coherence also suggests that schools' adaptation to multiple competing demands may improve performance, usually a result of additional resources (Hatch, 2004; Honig & Hatch, 2004). In our analysis of policy collision, the aims of each competing policy seem to be in direct conflict, where advancement of one policy does not advance the other. Finally, policy collision is a result of granular analysis of how two policies are implemented, as experienced by street-level bureaucrats. Policy coherence, in contrast, speaks more generally to policy design and alignment to institutional goals (Honig & Hatch, 2004; Fuhrman, 1993); it tends not to refer to the ways in which administrators, teachers and principals navigate policies or programs that may conflict with one another during the implementation phase.

In response to colliding policies for transfer students, advisors, administrators, and faculty are compelled to implement the policies differently than they were designed. Street-level divergence, or a policy's deviation from its original design as it is implemented (Lipsky, 1980), helps explain the process of exempting transfer students from policies. Many scholars have found street-level divergence to be an inevitable part of policy implementation, although the reasons for its occurrence are varied (Hill, 2005; Lipsky, 1980; Majone & Wildavsky, 1978). One explanation is that street-level bureaucrats accrue and wield power within the organization by acting as boundary actors for the organization with its environment (Prottas, 1978). In our study, we find similar evidence of street-level bureaucrats wielding power as boundary actors for the organization (Prottas, 1978) with university advisors and administrators wielding power and acting with discretion as they operate as intermediaries between university policymakers and transfer students.

Our findings of collective divergence may also be explained by how street-level bureaucrats often face inevitable complexity of work along with scarcity of resources that necessitate discretion in policy implementation. With these scarce resources, street-level bureaucrats may develop routines for decision-making to avoid having to make individual decisions on policy enforcement for each individual client (Loyens & Maesschalk, 2010). Faculty and advisors talked extensively about the complexities of dealing with transfer student course plans and making decisions about what courses to recommend, particularly when students were not allowed to take upper-level major courses. As a result, an exemption was used as a mechanism by which to routinize the decision-making process for advising students with respect to course-taking, allowing faculty and advisors more options and less complexity in recommending courses. Gofen (2013) distinguishes between individual and collective street-level divergence, where the former is divergence executed by individual street-level bureaucrats based on individual client needs, and the latter is a divergence in policy executed collectively be an entire group of street-level bureaucrats. In our case, we find collective divergence as faculty and advisors have standardized the modification to the course-taking restriction portion of the enrollment management policy for incoming community college engineering transfer students. Although findings of individual divergence for this policy did not emerge in interviews, it is possible that faculty and advisors are exempting students from the policy on a case-by-case basis, indicative of concealed divergence of the policy for 2nd term transfer students who had not yet transitioned into a degree-granting major.

Although other studies have focused on power and complexity as reasons to explain street-level divergence, we find that street-level bureaucrats are forced to engage in street-level divergence because of the collision of two disparate policies. In our case, although both policies serve relevant parts of the enrollment process for the university, the articulation agreement and enrollment management policies were designed with different purposes by different groups of stakeholders. As a result, as students flow between the community college and university, they experience misalignment under the auspices of both policies, which is not experienced by other student populations. Faculty and advisors, then, as policy implementers for both, respond by having to adjust one policy or the other to bring them into better alignment.

Often policy-makers and policy analysts consider policy spillover effects and externalities when designing a specific policy (Dunn, 2011). However, less frequently considered is how a policy will interact with other policies. This phenomenon is a particularly novel finding in the context of higher education transfer as most literature on articulation agreement efficacy does not consider interactions with other university policies. A consideration of this exemption is how advisors may end up making curricular decisions for students, or at least may override structural and curricular sequence decisions enacted by curriculum committees; that overriding decision authority rests outside of the traditional governance processes of academic disciplines.

Confronted with colliding policies with disparate aims, we found that participants were compelled to a rationalization process, generating policy justifications that may or may not reflect those intended in the design of policies, particularly enrollment management. Enrollment management policies often are designed and implemented at colleges and universities for the expressed purpose of funneling student enrollments to fit department structures and academic program resources (Hossler & Bontrager, 2014). Thus, it is not surprising to see participants deriving the enrollment funnel rationale for the policy. Although a wealth of literature exists on enrollment management practices employed by universities to control enrollment flows for FTIC students (Hossler & Bontrager, 2014; Humphrey, 2006; Snowden, 2010), there is a dearth of literature on enrollment management policies for transfer students. Our findings highlight a need to understand how enrollment management policies are applied, or should be applied, to transfer students, particularly in contexts where institutions have articulation agreements for vertical transfer.

Rigor was the most prevalent justification and may stem from the fact that enrollment management practices often target recruitment and selection of the most competitive student academically (Cheslock, 2005; Hossler & Bontrager, 2014; Hossler, 2004). The use of enrollment management for increasing the academic profile and rank of a program is particularly prevalent in STEM disciplines (Nicholls et al., 2007; Phelan, 2000). However, there is emerging scholarship linking the use of rigor-based rationales to maintain systematic privileges for those in power (Riley, 2017). Other scholarship has linked the use of rigor to perpetuate transfer stigma, or the belief that community college transfer students are ill-prepared for the academic rigor of university coursework (Thompson, 2019). The prominent emergence of this rationale in our study may have important implications for transfer stigma that warrant attention in future scholarship.

Interestingly, in contrast with our first finding of street-level divergence, where advisors and faculty make exceptions to policies for transfer students, there was little evidence of faculty and advisors considering preclusion of transfer students from the EM policy altogether. Instead, equal application of the policy to all students was a commonly derived rationale for inclusion of transfer students in the policy. How policies should be enforced, and for whom, are considerations for policy makers throughout the process of creating and enacting a policy (Dunn, 2015). The decision to include students in application of a policy with workarounds or adjustments to it, rather than excluding them from the policy altogether, is a compelling finding that deserves more attention in future studies. The process of deciding between modifying policy to fit subgroup needs or excluding subgroups from its application is not something frequently explored in scholarship, particularly in the context of higher education and vertical transfer.

"Transfer shock", or a temporary dip in GPA during transfer students' first semester after transfer, has received considerable attention from transfer scholars and practitioners (Cejda, 1997; Hills, 1965; Ishitani, 2008). Transfer students face multiple challenges as they adjust to the university academically and socially, and we find that those adjustments may be compounded by the collision of articulation and EM policies. While designed as a benefit for transfer students in the articulation agreement, fulfillment of a general education coursework requirement may not be advantageous, at least as it intersects with the EM policy requirements in students' first semester after transfer. We find that, not only are students left with a difficult course load post-transfer, they also immediately encounter high stakes conditions imposed by the EM policy to guarantee entry into their major. This collision may also be perpetuating inequities for community college transfer students who, to succeed in meeting admissions criteria while competing a technically overloaded courseload, may miss out on participation in co-curricular activities, forming peer relationships, and engaging in professional development opportunities such as career fairs that may be critical to future professional opportunities in engineering. The difficult circumstances that students encounter as they transfer influences and is indicative of how transfer receptive a 4-year institution is of the community college transfer pathway (Jain et al., 2011). We are not recommending that future articulation agreements remove the general education incentive, nor are we recommending that universities preclude students from program entry requirements through enrollment management policies. Instead, we suggest that policy makers at universities, community colleges, and at state levels, consider the collision of converging policies and the implications of their interactions on students and how those students may be incentivized to behave in ways that extend their longer-term degree progression to meet a shorter-term policy requirement.

2.8 Implications

Our findings have several implications for transfer students and the scholars, practitioners, and policy makers who support them. We focus on five such implications for policy design, implementation, and research: 1) policies should be examined from the perspective of convergence, understanding how policies may be experienced by students as they collide, and prioritize alignment, particularly in contexts and disciplines with competitive entry; 2) justifications generated by street-level bureaucrats attempting to make sense of disparate policies have potential influences on transfer students, including perpetuation of transfer stigma; 3) unwritten policies (or exemptions) can influence students' decision making around transfer, particularly for the most vulnerable students (i.e., those with low levels of transfer student capital); 4) street-level bureaucrats may exempt or exclude sub-groups of students during policy implementation; and 5) future research on articulation policy that focuses on implementation and implementers may improve our understanding of their efficacy.

Prior scholarship on articulation agreements has focused too narrowly on the contents of those policies, specifically, without considering broader contexts. Findings from our study suggest that we should not examine policy solutions in isolation but from the perspective of their convergence with other policies. Understanding how other university policies, such as the EM policy in this study, collide with and impact the efficacy of an articulation agreement, is often not considered. Policy interactions may help explain why articulation agreements are inconsistently effective at increasing transfer or uncover how a component of the policy intended to benefit the student may actually have unintended consequences. This finding is particularly relevant for competitive disciplines that have additional policies in place “behind the scenes” to control access. Although examining policy collisions is applicable across contexts, it is particularly important in the context of this study as universities grapple with national movements to remain competitive in a global academic marketplace while simultaneously diversifying and making campuses more inclusive. As in our study, it is also important to recognize how policy collisions may influence subpopulations differently, especially when a policy designed for a different target population negatively influences a particularly vulnerable subpopulation.

A second implication relates to how advisors, administrators and faculty reconcile implementation of disjointed policies through rationalization. Zacka (2017) found that organizational pressures lead street-level bureaucrats to adopt reductive and pathological moral dispositions including indifference, enforcement, or caregiving when acting with discretion in policy implementation. We arrive at a slightly different conclusion in this study, as we found that participants generated varying justifications for the existence of policies that are then communicated to students. We suggest that it is important for advisors, administrators, and faculty, acting as street-level bureaucrats, to understand the roots of why they generate these justifications and to consider how they may be interpreted when they are communicated to marginalized students. Relying on academic rigor to justify the existence of contrasting policies, for example, may perpetuate students' experiences of transfer stigma and self-doubt as they transition to the university. University policy makers also should consider the explicit versus implicit nature of their policies. In our case, because the aims of the enrollment management policy were not stated explicitly, policy implementers generated their own justifications for policy, particularly as students experienced dissonance with the tenants of the articulation agreement. Having multiple justifications for policies across street-level bureaucrats can create ambiguity among transfer students as they work with peers to transition to their new institutional environment.

Another implication of unwritten policies is that, for transfer students and the community college faculty and advisors supporting them, the planning process for coursework begins well before transfer. We found that community college faculty and staff were aware of the EM policy rule and communicated its existence to students in advance of transfer. However, because the policy, and particularly the exemption, were not explicit and public knowledge, students and community college faculty may not be aware of workarounds to coursework issues that emerge from colliding policies. Thus, students with lower amounts of transfer student capital, or the knowledge, skills and abilities needed to navigate the transfer process (Laanan, 2004; Laanan et al., 2010; Santos Laanan, 2007) may be at a severe disadvantage. If a student is considering transferring and does not know to ask someone at the university about possible workarounds to the policy, or if that student does not have community college faculty advisors with insider knowledge or connections to university faculty and staff, that student might make a different decision about the transfer pathway. This scenario illustrates an important unintended consequence of having exceptions to policies that are not stated explicitly and publicly that yield inequities between students.

Fourth, we encourage researchers and practitioners to pay attention to street-level divergence, or the adjustment of policies to fit different contexts or needs. As street-level bureaucrats at universities grapple with colliding policies that affect students differently, how should they decide when to adjust policies to better fit the needs of a subgroup of students? In our case, faculty and advisors chose to engage in concealed divergence (Gofen, 2013), informing only transfer students about their exemption from upper-level coursework registration restrictions of the enrollment management policy. Simultaneously, universal application of the policy to all students emerged as a justification for including transfer students in the policy. As universities balance enrollment management practices and articulation agreements with community colleges, they will often face these kinds of predicaments when choosing who will be affected by policies and how exemptions or exceptions will be made.

Findings from this study also have important implications for future research on policy implementation. For example, future studies examining the efficacy of articulation agreements may need to be more granular and involve practitioners who are acting as street-level bureaucrats. In our case study, we only discovered the policy collision by engaging advisors, administrators, and faculty who implement both the articulation policy and the college's EM policy – previous work at the institutional or state level may not capture this type of interaction that articulation policies may have with other institutional policies. Additionally, there is a general lack of focus on the implementation stage of policy creation and adoption, and this study highlights the value of close examination of this stage of the policy process. Future research on policy implementation can uncover organizational conditions and actors that may influence how a policy is realized during implementation. Finally, future research should incorporate students' perspectives to understand the perceived impact of policies on students' navigation through vertical transfer. Although we believe the faculty and advisors in our study have a deep understanding of the system through their close interactions with students, bringing the direct student perspective into this inquiry is an important next step.

2.9 Conclusion

This paper advances previous scholarship on articulation and enrollment management policies by showing how they interact and influence each other at their collision. Exploring this phenomenon through the lived experiences of street-level bureaucrats (i.e., the faculty and advisors who have to implement policies), we find the collision of articulation and enrollment management policies to be complex and potentially confusing, frustrating, and harmful for transfer students. We find that faculty and advisors engage in street-level divergence, making exceptions to policy to account for nuances in the needs of transfer students. Our study highlights the importance of seeking feedback from policy implementers during the early stages of policy creation. Further, our findings suggest that the influence of other policies, like enrollment management, may help explain why successful implementation of transfer articulation agreements may not act to support college student transfer, despite efforts from the state to mandate them (e.g., Leslie & Berdahl, 2008).

Translatable to other contexts, these findings suggest that other institutions will benefit from in-depth analyses of adopted policies, how they collide, how university faculty and staff manage implementation around those collisions, and what the implications are for students, specifically subpopulations of students. This paper advances previous research on transfer students and policy impacts by engaging the complexity of converging policies and the emerging impact on students. Within the policy context, this research highlights the need to understand the transfer of coursework process beyond articulation agreements, examining instead the interaction of policies at the state, system and institutional levels.

Chapter 3: *Operationalizing Transfer Receptive Institutions in Engineering*

3.1 Introduction

The vast majority of research on transfer students and transfer pathways has focused on students (e.g., background characteristics, previous academic experiences and performance, non-academic commitments) and community colleges (e.g., support programs, advising, coursework) as influences on students' eventual attainment of a bachelor's degree (Bahr et al., 2013). Research focused on students includes understanding students' motivations and academic goals (Alexander, Bozick, & Entwisle, 2008; Bahr, 2008; Hom, 2009), student-level variables that influence likelihood of transfer, academic performance pre- and post-transfer, and students' experiences throughout the transfer pathway (Carlan & Byxbe, 2000; Dowd, Cheslock, & Melguizo, 2008; Doyle, 2011; Melguizo & Dowd, 2009; Roksa, 2006; Roksa & Calcagno, 2010; Wang, 2009; Wang & Pilarzyk, 2009). Research focused on community colleges as influencers on transfer outcomes includes "cooling out" versus "warming up." Cooling out is the reorientation of low-performing students by community colleges toward alternative, terminal, non-transfer programs, and warming up is the provision by community colleges of a sequence of remedial courses and support services to serve as a step-ladder to college level coursework (Alexander et al., 2008; Bahr, 2008). Other research focused on the community college context includes institutional academic and non-academic support services for transfer students (Eagan & Jaeger, 2009) and articulation agreements and transfer partnerships that enable smooth transfer (Hagedorn, 2010; Kisker, 2007; Roksa & Keith, 2008). Although both students and community colleges warrant focused attention in how they influence transfer, this approach does not account for the important role that 4-year institutions should play in the transfer process (Bahr et al., 2013).

Recently, some scholars have recognized this gap in transfer literature and have begun analyzing the role that 4-year institutions play in the transfer pathway to a bachelor's degree. Bahr et al. (2013) conducted a systematic review of post-transfer research and grouped studies into five themes: 1) student integration into the 4-year institution, 2) student involvement in 4-year institutions, 3) environmental factors that pull or push students away from successful integration and involvement in the 4-year institution, 4) transfer student capital as originally coined by Laanan (1996, 2000, 2001, 2004; Laanan et al., 2010), and 5) transfer receptivity (Jain et al., 2011). Studies of integration and involvement, which Bahr et al. (2013) found are often conflated and not clearly defined, usually focus on asking transfer students about their perceptions of fit and levels of engagement within academic and non-academic environments at the 4-year institution. Research on environmental pull factors tend to highlight non-academic commitments (e.g., work, family) that make integration and involvement more challenging, whereas push factors include cultural and programmatic issues (e.g., transfer stigma, lack of programs for older students) that inhibit successful integration and involvement post-transfer. Laanan (2000, 2001, 2004) originally authored the idea of transfer student capital (TSC) which focuses on how students accrue knowledge, skills and abilities to transfer, and his more recent work focused on how TSC influences integration and involvement after transfer (Laanan et al., 2010). Finally, Jain et al. (2011) proposed a framework of post-transfer research called transfer receptivity, which describes an "institutional commitment by a four-year college or university to provide the support needed for students to transfer successfully" (p. 253). The bulk of research in this area has focused on receiving institutions' cultures and how they may impact transfer students' post transfer experiences.

Although not focused solely on 4-year institutions, another group of scholars have identified best practices that support vertical transfer at both 2-year and 4-year institutions through examination of highly effective transfer partnerships (Fink & Jenkins, 2017; Kisker, 2007; Wyner et al., 2016). Fink and Jenkins (2017), using student records from the National Student Clearinghouse (NSC), identified transfer partnerships that stood out as being more effective at helping community college students transfer to and graduate from 4-year institutions. Through interviews with faculty, staff and students they identified practices that are common among high performing transfer partners. This collection of prior research has helped us to begin to understand how 4-year institutions can enable vertical transfer pathways to bachelor degrees, but more research is needed, particularly research that explores transfer within specific disciplinary contexts (Bahr et al., 2013). This paper seeks to fill this void and focuses on the role 4-year institutions play in vertical transfer in engineering.

This manuscript expands prior work on transfer receptivity and highly effective transfer partnerships, specifically examining the landscape of access and graduation for transfer students in engineering at 4-year institutions as well as exploring the data systems available publicly to assess and evaluate vertical transfer pathways in engineering. Although transfer receptivity is conceptualized as how an institution's practices, policies and cultures influence transfer students' experiences (Jain et al., 2011), research has almost exclusively focused on culture, predominantly through attempts to measure students' experiences of transfer stigma (Alexander et al., 2008; Bahr, 2008; Laanan, 2004; Ruiz & Pryor, 2011; Townsend, 2008). Instead, this study focused on how elements of transfer receptivity relate to state and institutional transfer policies and institutional characteristics. More specifically, this study seeks to characterize the landscape of: 1) data systems and tools to assess and evaluate transfer student enrollment and graduation in engineering via the transfer pathway, 2) accessibility for transfer students into engineering programs, and 3) graduation of transfer students in engineering degrees at 4-year institutions in engineering. The following research questions guide this study:

- What types of publicly available data are utilized by 4-year institutions to assess and evaluate transfer student matriculation and graduation in engineering programs?
- How do engineering transfer student enrollment and graduation rates vary across 4-year institutions?
- What institutional characteristics, state-level transfer policies, and institution-level transfer admissions policies relate to engineering transfer enrollments and graduations across four-year institutions?

I combine data from institutions' Institutional Research (IR) websites, the American Society for Engineering Education (ASEE) Data Management System, and the Integrated Postsecondary Education Data System (IPEDS) to form a new dataset. Then, relying on these new data, I characterize engineering transfer enrollments and graduation rates, compare rates across institutions through a derived metric (i.e., transfer composition), and link that metric with institutional characteristics and transfer student policies. By collecting data from institutions' IR websites, I also compare and contrast the available data and tools used by institutions to assess and evaluate enrollments and graduation of engineering transfer students.

This quantitative approach to explore enrollment and graduation data for transfer students in engineering, along with an examination of what data institutions have available to assess and evaluate the viability and quality of transfer pathways in engineering, is a novel way to characterize institutions that may be transfer receptive. I extend beyond previous studies of transfer receptivity, which have focused primarily on institutional culture and students' experiences of transfer stigma, by focusing on transfer student enrollment and graduation data as well as larger-scale institutional policies and characteristics. My analysis takes place within a specific disciplinary context, engineering, which also represents a research advance within the transfer receptivity literature.

Throughout this manuscript, I suggest that examination of enrollment and graduation rates of transfer students may be helpful to understand transfer receptivity of 4-year institutions – this approach aligns with how Fink and Jenkins (2017) systematically identified institutions with highly effective transfer partnerships. However, it is important to note that these measures only serve as proxies for transfer receptivity in engineering. If an institution enrolls and graduates high numbers of transfer students in engineering and has detailed reporting tools in place to track engineering transfer students, it does not ensure the presence of transfer-friendly policies, transfer-centered programs and practices, and transfer-supportive cultures. However, institutions that do enroll and graduate more transfer students and have data systems to evaluate transfer pathways by discipline are more likely than not to be transfer receptive. The newly created data set, as a product of my dissertation, will provide a platform for future research to examine closely the transfer function of these institutions in engineering.

3.2 Literature Review and Theoretical Framework

As context for this study, I review previous literature on transfer receptivity, the theoretical framework guiding this study, and organize the discussion into three themes. First, I summarize research on highly effective transfer partnerships, which, in part, identifies how 4-year institutions can influence post-transfer experiences and outcomes. Next, I summarize the work of Jain et al. (2011), who originally authored the transfer receptivity framework. Finally, I highlight subsequent scholarship that has utilized Jain et al.'s (2011) transfer receptivity framework to explore post-transfer student experiences.

3.2.1 The Influence of 4-Year Institutions on Post-Transfer Student Experiences

The bulk of what we know about how four-year institutions can influence transfer student outcomes comes from research on highly effective transfer partnerships (Eggleston & Laanan, 2001; Fink & Jenkins, 2017; Handel, 2011; Kisker, 2007; Laanan et al., 2010; Miller, 2013; Wilson & Lowry, 2017; Wyner et al., 2016). Although this work does not exclusively examine four-year institutions, instead seeking to understand how they work in tandem with community college partners, this area of scholarship highlights the kinds of policies and practices that have been promising for supporting transfer students at 4-year institutions. Similar to prior researchers (Yeh, 2018), I organize discussion of prior literature into three groups: policies, practices, and institutional cultures.

3.2.2 Policies that Support Transfer Students

The majority of research on policies that enhance transfer student success focus on the transfer of coursework and credits between institutions. Articulation agreement policies, which are agreements between 2-year and 4-year institutions that facilitate transfer of coursework between institutions, tend to receive the most attention (Ignash & Townsend, 2001; Roksa & Keith, 2008; Roksa, 2007). Authors of articulation policy studies focus on the contents, design, and purpose of agreements (O'meara et al., 2007; Roksa and Keith, 2008; Zinser & Hanssen, 2006), the efficacy of those policies in increasing or improving transfer (LaSota & Zumeta, 2016; Roksa, 2007; Roksa & Keith, 2008), and comparing degree production of students who utilize these agreements with those who do not (Garcia Falconetti, 2009; Giani, 2019; Huffman, 2012; Kopko & Crosta, 2016).

Wyner, Jenkins, and Fink (2016) analyzed six high performing transfer partnerships across six states (Colorado, Connecticut, Florida, Louisiana, Massachusetts, and Washington) and found that articulation policies were critical tools to create clear programmatic pathways that are in alignment between transfer institutions. The contents of those policies, particularly those implemented statewide and mandated through state legislatures, varied substantially across states. The full list of policy elements in at least one of the articulation policies across the six states included: common course numbering, course equivalency database, transferrable general education core, major-specific pathways, field-focused pathways, competency-based transfer maps, Associate of Arts transfer guarantee, a statewide transcript database, reverse transfer policies, and student unit record (SUR) data on transfer outcomes (Fink & Jenkins, 2017; Wyner et al., 2016). None of these elements were common across all six states, although common course numbering and a transferrable general education core were common across five states.

Kisker, Wagoner, and Cohen (2011) conducted a similar analysis of policies across four states (Ohio, Arizona, New Jersey & Washington) and found seven common curricular/policy elements: 1) common general education package, 2) common lower-division pre-major and early-major pathways, 3) credit applicability, 4) students granted junior status upon transfer, 5) guaranteed and/or priority university admission, 6) associate/bachelor's degree credit limits, 7) acceptance policy for upper-division courses. The variation in articulation policies has made understanding their effectiveness in supporting transfer difficult. However, there is substantive evidence that such policies play a significant role in effective transfer partnerships and must be included in understanding transfer receptivity (Fink & Jenkins, 2017; Handel, 2011; Kisker, 2007; Kisker et al., 2011; Miller, 2013; Wyner et al., 2016; Yeh, 2018). Although important, articulation policies often are limited in scope, focused primarily on preservation and alignment of course credits; institutions complement these policies with other practices, programs, and services to support transfer students in highly effective partnerships.

3.2.3 Practices that Support Transfer Students

Prior research on effective transfer partnerships has spotlighted practices that 4-year institutions can adopt to become more transfer receptive and increase the likelihood of transfer student success. Kisker (2007), one of the first authors to examine transfer in this way, conducted a case study of a community college-university partnership and found that previous relationships between members of each institution, presidential support for partnerships, adequate and sustained funding mechanisms, and university presence on the community college campus were critical practices that enhanced the success of transfer partnerships. For my study, I focus on three areas of practice that have been linked to enhanced transfer partnerships: transparent and accessible admissions and transfer information, advising plans and support services for transfer students, and involvement of faculty in the transfer process.

A common finding across literature on best practices for transfer partnerships is transparent transfer credit evaluations prior to admission as well as clearly explained admissions criteria (Bailey et al., 2015; Handel & Williams, 2012). Institutions can best support vertical transfer by making transfer information easily accessible for transfer students, streamlining information available to students on how to apply, and clearly explicating how courses will transfer. Transfer students must navigate admissions requirements and transfer of coursework policies across multiple institutions as they consider vertical transfer (Laanan, 2004). Four-year institutions that clearly outline those requirements and policies for students will better support students' accrual of transfer student capital (TSC), or the knowledge, skills and abilities that enable students to navigate the transfer process (Laanan et al., 2010).

Fink and Jenkins (2017) found that tailored and intrusive onboarding services were prevalent among high performing transfer institutions, or institutions with higher than average enrollments and graduation rates of community college transfer students. In particular, the authors found that "4-year college partners exhibited a commitment to supporting transfer students before, during, and after they matriculated from their community college partner . . . [by] providing a robust onboarding process that involved regular meetings with their advisors" (p. 305). Included in the onboarding process were advising meetings during a transfer specific orientation explicitly designed for transfer students so that they could craft a schedule and identify a set of support services that meet their unique needs. Another key contribution by advisors at four-year institutions to improve transfer students' experiences included regular maintenance and updating of program plans to reflect the most current degree pathway options and course requirements (Fink & Jenkins, 2017; Handel, 2011; Wyner et al., 2016). The commitment by four-year institutions to comprehensive and timely support services seems to be an important practice to support transfer students.

Another finding of Kisker (2007) supported by other scholars (Cejda, 1994) was the critical need for involving four-year faculty in the transfer process. Kisker (2007) found that efforts by faculty to collaborate across institutions, usually fostered through prior relationships within disciplines, were vital to the success of transfer partnerships, particularly as it pertained to the academic environment and curriculum alignment. Cejda (1994) examined the impact of faculty from a four-year institution collaborating with faculty from a 2-year institution on the academic performance of transfer students in the field of education. The author found that students who transferred in the program where faculty actively collaborated across institutions did not experience transfer shock (i.e., a notable drop in GPA post-transfer) (Cejda, 1997; Cejda et al., 1998; Hills, 1965; Rhine et al., 2000), yet transfer shock persisted for students who were not involved in the collaborative program (Cejda, 1994).

Other practices noted in literature yet receiving less attention include investing substantial resources in transfer services, prioritizing financial aid money specifically for transfer students, funding transfer initiatives through collaborative projects, and sharing student success data with partner community colleges (Wyner et al., 2016). Collectively these findings are indicative of a variety of ways that four-year institutions can support transfer students. However, making transfer students a priority is a more holistic consideration of an institution's culture, mission, goals and academic identity. My study is scoped to policies and institutional characteristics, which can serve as a proxy for a variety of practices, but future work should examine specific institutional practices that impact transfer receptivity.

3.2.4 Institutional Cultures that Support Transfer Students

Other literature on transfer partnerships focuses more broadly on institutional cultures around transfer (Handel & Williams, 2012; Kisker, 2007; Miller, 2013; Wyner et al., 2016). Institutions that foster a culture supportive of transfer students often have backing from presidential and academic leadership, use transfer-affirming messaging that acknowledges that transfer students are an institutional priority, and have a demonstrable presence of faculty, staff and services on community college partner campuses (Yeh, 2018). Institutions that prioritize transfer communicate transfer as a key component of advancing the mission of the institution, share the benefits of improving and investing in transfer students for the institution's success, and dispel myths and misconceptions often held about community colleges and community college transfer students (Wyner et al., 2017). Overcoming these misperceptions, however, is a major hurdle for many institutions and requires an institution-wide commitment. Like institutional practices, institutions' cultural elements regarding transfer are important for understanding transfer receptivity but are not within the scope of my study. Future research should incorporate these cultural elements to understand how such elements may link to transfer receptivity in engineering disciplines.

3.2.5 Transfer Receptivity: Theoretical Framework to Understand Post-Transfer

Research that shaped the work by Jain et al. (2011) on transfer receptive cultures includes work by McDonough (1997), who examined how social class influenced college access for high school students and produced "college-going cultures," and Ornelas and Solorzano (2004), who followed a critical approach to understand how community college structures influence a "transfer sending culture." Their work was foundational because it made explicit the role of high schools and community colleges in preparing students for advancement to the next tier of the education system and called attention to best practices that foster college-going and transfer-sending cultures. However, as is the case with much of the research on transfer students, these theoretical frameworks focused exclusively on sending institutions, leaving noticeably absent the role that receiving institutions play in the process of transitioning students successfully to the next stage of postsecondary education.

Jain et al. (2011) addressed this gap by proposing a new lens to examine transfer critically; they defined a transfer receptive culture as "an institutional commitment by a four-year college or university to provide the support needed for students to transfer successfully" (p. 257). Relying on critical race theory (Delgado & Stefancic, 2017)—which emphasizes the need to challenge dominant ideologies of meritocracy, colorblindness, objectivity and race neutrality—the authors created a model of five elements that are essential for creating a transfer receptive culture. The first two of five elements occur before students transfer to the university, whereas the latter three are designed to support students post-transfer:

> 1) Establish the transfer of students, especially non-traditional, first-generation, low-income, and underrepresented students, as a high institutional priority that ensures stable accessibility, retention and graduation.
>
> 2) Provide outreach and resources that focus on the specific needs of transfer students while complementing the community college mission of transfer.
>
> 3) Offer financial and academic support through distinct opportunities for nontraditional/reentry transfer students where they are stimulated to achieve at high academic levels.
>
> 4) Acknowledge the lived experiences that students bring and the intersectionality between community and family.
>
> 5) Create an appropriate and organic framework from which to assess, evaluate, and enhance transfer receptive programs and initiatives that can lead to further scholarship on transfer students (p. 258).

The transfer receptivity framework acknowledges the systematic oppression that exists in the stratified higher education system and suggests high-level ways to address it (Jain et al., 2011). It is also pragmatically useful in organizing 4-year institutional efforts to shift to a culture that is comprehensively supportive of vertical transfer.

To align with prior research on highly effective transfer partnerships (Wyner, Fink, & Jenkins, 2017), my study focuses primarily on the first and fifth elements of transfer receptivity, and in particular, on how institutions ensure stable access and graduation of transfer students, and the data and tools they rely upon to assess and evaluate the efficacy of transfer pathways.

Jain et al. (2011) suggest that addressing these needs for transfer student access and successful degree attainment is critical for establishing transfer as a high institutional priority and is enabled by data and tools that continually assess and evaluate how well a 4-year institution supports transfer pathways. In my study, by collecting data from institutions' IR websites, I observe variation in data availability with respect to transfer students in engineering that may offer evidence around the extent to which the institution assesses and evaluates the transfer pathway. I then compare institutions' transfer student enrollment numbers with FTIC enrollment numbers in engineering as one way to understand the extent to which transfer students comprise the student population within engineering programs at the institution. Finally, I examine transfer graduation rates as one way to determine institutions' ability to support transfer students to degree completion. In doing so, I advance understanding of the first and fifth elements of transfer receptivity.

One component of transfer receptivity is fostering an institutional culture that establishes transfer students as a high institutional priority, and in turn reducing transfer stigma. Several authors have explored transfer stigma, both prior to and after Jain et al. (2011) established the transfer receptive culture framework (Bahr et al., 2013). As part of the TSC framework, Laanan (2004) incorporated students' perceptions and experiences of stigma as part of the L-TSQ survey instrument. Ruiz and Pryor (2011) and Alexander, Ellis and Mendoza-Denton (2009) developed other survey instruments that also sought to assess students' experiences of transfer stigma at receiving institutions. Others have relied on focus groups and interviews with post-transfer students about their experiences of stigma. Findings on the prevalence of stigma and how students experience stigma at four-year institutions vary across studies and warrant more consideration from scholars (Bahr et al., 2013). However, transfer stigma is only one component of understanding transfer receptive cultures at receiving institutions. In general, these studies have not sufficiently met the call of Jain et al. (2011) to "advocate for policies . . . that advance the notion to include four-year institutions' responsibility in creating a welcoming environment for transfer students . . . [and] a transfer receiving agenda that places transfer students not as an afterthought but, instead, centralizes the community college experience seamlessly into the context of a baccalaureate degree" (pg. 263).

An exception is scholarship by Wyner et al. (2016) who identified 2-year and 4-year transfer partnerships that were effective in supporting vertical transfer, as operationalized through high transfer enrollment and graduation rates. They conducted interviews with faculty, staff and students at ten institutions—five community colleges that partnered with five 4-year institutions—to understand key factors in creating and sustaining highly effective vertical transfer. Although they focused on understanding efficacies of the transfer partnership, their results include myriad recommendations for best practices, several of which that occur at the 4-year institution. I adapt a similar approach in this study and link enrollment and graduation rates of engineering transfer students with institutional characteristics and transfer policies to identify potential ideas that may help 4-year institutions be more transfer receptive. To summarize, the purpose of my manuscript is to extend the work of Jain et al. (2011) and Wyner et al. (2016) on transfer receptivity within a discipline-specific context (i.e., engineering), which for vertical transfer may have particular complexities, challenges, and broader opportunities aligned with national broadening participation initiatives.

3.3 Data and Methods

I organize the data and methods section into five subsections. First, I describe how and where data were collected from for my study and the rationale for determining which institutions would be included in my sample. Next, I contextualize the focal variables in this study and, when relevant, depict how they were operationalized. Then, I detail the institutional and policy variables that were included in analyses with focal variables. Finally, I describe the analyses that were conducted and address relevant limitations.

3.3.1 New Data Set Development and Institutional Sample

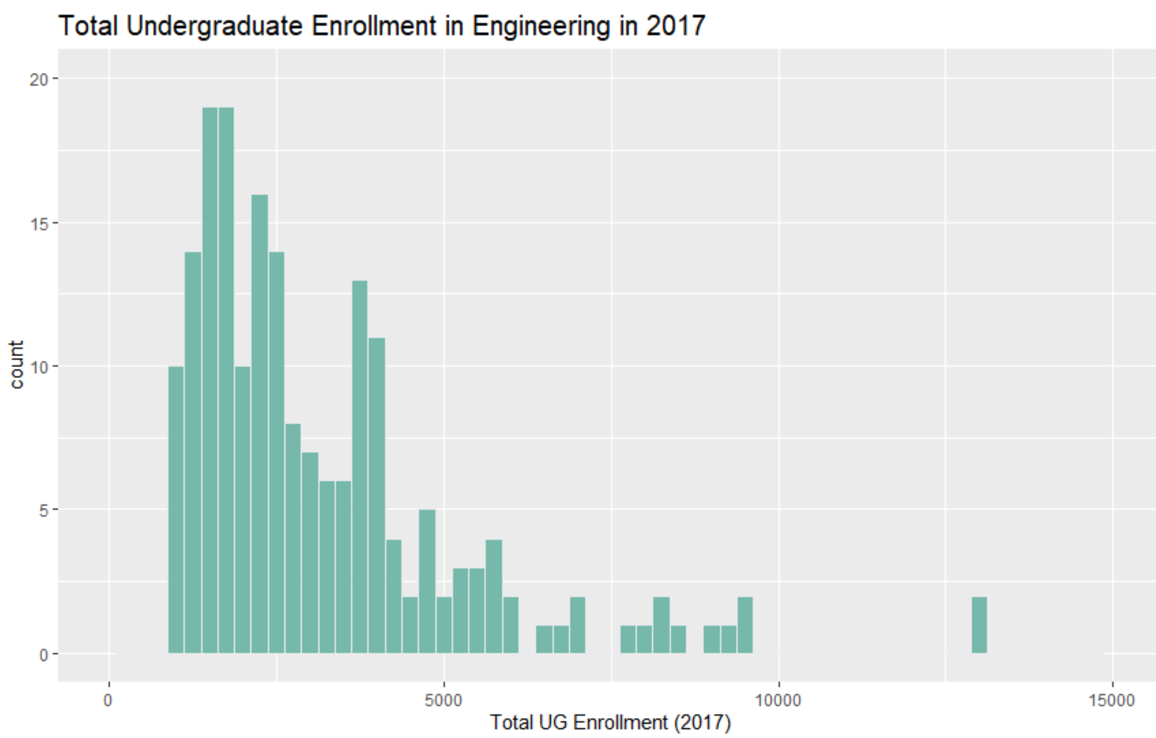
Data for this study were collected from three sources and aggregated into a new dataset for the field. I collected college-level data from the American Society of Engineering Education (ASEE) Data Management System. The database is managed by ASEE and contains information from over 370 institutions in the United States and Canada that offer programs in undergraduate and graduate engineering, computer science, and engineering technology. The types of data available in the ASEE database include annual enrollment, faculty headcounts, degrees awarded, and research expenditures for engineering programs by institution. Data for my study included annual enrollment data for undergraduates in engineering and computer science disciplines, and excluded enrollments in engineering technology and graduate programs. Computer science is included for institutions that house computer science within the college of engineering, but not for those with computer science outside of the college of engineering.

First, I collected *Full-Time and Part-Time Enrollment (2005-Present)* for *Freshman*, *Sophomore*, *Junior*, and *Senior* classes for *2017* and aggregated them into a *Total Undergraduate Enrollment* variable for each institution and sampled institutions with the highest enrollments of undergraduate students across *All Engineering Disciplines* in the United States. The sample in this study includes U.S. institutions with more than 1,000 total undergraduate enrollments in engineering (2017); following these criteria, my sample filtered to a total of 193 institutions. This sample included 92% of national enrollments in engineering in 2017. Figure

MS2-1 visualizes the distribution of total undergraduate engineering enrollments in 2017 across the 193 institutions in the sample. The size of undergraduate engineering enrollments varies considerably across the sample ranging from 1,013 to 12,995 student headcounts. As evidenced in the histogram, the majority (165 out of 193 = 85%) of institutions in the sample enrolled fewer than 5,000 students in engineering in 2017, with 26 (13.5%) enrolling more than 5,000 but less than 10,000 students. Two institutions (1%) in the sample enrolled more than 12,000 students in undergraduate engineering programs in 2017.

Figure MS2-1

Distribution of 2017 Total Engineering Undergraduate Enrollments for Sample Institutions



Because data on transfer students' enrollments and graduation rates are not systematically collected through IPEDS and engineering enrollment and graduation data in the ASEE database are not disaggregated for transfer students, I collected data from institutions' IR websites and generated a new data source for the field. Additionally, by collecting data from each institution individually, I gained insight into how institutions managed transfer student data and reporting, a proxy for understanding how they may assess and evaluate transfer student pathways. To capture enrollment trends across time, enrollment data were collected for 2010–2018. Additionally, for consistency of measurement across institutions in the sample, only Fall enrollment data were collected. Enrollment data for 'New Transfer' students in engineering were publicly available for 113 institutions (58.5%) in the sample. For institutions where these data were not publicly available, I contacted members of the IR office to request engineering transfer enrollment data.

Publicly available graduation data were far more limited across the sample with only 32 institutions (17%) providing graduation rates for transfer students in engineering. The time intervals of graduation data available by transfer cohort were inconsistent across the sample with some institutions reporting rates at 2-year through 8-year points, and others reporting as few as one of those time intervals. Additionally, the cohort years reported by institutions were inconsistent, with institutions reporting some or all cohorts between 2008 and 2016. With so few institutions providing graduation data publicly and inconsistency in the rates and years reported for those institutions that did report data, I did not contact IR offices to acquire additional graduation rate data for engineering transfer students at this stage of the study. Given the variability in data availability across institutions, I report on differences in the tools that institutions use to report engineering transfer enrollment and graduation data. Collectively, these IR data were used to derive focal variables for this study.

3.3.2 Focal Variables

The focal variables of interest in this study intend to capture three key elements of the transfer receptivity framework: 1) data tools that enable institutions to assess and evaluate the quality of transfer pathways in engineering, 2) accessibility of transfer students to engineering programs, and 3) graduation of transfer students in engineering. These variables, in combination, may inform variation in transfer receptivity across institutions in the sample.

To understand the data and tools that institutions use to assess and evaluate transfer pathways to engineering degrees, I categorized types of enrollment and graduation data on engineering transfer students that were publicly available as well as the tools used to organize and present those data. Generally, this process began with a Google search that included "[institution name] institutional research" which usually directed me to the institution's landing page for the IR office. Only a few institutions did not have formal IR offices – in those instances, I searched the institution's website for contact information of staff members involved in some version of external data reporting, assessment, or planning and analysis. For the majority of institutions with IR offices, I was able to locate an "Institutional Data" page that provided summaries of the institution's data. For institutions that I could not find an "Institutional Data" page, I searched the institution's website to identify a staff member who I could contact in IR to begin the data request process. These institutions received a customized email requesting summary enrollment count data for new transfers in engineering; the following provides an example of language used in the email:

> I hope this email finds you well! My name is Dustin Grote and I am a PhD Candidate at Virginia Tech in the Higher Education program and my dissertation study is exploring transfer receptivity in engineering. [Institution] is included in my sample as it enrolls a substantial number of students in engineering annually. I am seeking to collect 10 years (Fall 2010 - Fall 2018) of Fall enrollment summary counts of New Undergraduate Transfer students that enter into engineering at [Institution]. I have located your factbook for 2017-2018 [LINK] which includes a table of enrollment counts for Engineering and also tables detailing scholarship awards and tuition costs for new transfer students. I am wondering if you could direct me to where I can find summary enrollment counts for Fall 2010 - Fall 2018 of New Undergraduate Transfer Students that enter into the College of Engineering?

As I located enrollment data for each institution, I catalogued the type of data tool used to report them. This process generated new variables for analysis capturing the types of tools institutions had to assess and evaluate transfer pathways to engineering. Namely, I categorized the tools (e.g., PDF report, Interactive Enrollment Dashboard) that institutions used to report enrollments of new transfer students in engineering into a *Transfer Enrollment Reporting Tool* composite variable; the categorization process is explained in detail in the results section.

I operationalized accessibility by examining engineering enrollments, deriving a *Transfer Composition* variable that characterizes the enrollment of new transfer students in engineering as a proportion of total new enrollments annually. With this characterization, access is a function of the percentage of engineering enrollments filled with transfer students, both from year to year and on average across all years. Institutions with higher proportions of transfer student enrollments may provide more access to engineering than institutions with smaller percentages of transfer students in their entering class. Collected from institutions' IR websites, transfer enrollments included total 'New Transfer' engineering enrollments in the Fall term for each year in the sample (2010–2018). These values were used as the numerator in the Transfer Composition proportion measure. Annual new enrollments of FTIC students in engineering were collected from the ASEE Data Management System for each year in the sample. Then, the aggregate total of new students in engineering, or the sum of annual new enrollments of FTIC students and Fall 'New Transfer' student enrollments, became the denominator in the Transfer Composition proportion measure. Transfer Composition was calculated for each year in the sample allowing for trend analysis in future studies. The majority of analyses in this study, however, focused on an aggregated measure, *Transfer Composition Average (2010–2018)*, in which transfer composition was averaged across all years to create a composite variable for analysis.

I also collected graduation rates for transfer students in engineering. As I did for enrollment data, I categorized the *Transfer Graduation Data Tools* (e.g., Referral to External Report, Interactive Graduation Dashboard) that institutions used to report graduation rates for engineering transfer students. Because the vast majority of institutions (83%) in the sample did not publicly report graduation rates for engineering transfer students, I categorized the types of graduation rates that were reported on institutional websites into a *Graduation Data Type* composite variable. The majority of institutions reporting graduation data reported rates at 2-year, 3-year, 4-year, and 6-year time intervals. Accordingly, the dependent variable, *Average Engineering Transfer Graduation Rates,* was created for 2-year (2008–2016 cohorts, with a cohort defined as Fall matriculation year), 3-year (2008–2015 cohorts), 4-year (2008–2014 cohorts) and 6-year (2008–2013) time intervals. Some institutions did not report rates for all cohorts in a time interval. To address this inconsistency and avoid reporting average graduation rates for an institution based on a limited number of transfer cohorts, institutions that reported fewer than three cohorts of data for a time interval were dropped from analysis. For example, an institution in the sample that only reported 6-year graduation rates for 2010 and 2011 cohorts was dropped from the analysis as those graduation rates may not adequately represent average graduation rates over time for transfer students at 6-year time intervals. The *Average Engineering Transfer Graduation Rate* variable may help inform how well institutions support engineering transfer students to degree completion in engineering. Institutions with higher average graduation rates may provide more stable graduation for transfers in engineering than institutions with lower percentages of transfer students graduating, or larger percentages of transfer students graduating at longer time intervals. Collectively, these variables inform the data that institutions make publicly available to assess and evaluate transfer enrollments and graduation in engineering.

3.3.3 Related Institutional and Policy Variables

The following related institutional and policy variables included in this study are grouped by level of the postsecondary system and are organized from macro- to micro-level: state level characteristics and policies, institution-level variables, college-level characteristics and policies, and student-level variables. In addition to examining differences across states using the *State* variable, I included four state-level transfer policy variables that formalize vertical transfer at the state level: *Transferable core of lower division courses*, *Statewide common course numbering system*, *Statewide guaranteed transfer of an associate degree*, and *Statewide reverse transfer*. These dichotomous variables indicate whether or not each transfer policy exists at the state level. Data for these variables was collected from the Education Commission of the States (ECS), which manages a national-level report that details state transfer and articulation policies across all U.S. states.

The second group of variables are institution-level; the majority of these variables were collected from the Integrated Postsecondary Education Data System (IPEDS), which is managed by the Institute of Education Sciences. Descriptive statistics for ratio variables are provided in Appendix MS2-A1, and summary counts data for nominal variables are provided in Appendix MS2-A2 – MS2-A13. The characteristics that were included in the analysis were purposefully selected based on prior scholarship on engineering transfer and transfer student success more generally (e.g., Bahr et al., 2013, Ogilvie, 2014). Groups of institution-level variables for this study included: institutional characteristics, institutional selectivity metrics, and institutional finance and student cost variables.

Institutional characteristics that were included as independent variables were: *Control of Institution, Multi-institution or multi-campus organization, Land Grant Institution, Degree of urbanization (Urban-centric locale)*, *Carnegie Classification 2010: Basic*, and *Carnegie Classification 2010: Undergraduate Profile*. Additionally, to understand how Minority-Serving Institution status related to transfer, data were collected from IPEDS for *Tribal College* and *Historically Black College or University*; *Hispanic Serving Institution* data were collected from the Hispanic Association of Colleges and Universities. However, only Hispanic Serving Institution (n = 28) was retained as a variable for analyses as both Tribal College (n = 0) and Historically Black College or University (n = 2) had insufficient sub-sample size for engineering programs with at least 1,000 undergraduates enrolled. Inclusion of these institutional characteristics consider factors that have been shown to relate to a transfer receptive culture.

Admissions selectivity data included *Avg. Percent Admitted (2010-2018)*, *Avg. SAT Math* 75^{th} *Percentile (2010-2018)*, and *Carnegie Classification 2010: Undergraduate Profile*. This collection of institutional data served as a proxy for institutional selectivity. The collection of finance data included the following institutional asset variables: *Avg. State Appropriations (2010-2018)*, *Avg. Public (GASB) Value of Endowments End of Fiscal Year (2010-2018)*, and *Avg. Private (FASB) Value of Endowments End of Fiscal Year (2010-2018)*. Additionally, the following student cost variables were included in analyses: *Avg. Published In-State Tuition & Fees (2010-2018)*, *Avg. Net Price – Students Awarded Grant or Scholarship Aid (2010-2017)* and *Avg. Total price for in-state students living off campus (not with family) (2010-2018)*.

Combined, these variables contextualized a few of the institutions' revenue sources as well as the average costs incurred by students to attend the institution.

College-level variables included in this study are engineering program rankings and admissions policies for engineering programs. Engineering program rankings are operationalized through the *2019 U.S. News and World Report Rankings of the Best U.S. Engineering Programs*. U.S. News and World Report ranking systems are widely used tools to rank universities, colleges, and academic programs nationally. A wealth of prior research has analyzed the utility and quality of these ranking systems (Enders, 2014; Frank, 1999, 2004; Stocum, 2013). Despite some critiques about how rankings are operationalized (Ehrenberg, 2005; Monks & Ehrenberg, 1999; Pusser & Marginson, 2013; Sponsler, 2009), these ranking tools remain a commonly used tool that institutions—and students and their families—rely upon to compare their levels of academic prestige with peer institutions (Bastedo & Bowman, 2010; Meredith, 2004; Merisotis & Sadlak, 2005). In this study, I incorporate two rankings as independent variables in the study: 1) *Best Undergraduate Engineering Programs that Offer Doctoral Programs*, and 2) *Best Undergraduate Engineering Programs that Do Not Offer Doctoral Programs*. These rankings are based solely on peer assessment surveys; inclusion in the survey requires institutions to have an ABET accredited engineering program. By including rankings as independent variables in this study, I compare prevalence of transfer with perceptions of quality and prestige of undergraduate engineering programs.

The other college-level variables included in my study were collected from ASEE's college profiles website (http://profiles.asee.org/) within the Undergraduate Admissions/Transfer Information Page in the 'Admissions Requirements for Transfer Students' subsection. The information institutions included in this subsection were inconsistent across institutions in the sample, but the most prevalent variables that could be compared across institutions were the *Minimum GPA for admissions into engineering* at the institution as well as the *Minimum number of credits that must be complete prior to admission*. By incorporating these variables in my study, I can explore the relationship of engineering-specific transfer policies and enrollment and graduation in engineering for transfer students.

Finally, student-level variables included in my study are institution-wide undergraduate enrollment data, enrollment data by race/ethnicity at the institution and in engineering, and retention/graduation data. The institution-wide undergraduate enrollment data included *Avg. Enrolled Total (2010-2018), Avg. Total entering students at the undergraduate level fall (2010-2018),* as well as the following variables specific to transfer students at the institution: *Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018), Avg. Percentage Transfer-In Full Time (2010-2018)*, and *Avg. IPEDS Undergraduate Transfer Composition for All Entering Students*. The latter is a variable I derived to examine the proportion of all new entering undergraduate students that are transfer students, an institution-level version of the Transfer Composition (Average) (2010-2018) focal variable that is specific to engineering.

Enrollment data broken down by race/ethnicity were collected from both IPEDS and the ASEE Data Management System and included the racial/ethnic demographic characteristics of students at the institution and in engineering programs. Proportions of students' race/ethnicity were calculated for each year of interest in the study (2010–2018) and then aggregated into an average composite for each race/ethnicity across all years. Because the focus of this study is to broaden participation in engineering, this study focuses on the proportions of Black/African American, Hispanic/Latinx, Minoritized, and Women as variables of interest. Specifically, the following institution-level variables were included in analyses: *Avg. Percent of total enrollment* *that are Black or African/American (2010-2018)*, *Avg. Percent of total enrollment that are Hispanic/Latino (2010-2018)*, *Avg. Percent of total enrollment that are Minoritized Race or Ethnicity*, and *Avg. Percent of total enrollment that are women (2010-2018)*. Note that Hispanic/Latinx will be used throughout the manuscript to refer to data collected from IPEDS and ASEE, which use Hispanic/Latino and Hispanic respectively. This slight modification addresses flaws in the IPEDS and ASEE race/ethnicity labels used for students who identify as Hispanic/Latinx. The Minoritized Race or Ethnicity group includes the proportion of enrollment that are Black/African American, Hispanic/Latinx, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander. As discussed in Manuscript 1, Asian students are excluded from this aggregation of racial groups into the Minoritized variable because they are overrepresented in science and engineering relative to their population representation (National Science Board, 1987; Burke & Mattis, 2010). Also discussed previously, I recognize that important distinctions exist amongst different racial and ethnic sub-groups of Asian students and that not all Asian students are overrepresented—however, the aggregation of data reported at the institutional level does not enable a more nuanced and critically-minded construction of the minoritized variable (Museus & Kiang, 2010). Similar proportions were calculated for enrollments within engineering and included as variables in analyses: *Avg. Percent of All Undergraduate Engineering Enrollments – African American*, *Avg. Percent of All Undergraduate Engineering Enrollments – Hispanic*, *Avg. Percent of All Undergraduate Engineering Enrollments – Minoritized*, and *Avg. Percent of All Undergraduate Engineering Enrollments – Women.* Combined, these variables provide context to the racial/ethnic makeup of each institutions and within their engineering programs and are compared with the focal variables. It is important to acknowledge that students' racial, ethnic, and gender identities are more complex than the manner in which these proportion measures are calculated, a limitation of relying on federally mandated institutional data collection that is aggregated in IPEDS.

Finally, retention/graduation data from IPEDS included: *Avg. Full-time retention rate (2010-2018)*, *Avg. Graduation rate – Bachelor degree within 4 years total (2008-2018)*, *Avg. Graduation rate – Bachelor degree within 5 years total (2008-2018)*, and *Avg. Graduation rate – Bachelor degree within 6 years total (2008-2018).* These variables contextualized the retention and graduation rates of all undergraduates at each institution when making comparisons to the focal variables.

3.3.4 Analyses

To address the first research question, which addresses the *Transfer Enrollment Reporting Tool*, *Transfer Graduation Data Tools*, and *Graduation Data Type* focal variables, I conducted descriptive analyses of institutions' publicly available data tools for transfer enrollment and graduation. These variables are also used as independent variables in inferential analyses to examine whether the availability of public transfer data relate to institutions' transfer composition and transfer graduation rates in engineering.

To address the second and third research questions, which address the *Transfer Composition* and *Average Engineering Transfer Graduation Rates* focal variables, I conducted both descriptive and inferential analyses. Because this study is exploratory, it was useful to begin with descriptive analyses to contextualize the dependent variables. Descriptive analyses included examination of descriptive statistics and distributions of values of each focal variable across the sample. Then, because many institutions in the sample did not provide any publicly available transfer enrollment data for engineering transfer students, I conducted descriptive analyses to compare the group of institutions that provided enrollment data with the group of institutions that did not. To complement these descriptive analyses, I conducted a logistic regression to identify independent variables predictive of institutions having publicly available enrollment data. A similar set of descriptive and logistic regression analyses were conducted to compare the group of institutions that did provide publicly available engineering transfer graduation data with the group of institutions that did not.

Having compared institutions with and without publicly available transfer enrollment and graduation data, I then explored the relationship of each focal variable with select independent variables using bar plots, scatterplots and correlation tests. Then, based on findings from these descriptive analyses, I used multiple regression analyses to examine the relationships between select independent variables and the focus variables. More specifically, I examined how groups of independent variables (i.e., engineering program rank, institutional selectivity metrics, finance data, student demographics) relate to Engineering Transfer Composition and Graduation Rates.

Table MS2-1 provides a full list of variables, variable descriptions, their data source, and denotes which analyses in which they were included.

Table MS2–1

List of Related Institutional and Policy Variables Included in Analyses

Variable	Variable Description	Variable Type	Data Source	Inf Ava Enr
State-Level Variables of Interest				
State	The state in which the institution is located.	Categorical	IPEDS	X
Transferable core of lower-division courses	A set of general education courses agreed upon across all public postsecondary institutions. It must be fully transferable at all public institutions. Institutions may have different naming conventions; however, if that is the case, there is a crosswalk for institutions to use in the transfer process.	Dichotomous	Education Commission of the States	X
Statewide Common Course Numbering System	A uniform numbering convention used at all public postsecondary institutions for lower-division courses.	Dichotomous	Education Commission of the States	X
Statewide guaranteed transfer of an associate degree	Guarantees students who are awarded an associate degree before transfer to a four-year institution can transfer all of their credits to the four-year institution and enter at the junior-standing level. The majority of policies state that students are not required to complete any further general education courses.	Dichotomous	Education Commission of the States	X
Statewide Reverse Transfer	Requires all public institutions to implement the process of retroactively granting an associate degree to students who had not completed the requirements of an associate degree before they transferred to a four-year institution.	Dichotomous	Education Commission of the States	X
Institution-Level Variables of Interest				
Control of Institution	Distinguishes public and private institutions	Categorical	IPEDS	X
Multi-institution or multi-campus organization (HD2013)	A postsecondary organization with two or more institutions or campuses	Dichotomous	IPEDS	X

Land Grant Institution (HD2013)	A land-grant college or university is an institution that has been designated by its state legislature or Congress to receive the benefits of the Morrill Acts of 1862 and 1890.	Dichotomous	IPEDS	X
Hispanic Serving Institution	Hispanic-Serving Institutions (HSIs) are defined in Title V of the Higher Education Act as not-for-profit institutions of higher learning with a full-time equivalent (FTE) undergraduate student enrollment that is at least 25 percent Hispanic.	Dichotomous	Hispanic Association of Colleges and Universities	X
Carnegie Classification 2010: Basic (HD2013)	A classification framework to organize institutions based on the production of doctoral, master's and bachelor's degrees as well as levels of research activity. The methodology can be found at http://carnegieclassifications.iu.edu/methodology/basic.php.	Categorical	IPEDS	X
Carnegie Classification 2010: Undergraduate Profile (HD2013)	The Undergraduate Profile Classification describes the undergraduate population with respect to three characteristics: the proportion of undergraduate students who attend part- or full-time; background academic achievement characteristics of first-year, first-time students; and the proportion of entering students who transfer in from another institution. Please see the Undergraduate Profile Methodology for more detail regarding how this classification was calculated at http://carnegieclassifications.iu.edu/definitions.php.	Categorical	IPEDS	X
Degree of urbanization (Urban-centric locale) (HD2013)	Locale codes identify the geographic status of a school on an urban continuum ranging from “large city” to “rural", based on a school’s physical address.	Categorical	IPEDS	X
Avg. Percent Admitted (2010-2018)	The number of total undergraduate applicants divided by the total undergraduate applicants at an institution. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X

Avg. SAT Math 75th Percentile (2010-2018)	The 25th and 75th percentile scores for SAT at institutions where scores are required for admission for first-time, degree/certificate-seeking undergraduate students. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Published In-State Tuition & Fees (2010-2018)	Tuition and Fees for full-time, first-time undergraduate students for the full academic year. Tuition is the amount of money charged to students for instructional services. Required fees are fixed sum charged to students for items not covered by tuition. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)	Average net price is generated by subtracting the average amount of federal, state or local government, or institutional grant and scholarship aid from the total cost of attendance. Total cost of attendance is the sum of published tuition and required fees (lower of in-district or in-state), books and supplies and the weighted average room and board and other expenses. This variable is a composite average of data collected from 2010-2017.	Continuous	IPEDS	X
Avg. Total price for in-state students living off campus (not with family) (2010-2018)	Cost of attendance for full-time, first-time degree/certificate seeking in-state undergraduate students living off campus (not with family) for academic year 2018-19. It includes in-state tuition and fees, books and supplies, off campus (not with family) room and board, and other off campus (not with family) expenses. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. State Appropriations (2010-2018)	State appropriations are amounts received by the institution through acts of a state legislative body, except grants and contracts and capital appropriations. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X

Avg. Public (GASB) Value of Endowments End of Fiscal Year (2010-2018)	Consists of gross investments of endowment funds, term endowment funds, and funds functioning as endowment for the institution and any of its foundations and other affiliated organizations. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Private (FASB) Value of Endowments End of Fiscal Year (2010-2018)	Consists of gross investments of endowment funds, term endowment funds, and funds functioning as endowment for the institution and any of its foundations and other affiliated organizations. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
College-Level Variables of Interest				
US News Ranking - Program Type	Distinguishes institutions offering a doctorate in engineering from institutions that do not.	Categorical	US News and World Report	X
US News World Report Best Undergrad Engineering Schools 2019 Ranking (Doctorate Offered)	The undergraduate engineering program rankings were based solely on peer assessment surveys and includes schools whose highest engineering degree offered is a doctorate.	Continuous	US News and World Report	X
US News World Report Best Undergrad Engineering Schools 2019 Ranking (No Doctorate Offered)	The undergraduate engineering program rankings were based solely on peer assessment surveys and includes schools whose highest engineering degree offered is a bachelor's or master's.	Continuous	US News and World Report	X
Transfer Enrollment Reporting Tool	Derived during data collection for this study, this variable categorizes the types of data reporting tools available publicly that include enrollment information for engineering transfer students.	Categorical	IR Websites	
Minimum GPA for EGR Transfer	The minimum GPA listed for admissions consideration into engineering colleges and programs	Continuous	ASEE Profiles Page	
Min Required Credits for EGR Transfer	The minimum number of credits required to be completed prior to applying for admissions into engineering colleges/programs	Continuous	ASEE Profiles Page	
Student-Level Variables of Interest				

Avg. Total entering students at the undergraduate level fall (2010-2018)	Total entering students at the undergraduate level including full-time, part-time, non-degree/certificate-seeking, returning, and transfer-in students	Continuous	IPEDS	X
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)	Total entering students at the undergraduate level including full-time, part-time, non-degree/certificate-seeking, returning, and transfer-in students	Continuous	IPEDS	X
Avg. IPEDS UG Transfer Composition All Entering Students (2010-2018)	Derived as a focal variable in this study, this variable calculates the proportion of all new undergraduate students entering into an institution that are transfer-in students in Fall terms. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Percentage Transfer-In Full Time (2010-2018)	Transfer-in degree/certificate seeking undergraduate men and women enrolled for credit in the fall of the academic year. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Percent of total enrollment that are Black or African American (2010-2018)	Percent of student body that is Black non-Hispanic in the fall of the academic year. This variable is derived from the enrollment component that is collected in the winter and spring surveys. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Percent of total enrollment that are Hispanic/Latino (2010-2018)	Percent of student body that is Hispanic in the fall of the academic year. This variable is derived from enrollment component that is collected in the winter and spring surveys.	Continuous	IPEDS	X
Avg. Percent of total enrollment that are Minoritized Race or Ethnicity (2010-2018)	Percent of student body that is Black/African American, Hispanic/Latino, American Indian/Alaska Native, or Native Hawaiian/Pacific Islander in the fall of the academic year. This variable is derived from enrollment component that is collected in the winter and spring surveys. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X

Avg. Percent of total enrollment that are women (2010-2018)	Percent of student body that are women in the fall of the academic year. This variable is derived from the enrollment component that is collected in the winter and spring surveys.	Continuous	IPEDS	X
Avg. % of All UG EGR Enrollments - African American	Percent of all undergraduate enrollments in engineering that are African American. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. % of All UG EGR Enrollments - Hispanic	Percent of all undergraduate enrollments in engineering that are Hispanic. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. % of All UG EGR Enrollments - Minoritized	Percent of all undergraduate enrollments in engineering that are African American, Hispanic, Native American or Native Hawaiian. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. % of All UG EGR Enrollments - Women	Percent of all undergraduate enrollments in engineering that are Women. This variable is a composite average of data collected from 2010-2018.	Continuous	IPEDS	X
Avg. Full-time retention rate (2010-2018)	The full-time retention rate is the percent of the (fall full-time cohort from the prior year minus exclusions from the fall full-time cohort) that re-enrolled at the institution as either full- or part-time in the current year	Continuous	IPEDS	X
Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)	This rate is calculated as the total number of students completing a bachelor degree or equivalent within 4-years (100% of normal time) divided by the subcohort of full-time, first-time students seeking a bachelor's or equivalent degree minus any allowable exclusions.	Continuous	IPEDS	
Avg. Graduation rate - Bachelor degree within 5 years total (2008-2018)	This rate is calculated as the total number of students completing a bachelor degree or equivalent within 5-years (125% of normal time) divided by the subcohort of full-time, first-time students seeking a bachelor's or equivalent degree minus any allowable exclusions.	Continuous	IPEDS	

Avg. Graduation rate - Bachelor degree within 6 years total (2008-2018)	This rate is calculated as the total number of students completing a bachelor degree or equivalent within 6-years (150% of normal time) divided by the subcohort of full-time, first-time students seeking a bachelor's or equivalent degree minus any allowable exclusions.	Continuous	IPEDS
Transfer Composition (Average) (2010 - 2018)	Derived as a focal variable in this study, this variable calculates the proportion of all new students entering into engineering programs annually that are transfer students in Fall terms. This variable is a composite average of data collected from 2010-2018.	Continuous	Composite of IR Websites and ASEE Database

3.3.5 Limitations

I acknowledge several limitations associated with the design of this study that should be taken into consideration when interpreting findings. First, the reliance on extant data, particularly across multiple datasets that are not directly linked, could lead to incongruences and issues with data quality. For example, there was considerable variation in reporting of enrollment and graduation data across institutions' IR websites. For enrollment data, in particular, some institutions disaggregated summer and fall enrollments of new transfer students, whereas others aggregated them. For graduation data, there was substantial variation in how institutions defined their cohorts to report graduation rates. Discussed at length in the results section, some institutions reported transfer graduation rates in aggregate for all transfer students—both lateral and vertical—whereas others' transfer graduation rate cohorts included only vertical transfers from the in-state community college system. Further, issues of data quality within each dataset for which data are gathered are not within my control. In any case where the enrollment or graduation data collected from ASEE or from IR websites seemed irregular, I conducted spot checks of the data collected and dropped the institution from the sample if I was unable to verify the data as accurate.

Second, there are limitations with the derivation of the Transfer Composition variable. Although the motivation of this study focuses on vertical transfer from community colleges, available data aggregate vertical transfer with other kinds of transfer. Separating out the multiple kinds of transfer, as Ogilvie did in the state of Texas (Ogilvie et al., 2015), would require in many cases institutional partners that could parse out paths at an individual student level. Many institutions do not disaggregate transfer paths systematically. Additionally, the current operationalization of transfer composition only captures Fall enrollments of new transfer students. I made this decision to reduce the potential for systematic discrepancies in reporting by institution; the majority of institutions in the sample reported Fall enrollments, whereas reporting for Spring and Summer terms was less consistent across institutions in the sample. In particular, institutions reporting engineering enrollment data via static PDF documents were limited only to Fall enrollments. This conceptualization will underestimate transfer composition for institutions that also admit engineering transfer students in Spring and Summer terms.

Third, the data included in this study include only those provided publicly or by email request. Conclusions drawn about transfer receptivity based on publicly available enrollment and graduation data will not capture institutions that may enroll large proportions of transfer students and graduate those students at high rates but restrict access of these data to employees and personnel internal to the organization. Similarly, conclusions drawn about transfer receptivity of institutions based on the tools and data available to assess and evaluate transfer student pathways do not account for institutions with robust reporting tools for transfer students with restricted access only for institutional personnel.

Finally, although I have made concerted efforts throughout this manuscript to argue why examining enrollment and graduation rates of transfer students may be helpful to understand transfer receptivity of 4-year institutions, it is important to note that these measures only serve as proxies. Just because an institution enrolls and graduates high numbers of transfer students in engineering and has robust reporting tools in place does not ensure the presence of transfer-friendly policies, transfer-centered programs and practices, and transfer-supportive cultures. However, institutions that do enroll and graduate more transfer students and maintain robust data systems disaggregated by college to evaluate transfer pathways by discipline probably are more likely than not to be transfer receptive. The newly created data set, as a product of my dissertation, will provide a platform for future research to examine closely the transfer function of these institutions in engineering.

3.4 Results

Results are organized into three sub-sections aligned with the research questions. First, I contextualize the public availability of enrollment and graduation data disaggregated for engineering transfer students and compare the types of data and data tools across institutions in the sample. Then, I compared institutions that provided enrollment and graduation data with those that did not through descriptive and logistic regression analyses. Next, I examine enrollment data for engineering transfer students through transfer composition, and observe the relationships between transfer composition and a collection of institutional characteristics and policy variables through descriptive and multiple regression analyses. Finally, I summarize findings from this study related to graduation for engineering transfer students.

3.4.1 Results Part 1: Information Availability

I organize the results relating to the availability of engineering transfer data accordingly. First, I contrast the different types of enrollment tools used by institutions to provide engineering transfer enrollment data publicly. Then, I compare institutions that have enrollment data available publicly with those that do not on a series of institutional and policy variables. Next, I contrast the different types of graduation data available as well as the types of tools used to provide engineering transfer graduation data publicly. Finally, I compare institutions that have graduation data available publicly for engineering transfer students with those that do not on a series of institutional and policy variables.

3.4.1.1 Engineering Transfer Enrollment Data Collection

To operationalize the *Transfer Composition* variable, summary enrollment count data for 'new transfers' in engineering were collected from each institution's IR website for Fall semesters (2010-2018). Then, after completing collection of engineering transfer enrollment data for the whole sample, I collated and categorized data tools available on institution's IR websites into distinct types of reporting tools, summarized in Table MS2-2.

Table MS2-2

Summary Count of Institutions' Reporting Tools for Enrollment of New Transfers by College

Transfer Enrollment Reporting Tool	Count	% of Total
No Transfer Data by College	80	41%
None	39	20%
Only available by email request	41	21%
Static Report	40	21%
PDF Factbook	6	3%
PDF Enrollment Report, Table by Admit Type	23	12%
PDF Transfer Student Enrollment Report	8	4%
PDF Transfer Student Profile	3	2%
Interactive Enrollment Dashboard	73	38%
Enrollment Dashboard, Filter by Admit Type	61	32%
Transfer Specific Dashboard	12	6%
All Institutions	193	100%

Reporting of engineering transfer student data fell into one of three categories. The largest proportion of institutions (41%) did not have any publicly available data on transfer student enrollments by college. Some of these institutions had some enrollment data for transfer students or enrollments by college that aggregated transfer students with FTIC students, but no institutions in this category provided a report on their IR website detailing new transfer enrollments broken down by college. The second largest portion of reports (38%) consisted of interactive dashboards that often provided drop-down options to drill down into student enrollment data by semester and included filters by college and admit type. The third and smallest portion of reports (21%) were static PDF documents – these reports took on a variety of forms but collectively were snapshots in time of enrollments for an institution and did include a table for engineering transfer students. In the following section, I describe in detail and provide examples of elements that fall within each of these sub-categories.

3.4.1.1.1 Institutions with No Engineering Transfer Enrollment Data

A total of 80 institutions in the sample did not have publicly available enrollment reports that detailed enrollments of new transfer students by entering college or major. The types of data that were available on IR websites at these institutions varied considerably. For example, some institutions seemed to have no publicly available enrollment data at all. Others had extensive reports available for FTIC students but lacked any reports for transfer students. In some cases, institutions appeared to have extensive enrollment data that were restricted for internal college/university personnel use. Collectively, this sub-category was the largest in the sample (41%) and required outreach to IR office staff members for inclusion in my study. Forty-one of those institutions (21%) from whom I requested data provided enrollment data for new engineering transfers via email.

Email responses to data requests varied considerably across institutions in the sample. Several institutions were fairly immediate in their response sending Excel or PDF reports detailing ‘new transfer’ enrollments in engineering at the institution. Other email responses provided more context about their engineering programs or about transfer students at the institution in addition to providing data for the study, such as disaggregating enrollments by engineering major and discussed why some majors were accepting transfer enrollments and others were not. Other institutions acknowledged that, because of considerably small enrollments of new transfer students, they did not typically publish enrollment reports for them but were happy to do so for the study. Other institutions provided data but did so with specific requests, including blinding data from their institution, sharing my final report with their office, and requesting more information about how their data will be used and contextualized in the study. For example, an institution identified a limitation previously discussed, wherein collecting only Fall enrollment of transfer students may underreport Transfer Composition for institutions that enroll transfer students in Spring and Summer terms in addition to Fall. Future iterations of this study should address this limitation and incorporate enrollments of transfer students in other terms.

Of the remaining 39 institutions (49%) that did not report any data for this study, several institutions replied via email to decline my request for engineering transfer data, citing various reasons for doing so. First, some institutions did not collect or report enrollment data by admit type and college. In other cases, institutions cited confidentiality or inability to respond to individual data requests at this time. Finally, a few institutions funneled my request for data to the public records request system and were willing to gather and provide the data for a fee. The remaining institutions did not reply to email requests for transfer enrollment data in engineering. In summary, institutions without publicly available transfer enrollment data on their IR websites responded in a variety of ways to email requests for data; the availability and willingness to share these data for this study, or lack thereof, may in some way inform the transfer receptivity of those institutions.

3.4.1.1.2 Institutions with Static Reports with Engineering Transfer Data

Another 40 institutions in the sample (21%) provided public enrollment data of new transfers into engineering via static PDF reports. These reports were typically a snapshot of enrollments for the institution by semester or were annual reports with tables of enrollments broken down by enrollment term. Many of these tables were available on landing pages with links to several years' worth of PDF reports. The types of static PDF reports grouped into four sub-categories: 1) Factbooks, 2) Enrollment Reports with a Table by Admit Type, 3) Transfer Student Enrollment Reports, and 4) Transfer Student Profiles.

The least advanced sub-category of static reports included a small subset of institutions (3%) that reported enrollment data of new transfers into engineering via university Factbooks. These large summary reports are published annually; are extensively detailed often extending beyond 100 pages; and include a wealth of information about the institution beyond enrollments including their mission statement, maps of the campus, organizational charts of executive leadership, degrees awarded, faculty research grants and awards, and financial statements. The six institutions in the sample that provided enrollment data of new transfers into engineering in a Factbook did so through tables of new student enrollments broken down by college and admit type; Figure MS2-2 is an example of a table pulled from an institution's Factbook.

Slightly more advanced, and the most common static reports, were PDF enrollment reports (12%) reported by enrollment term (e.g., Fall 2016) that included tables of enrollments across the institution. These reports were usually extensive and included all undergraduate and graduate enrollments by college or major. All 23 institutions in the sample with a PDF enrollment report incorporated enrollment of new transfer students in a table of new students broken down by college and admit type. Figure MS2-3 provides an example of an enrollment report with a table of enrollments with columns that distinguish admit type and rows that distinguish entering college. A utility of these reports was that they typically included multiple years of enrollment data in one table with columns to compare differences year to year, as is the case in the example Figure MS2-3.

Figure MS2-2

Example Static Report – PDF Factbook

Fact Book 2017-2018
Office of Institutional Effectiveness and Analytics
University of Nebraska-Lincoln

FALL ENROLLMENT

Enrollment by College and Student Level
Fall 2017
Page 1 of 2

Undergraduate Enrollment								
College	**First-Time Freshmen**	**Other Freshmen**	**Sophomore**	**Junior**	**Senior**	**Unclassified**	**Total**	**New Transfers***
Agricultural Sciences & Natural Resources	491	79	454	610	699	0	2,333	131
Architecture	115	16	90	76	104	0	401	14
Arts & Sciences	785	162	740	1,240	1,399	0	4,326	143
Business	839	183	740	1,047	1,109	0	3,918	137
Education & Human Sciences	448	93	552	757	929	0	2,779	100
Engineering	654	70	569	748	1,076	0	3,117	132
Fine & Performing Arts	174	30	139	187	190	0	720	24
Journalism & Mass Communications	157	39	212	331	301	0	1,040	27
Explore Center Undergraduates	1,242	229	436	137	30	0	2,074	103
Other (includes Intercampus & Visitors)	0	10	0	1	1	234	246	0
Total Undergraduate	**4,905**	**911**	**3,932**	**5,134**	**5,838**	**234**	**20,954**	**811**

***New Transfers** are included in "**Total**" column.

(University of Nebraska-Lincoln, Fall 2017, https://iea.unl.edu/publications/fb17_18.pdf)

A smaller group of institutions (4%) provided enrollment data for new transfers in engineering through PDF transfer student enrollment reports. Institutions with these transfer-specific reports usually incorporated more detailed information about new transfers in engineering, including trend data of new transfer enrollments by college over time as well as acceptance and yield rates of transfer applicants by college. Figure MS2-4 provides an example from an institution in the sample that included enrollment counts of new transfer students by entering college over the past five years and details acceptance and yield rates.

Finally, a few institutions (2%) provided enrollment data for new transfers in engineering through PDF transfer student profiles, which were the most advanced type of static reporting tool for transfer students. Institutions with these transfer-specific profile reports usually incorporated more detailed information about new transfers in engineering beyond enrollments, such as sending institution and major. Figure MS2-5 provides an example of these types of detailed PDF profiles of incoming transfer students.

Figure MS2-3

Example Static Report – PDF Enrollment Report with Table by College & Admit Type

Table E1.1
THE UNIVERSITY OF ALABAMA
New First-Time Undergraduates and New Transfers
Fall 2018

New First-Time Undergraduates

	Fall Enrollment				18 vs 17		18 vs 16		18 vs 15	
College or School	2018	2017	2016	2015	Diff	% Diff	Diff	% Diff	Diff	% Diff
Arts & Sciences	2,282	2,490	2,425	2,518	-208	(8.35%)	-143	(5.90%)	-236	(9.37%)
Capstone Col of Nursing	536	646	588	534	-110	(17.03%)	-52	(8.84%)	2	0.37%
Comm & Info Scs	402	377	513	484	25	6.63%	-111	(21.64%)	-82	(16.94%)
Continuing Studies	0	0	0	0	0		0		0	
Culverhouse Col of Business	1,460	1,650	1,676	1,386	-190	(11.52%)	-216	(12.89%)	74	5.34%
Education	259	308	299	324	-49	(15.91%)	-40	(13.38%)	-65	(20.06%)
Engineering	1,223	1,435	1,579	1,480	-212	(14.77%)	-356	(22.55%)	-257	(17.36%)
Human Environmental Scs	469	477	456	457	-8	(1.68%)	13	2.85%	12	2.63%
Social Work	32	24	23	28	8	33.33%	9	39.13%	4	14.29%
University Total	*6,663*	*7,407*	*7,559*	*7,211*	*-744*	*(10.04%)*	*-896*	*(11.85%)*	*-548*	*(7.60%)*

New Transfers

	Fall Enrollment				18 vs 17		18 vs 16		18 vs 15	
College or School	2018	2017	2016	2015	Diff	% Diff	Diff	% Diff	Diff	% Diff
Arts & Sciences	293	303	330	347	-10	(3.30%)	-37	(11.21%)	-54	(15.56%)
Capstone Col of Nursing	185	134	134	143	51	38.06%	51	38.06%	42	29.37%
Comm & Info Scs	64	87	87	79	-23	(26.44%)	-23	(26.44%)	-15	(18.99%)
Continuing Studies	0	0	0	0	0		0		0	
Culverhouse Col of Business	347	381	358	396	-34	(8.92%)	-11	(3.07%)	-49	(12.37%)
Education	99	96	116	106	3	3.13%	-17	(14.66%)	-7	(6.60%)
Engineering	220	212	169	205	8	3.77%	51	30.18%	15	7.32%
Human Environmental Scs	325	305	269	269	20	6.56%	56	20.82%	56	20.82%
Social Work	22	18	15	22	4	22.22%	7	46.67%	0	0.00%
University Total	*1,555*	*1,536*	*1,478*	*1,567*	*19*	*1.24%*	*77*	*5.21%*	*-12*	*(0.77%)*

(University of Alabama, Fall 2018, https://oira.ua.edu/new/reports/5b9a6ebfd7005c7c3be281bc#Table%20E1.1%3A%20New%20First-Time%20Undergraduates%20and%20New%20Transfers)

Although enrollment data for new transfers by college are available in these static reports, the information is limited, particularly when compared with information available in interactive enrollment dashboards subsequently described. Finding data this way was cumbersome and may limit how practitioners at these institutions, members of the public, or prospective and current students and their families can assess and evaluate matriculation through transfer pathways, thereby suggesting a more limited form of transfer receptivity.

Figure MS2-4

Example Static Report – PDF Transfer Student Enrollment Report

University of Maine
Undergraduate Applications, Acceptances, & Enrollments
New Transfers

		Fall 2015	Fall 2016	Fall 2017	Fall 2018	Fall 2019
College of Education & Human Development	Applicants	121	121	141	127	158
	Completed Applications	93	101	109	99	108
	Acceptances	78	86	86	80	82
	Acceptance Rate	**84%**	**85%**	**79%**	**81%**	**76%**
	Enrollment	40	46	47	42	41
	Yield	**51%**	**53%**	**55%**	**53%**	**50%**
College of Engineering	Applicants	190	165	196	234	292
	Completed Applications	152	140	166	176	214
	Acceptances	122	117	126	133	164
	Acceptance Rate	**80%**	**84%**	**76%**	**76%**	**77%**
	Enrollment	88	66	64	77	93
	Yield	**72%**	**56%**	**51%**	**58%**	**57%**

(University of Maine, Fall 2019, https://umaine.edu/oira/wp-content/uploads/sites/502/2019/11/15-19-TRF-Apps-by-College-11.7.19-1.pdf)

Figure MS2-5

Example Static Report – PDF Transfer Student Profile

Enrollment by Academic Unit

	Corvallis	Ecampus	Cascades	LaGrande	Portland	Total
Primary College						
Agricultural Sciences	96	146	0	15	0	257
Business	200	54	32	0	2	288
Earth, Ocean, and Atmospheric Sciences	49	50	0	0	0	99
Engineering	316	0	32	0	0	348
Forestry	35	36	30	4	0	105
Liberal Arts	194	157	49	0	2	402
Public Health and Human Sciences	132	24	30	0	1	187
Science	184	0	23	0	0	207
University Exploratory Studies	22	8	7	0	0	37
Total	**1228**	**475**	**203**	**19**	**5**	**1930**
Top Majors						
Business Administration*	96	54	25	0	2	177
Psychology	53	51	22	0	2	128
Computer Science*	86	0	24	0	0	110
Fisheries and Wildlife Sciences	14	84	0	0	0	98
Mechanical Engineering*	77	0	0	0	0	77
Biology	53	0	23	0	0	76
Natural Resources	12	36	22	4	0	74
Kinesiology	53	0	19	0	0	72
Human Dev. and Family Sciences	19	49	0	0	0	68
Environmental Sciences	32	24	11	0	1	68
Agricultural Sciences	15	19	0	8	0	42
Electrical and Computer Engineering*	41	0	0	0	0	41
Sociology	20	16	0	0	0	36
Anthropology	13	22	0	0	0	35
Horticulture	9	25	0	0	0	34

*Includes Pre-Professional Major

Where They Came From

Oregon Community Colleges	
Blue Mountain Comm College	15
Central Oregon Comm College	150
Chemeketa Community College	151
Clackamas Community College	71
Clatsop Community College	1
Columbia Gorge Comm College	11
Klamath Community College	11
Lane Community College	57
Linn-Benton Community College	137
Mt Hood Community College	38
Portland Comm College-Main	132
Rogue Community College	23
Southwestern Ore Comm College	20
Tillamook Bay Comm College	3
Treasure Valley Com College	9
Umpqua Community College	32
Total	**861**

Oregon Public Universities	
Eastern Oregon University	8
Oregon Inst of Technology	10
Portland State University	39
Southern Oregon University	18
University of Oregon	17
Western Oregon University	23
Total	**115**
Oregon Private Institutions	
Art Institute of Portland	2
Concordia University	3
Corban University	1
George Fox University	2
Linfield College	5
Marylhurst University	2
Pacific University	4
University of Portland	1
Warner Pacific College	1
Willamette University	1
Total	**22**

Out-of-State Institutions (Top 10 States Listed)	
California	210
Washington	92
Texas	30
Arizona	23
Idaho	23
Colorado	20
Florida	19
Pennsylvania	18
New York	16
Alabama	15
Total Out-of-State	**718**
Other	
Foreign Country Institutions	33
Unknown	181

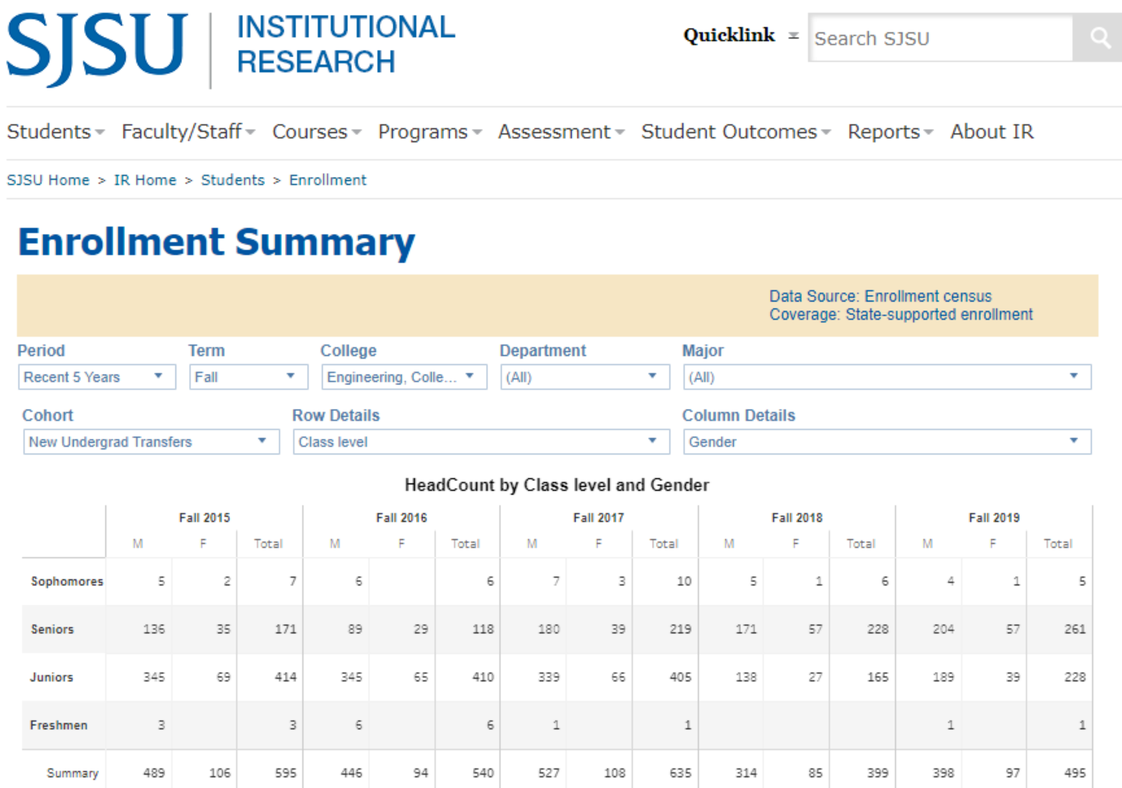
(Oregon State University, Fall 2018, https://institutionalresearch.oregonstate.edu/sites/institutionalresearch.oregonstate.edu/files/new-student-profile_fall-2018.pdf)

3.4.1.1.3 Institutions with Interactive Dashboards for Engineering Transfer Enrollment

The most advanced reporting tools to examine transfer enrollments in engineering were interactive enrollment dashboards. A total of 73 institutions in the sample (38%) provided public access to interactive enrollment dashboards with a variety of ways to drill down and analyze enrollments at the institution. There were two types of enrollment dashboards. The most prominent were institution-wide enrollment dashboards that included summary enrollment counts for all undergraduate and graduate students. All 61 institutions in the sample (31%) with these dashboards had a way to filter enrollments by admit type and entering college. These dashboards typically allowed for examination of enrollment trends across a period of years set by the viewer as well as detailed information of enrollment cohorts by term. Many of these reports provided extensive access to data about students including race/ethnicity, gender, first-generation status, Pell eligibility, and enrollment status (i.e., Full/Part-time); Figure MS2-6 provides an example.

Figure MS2-6

Example Interactive Enrollment Dashboard – All Students



	Fall 2015			Fall 2016			Fall 2017			Fall 2018			Fall 2019		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Sophomores	5	2	7	6		6	7	3	10	5	1	6	4	1	5
Seniors	136	35	171	89	29	118	180	39	219	171	57	228	204	57	261
Juniors	345	69	414	345	65	410	339	66	405	138	27	165	189	39	228
Freshmen	3		3	6		6	1		1				1		1
Summary	489	106	595	446	94	540	527	108	635	314	85	399	398	97	495

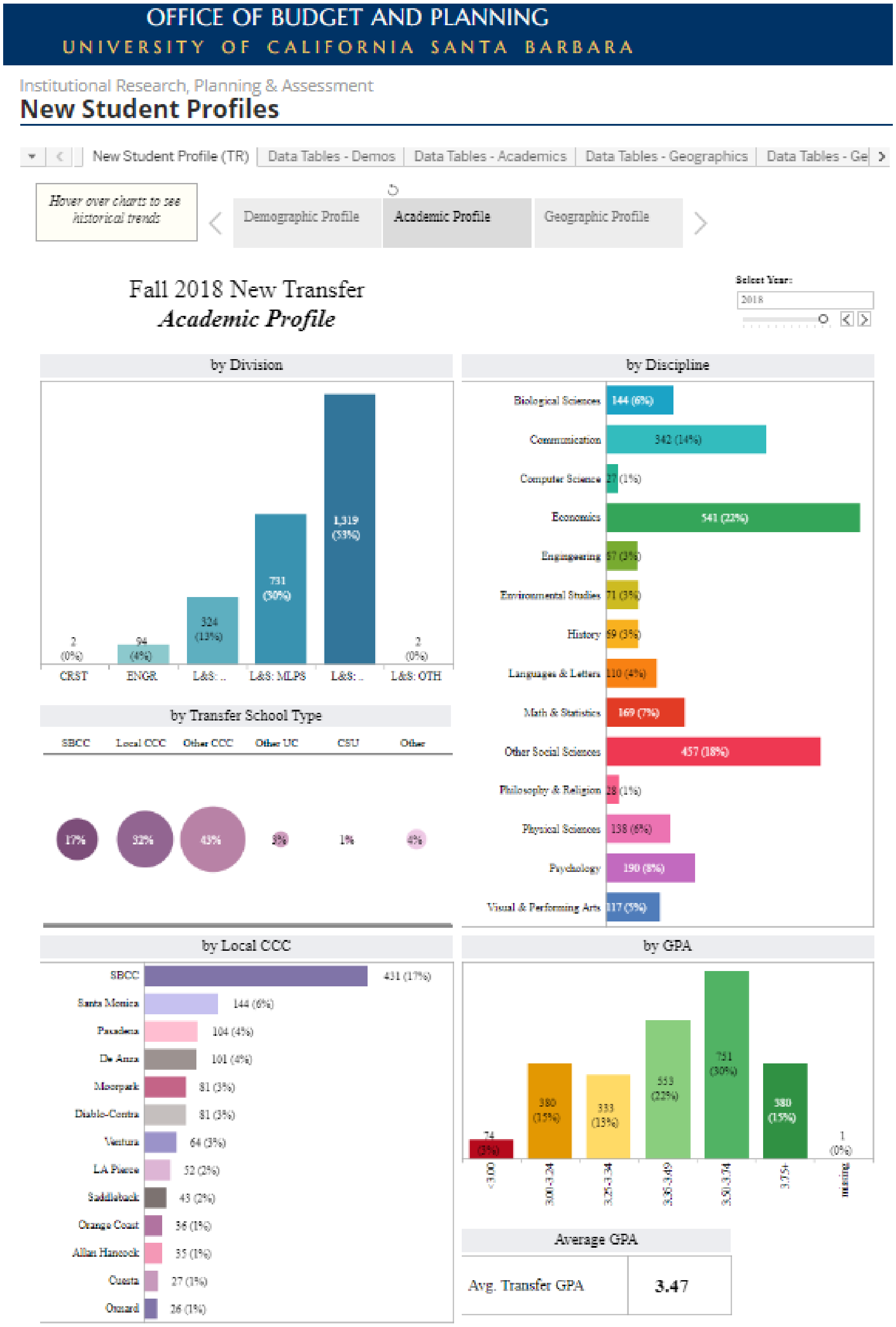
(San Jose State University, Fall 2019, http://iea.sjsu.edu/Students/enrollment/enrollment_others.php)

Fewer institutions (6%) had a further nuanced interactive dashboard that included data exclusively for undergraduate transfer students. All of these transfer-specific dashboards had filters for entering college and provided access to even more detailed information about new transfer students including sending institution, average number of transfer credits for entering students, and community college GPA. As discussed in detail subsequently in this manuscript, another key advantage of institutions with transfer-specific dashboards was that institutions tended to report graduation rate data for transfer students by college as well as enrollment data. Figure MS2-7 visualizes an example of a transfer-specific dashboard from one sample institution.

Institutions with publicly available interactive enrollment dashboards and transfer-specific dashboards may be better able to support transfer student matriculation and thus be more transfer receptive. I acknowledge that some institutions in the sample may have similar interactive enrollment dashboards that are not made available to the public, which is a limitation when trying to compare across institutions and draw conclusions about transfer receptivity. However, the transparency and extent of willingness to share data publicly may play a role in how prospective and current students feel they are being served, valued and prioritized at the institution.

Figure MS2-7

Example Transfer-Specific Interactive Enrollment Dashboard



(University of California – Santa Barbara, Fall 2018, http://bap.ucsb.edu/institutional.research/new.student.profiles/new.transfer.student.profile/)

3.4.1.2 Comparing Institutions with and without Publicly Available Enrollment Data

A total of 113 institutions in the sample (59%) had enrollment data for new transfer students entering engineering available publicly through IR websites. An additional 41 institutions (21%) provided data via email upon request for this study. For the latter group of institutions, although they did not provide data on their IR websites, they provided data upon email request without cost and thus are considered to have provided data publicly for the purposes of this study and are included as having publicly available data in the following analyses. Combined, 154 institutions provided some engineering transfer enrollment data, with 39 remaining institutions providing no data.

I conducted descriptive analyses that compared the institutions with some engineering transfer enrollment data with institutions with no engineering transfer enrollment data. Doing so brings attention to systematic differences between institutions with and without transfer data. Because public and private institutions have different expectations for transparency of sharing information, I first present findings related to institutional control. Then, I organize the rest of the findings moving from macro-level variables to micro-level variables beginning with differences at the state level and with state-level transfer policies. Next, I focused at the institution level by examining differences between groups in their institutional characteristics, institutional selectivity, and finance and student cost variables. Then, I examined the relationship of a college-level variable—engineering program rank— and transfer composition. Finally, I compared institutions with publicly available enrollment data with those that did not on several student-level variables including enrollment data for undergraduates, student demographics and student success outcomes.

Clustered bar charts compare frequency counts across groups for nominal variables. For ratio variables, medians are used to avoid issues that outliers and skewness can pose for means. Additionally, boxplots (Appendix MS2-B) compare the distributions of each independent variable for the two groups visually and, when possible, include “notches” around the median, which signify the 95% confidence interval of the median value. If the notches for the two distributions do not overlap, there is strong evidence (95% confidence) that the medians differ (Chambers et al., 1983). Figures that do not include notches had confidence intervals that fell outside of the interquartile range. Table MS2-3 provides summary data about the medians for variables in which there were significant differences between institutions with publicly available engineering transfer enrollment data and those not reporting data publicly. These findings are detailed in the proceeding sections. Boxplots are provided for non-significant results in Appendix MS2-E.

Table MS2-3

Summary of Significant Results – Comparing Institutions With and Without Enrollment Data

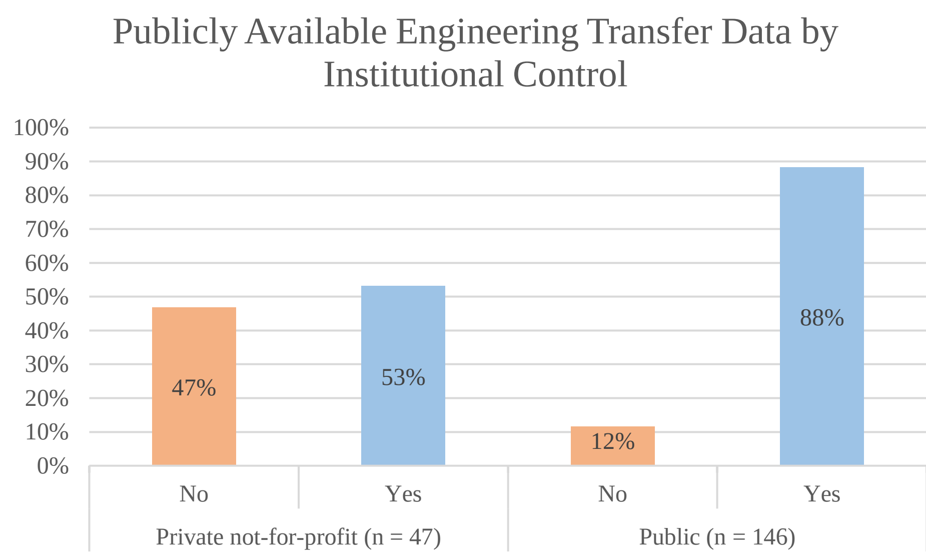
Variable	Median - Publicly Available Enrollment Data	Median - No Publicly Available Enrollment Data	Diff
Avg. Percent Admitted (2010-2018)	66.20%	55.30%	
Avg. Percent Admitted (2010-2018) (Publics Only)	69.20%	63.30%	
Avg. Percent Admitted (2010-2018) (Privates Only)	42.80%	35.90%	
Avg. SAT Math 75th Percentile (2010-2018)	638	688	
Avg. SAT Math 75th Percentile (2010-2018) (Publics Only)	633	667	
Avg. SAT Math 75th Percentile (2010-2018) (Privates Only)	723	760	
Avg. State Appropriations (2010-2018) (Publics Only)	$ 161,070,333	$ 97,426,328	$63
Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2018) (Privates Only)	$ 31,820.12	$ 27,185.81	$
US News World Report Best Undergraduate Engineering Schools 2019 Ranking (Doctorate Offered)	93	54	
US News World Report Best Undergraduate Engineering Schools 2019 Ranking (Doctorate Offered)(Publics Only)	93	101	
US News World Report Best Undergraduate Engineering Schools 2019 Ranking (Doctorate Offered) (Privates Only)	61	29	
US News Engineering Program Rank for Institutions with No Doctoral Programs	38	38	
Avg. Total entering students at the undergraduate level fall (2010-2018)	5475	2803	
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)	1346	408	
Avg. IPEDS UG Transfer Composition % - All Entering Students	24.8%	14.8%	
Avg. Percent of total enrollment that are Minoritized Race or Ethnicity	14.2%	12.9%	
Avg. % of All UG EGR Enrollments - Minoritized	11.5%	12.5%	
Avg. Percent of total enrollment that are women (2010-2018)	51.2%	47.9%	
Avg. % of All UG EGR Enrollments - Women	19.2%	22.3%	
Avg. Full-time retention rate (2010-2018)	85.4%	91.6%	

3.4.1.2.1 Descriptive Comparison by Institutional Control

Institutional control (i.e., public/private) played a considerable role in whether or not institutions reported engineering transfer data publicly (Figure MS2-8). A higher proportion of public institutions (n = 146; 88%) had publicly available enrollment data of new transfer students entering into engineering. Only 53% of private, not-for-profit institutions (n = 47) in the sample reported some engineering transfer enrollment data. This result is unsurprising given public institutions' reliance on public taxpayer monies coming with increased expectations for transparency.

Figure MS2-8

Comparing Engineering Transfer Enrollment Data by Institutional Control

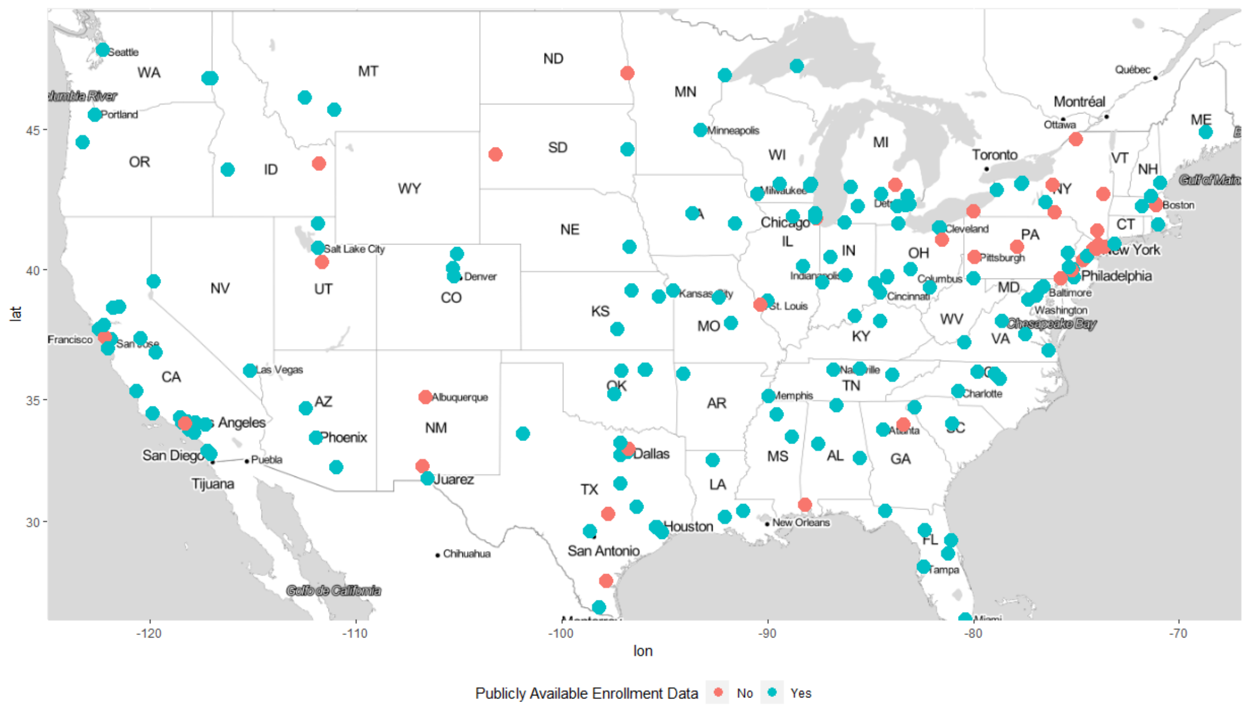


3.4.1.2.2 Descriptive Comparison by State & State-Transfer Policies

To understand differences between states in reporting of engineering transfer enrollment data publicly, I first conducted visual analyses through mapping. Figure MS2-9 includes all 193 sample institutions. Most notably is that institutions that did not report data publicly seemed to cluster in the northeastern United States, with several institutions in New York, Pennsylvania and New Jersey not reporting enrollment data for engineering transfer students publicly. This finding is likely confounded with the previous finding of differences in reporting by institutional control as more of the private institutions in the sample reside in the northeast. A few other states including New Mexico, South Dakota and North Dakota also have a lack of institutions reporting engineering transfer data publicly, albeit with each state only having one or two institutions in the sample.

Figure MS2-9

Map of Sample Institutions by Publicly Available Engineering Transfer Enrollment Data



To extrapolate differences in reporting by state while accounting for institutional control, I calculated the percentages of public institutions within each state that reported enrollment data publicly and then compared those values across states (Table MS2-4). Thirty-six of the 47 states (77%) in the sample had 100% of their public institutions report engineering transfer enrollment data publicly. Of particular note were California (n = 19), Michigan (n = 8), Florida (n = 5), and

Virginia (n = 5), which are home to a substantial number of public institutions in the sample, all of which reported data publicly. In contrast, six states (i.e., Delaware, North Dakota, New Mexico, Pennsylvania, Georgia, and South Dakota) had 50% or less of their public institutions providing enrollment data publicly, although only Pennsylvania (25%; n = 4) had more than two public institutions in the sample. New York (60%; n = 5), Texas (73%, n = 11), and Ohio (88%; n = 8) fell in between and are home to a considerable number of public institutions in the sample. In summary, there are some differences across states when comparing the public availability of engineering transfer enrollment data. If we consider the positive impacts that publicly available enrollment data may have on transfer receptivity, institutions may benefit from looking to California, Michigan, Florida, and Virginia as exemplars at the state level for public enrollment reporting disaggregated for transfer students.

Table MS2-4

Percentage of Public Institutions Reporting Engineering Transfer Enrollment Publicly by State

State	% of Public Institutions within State Reporting Enrollment Data Publicly	Total Public Institutions Within State
DE	0%	1
ND	0%	1
NM	0%	2
PA	25%	4
GA	50%	2
SD	50%	2
NY	60%	5
NJ	67%	3
TX	73%	11
AL	75%	4
OH	88%	8
AR	100%	1
AZ	100%	2
CA	100%	19
CO	100%	3

CT	100%	1
FL	100%	5
HI	100%	1
IA	100%	2
ID	100%	2
IL	100%	4
IN	100%	2
KS	100%	3
KY	100%	2
LA	100%	3
MA	100%	3
MD	100%	3
ME	100%	1
MI	100%	8
MN	100%	2
MO	100%	2
MS	100%	2
MT	100%	2
NC	100%	3
NE	100%	1
NH	100%	1
NV	100%	2
OK	100%	2
OR	100%	2
RI	100%	1
SC	100%	2
TN	100%	3
UT	100%	2
VA	100%	5
WA	100%	2
WI	100%	3
WV	100%	1

To understand the influence of state-level transfer policy on institutions' reporting of transfer enrollment data, I then compared institutions that reported engineering transfer enrollment data publicly with those not reporting data publicly based on the existence of four state-level transfer policies: 1) transferable core of lower-division courses, 2) statewide common course numbering systems, 3) statewide guaranteed transfer of an associate degree, and 4) statewide reverse transfer (Appendix MS2-E). There were no notable differences between groups of institutions for any of these state-level transfer policies. It is important to note that increased transparency of enrollment data for transfer students may not be an intended outcome of these policies, but it seemed plausible that it might be indirectly affected by the existence of these policies. Alternatively, it could be that examination of the influence of state-level policies is muddied when aggregated at the state-level, and differences at the institution level play a larger role in public availability of transfer enrollment data.

3.4.1.2.3 Descriptive Comparison by Other Institutional Characteristics

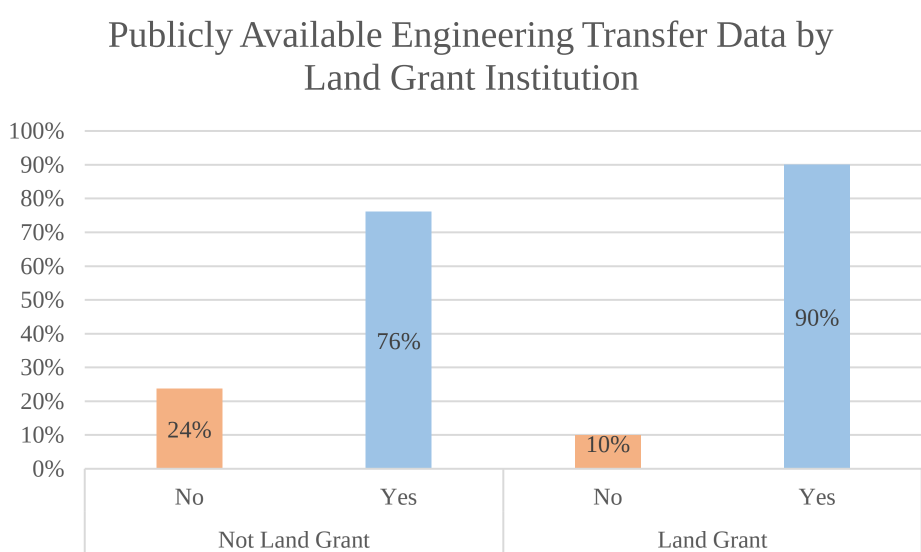
I compared institutions that reported enrollment data for engineering transfer student publicly with those that did not across a number of other institutional characteristics in addition to institutional control and found few notable differences. The exceptions were Land Grant Institution, and multi-institution/multi-campus organization. In the case of the former, as evidenced in Figure MS2-10, land grant institutions more frequently reported engineering transfer enrollment data publicly compared with non-land grant institutions. With only one private land grant institution in the sample, this difference is not entirely conflated with institutional control, with public land grant institutions reporting data more frequently than public non-land grant institutions.

That was not true, however, for multi-institution campus organizations. I compared multi-institution/multi-campus organizations with single-institution/single-campus organizations in the availability of public engineering transfer enrollments (Appendix MS2-E). All 47 private institutions in the sample are also single-institution/campus organizations, meaning only 40 of the 146 public institutions are single/campus institutions. After removing private institutions and comparing the single and multi-institution campus institutions by public availability of engineering transfer enrollment data, I observed no meaningful differences (Appendix MS2-E).

Public single campus and multi-campus institutions reported engineering transfer enrollment data similarly. Several other institutional characteristics that can be directly compared across all institutions in the sample including Land Grant Institution, Carnegie Classifications: Basic and Undergraduate Profile, as well as Degree of urbanization, and Hispanic Serving Institution Membership seemed to have little relationship with whether an institution had publicly available engineering transfer enrollment data (Appendix MS2-E).

Figure MS2-10

Comparing Engineering Transfer Enrollment Data by Institutional Control



3.4.1.2.4 Descriptive Comparison by Institutional Selectivity Metrics

Next, I examined the relationship between public availability of engineering transfer data and two metrics for institutional selectivity: admit rate and average 75th percentile SAT Math score. An institution's admit rate compares the proportion of total applicants to the number of applicants who receive offers of admission. SAT Math scores are particularly informative for selectivity of admissions in STEM programs. Institutions not reporting transfer enrollment data had a lower median admit rate ($\tilde{X}$ = 55.3%) than institutions with transfer enrollment data ($\tilde{X}$ =

66.2%). As evidenced in Appendix MS2-B1, although the range of admit rates for each group were similar, the interquartile range (i.e., middle 50%) of admit rates for institutions that did not have engineering transfer data was much wider (23%–70%) than for institutions that had publicly available engineering transfer enrollment data (50–76%).

The differences between the average 75th percentile SAT Math scores for institutions with publicly available engineering transfer enrollment data and those that did not (Appendix MS2-B4) was even more pronounced than those for admit rates. Institutions not reporting engineering transfer enrollment data had a higher median 75th percentile SAT Math score ($\tilde{X}$ = 688) than those that did ($\tilde{X}$ = 638). A consideration of these findings is that they may be conflated by institutional control, wherein privates are generally more selective than public institutions. To examine this, I generated similar boxplots comparing the relationship of publicly available enrollment data with selectivity measures separating private and public institutions. For admit rate, the differences between admit rates of institutions with publicly available engineering transfer enrollment data and those that did not were varied by control, but I did observe some differences among public institutions ($\tilde{X}_{YesData}$ = 69.2%; $\tilde{X}_{NoData}$ = 63.3%) (Appendix MS2-B2) and private institutions ($\tilde{X}_{YesData}$ = 42.8%; $\tilde{X}_{NoData}$ = 35.9%) (Appendix MS2-B3). For admit rate, it seems that institutional control is not entirely conflated with the differences observed between institutions that reported data and those that did not.

When examining differences in average 75th percentile SAT Math scores for entering students at institutions with publicly available engineering enrollment data with those without data, accounting for institutional control, a similar relationship emerged. Although the scores for public institutions (Appendix MS2-B5) were lower in both groups ($\tilde{X}_{YesData}$ = 633; $\tilde{X}_{NoData}$ = 667) compared with private institutions ($\tilde{X}_{YesData}$ = 723; $\tilde{X}_{NoData}$ = 760) (Appendix MS2-B6), the differences in scores based on availability of enrollment data are similar, indicating that differences are not entirely confounded by differences in institutional control. Considered jointly, these descriptive analyses suggest that more selective institutions less frequently provided publicly available engineering transfer enrollment data than less selective institutions in the sample, regardless of institutional control, an indication that they may be less transfer receptive than less selective institutions.

3.4.1.2.5 Descriptive Comparison by Student Cost and Institutional Finance Data

Next, I compared institutions that provided engineering transfer enrollment data publicly with those that did not in the following student cost metrics: published tuition and fees, net price for students with grants and scholarships, and total price for in-state students living off campus. Then, I compared the same groups on average state appropriations and endowment assets. Although incorporated together in logistic regression analyses, conducting meaningful descriptive analysis, particularly visually using boxplots of distributions, required separation of institutions by institutional control. A limitation to consider when interpreting the following descriptive analyses of financial data for public institutions is the small sub-sample size for public institutions that did not report engineering transfer enrollment data. This limitation is evident in some of the figures that have increased size of the notches around the median, indicative of a larger variation in the 95% confidence interval of the median.

For public institutions, the medians for each of the student cost variables were similar for institutions that provided publicly available engineering enrollment data and those that did not, including: net price for students receiving grants and scholarships, tuition and fees, and total price for in-state students living off campus (Appendix MS2-E). Student cost for public institutions seems to be unrelated to whether or not institutions report publicly available engineering transfer enrollment data. Additionally, in comparing endowment assets of public institutions by the availability of engineering transfer enrollment data, there was no difference in median averages (Appendix MS2-E), indicative that no relationship exists between these variables. However, there was a difference when comparing state appropriations between the groups (Appendix MS2-B7). Institutions that reported publicly available engineering transfer enrollment data had higher median state appropriation revenues ($\tilde{X}$ = $161,070,333) relative to institutions not reporting engineering transfer enrollment data ($\tilde{X}$ = $97,426,328). One possible explanation for this finding is that public institutions with more state funding are more likely to have fiscal resources available to report enrollment data publicly by college and admit type. It also could be that, with more funding, there are higher state expectations for public reporting and transparency of institutional enrollment data. In either case, institutions with more state appropriations seemed more likely to report engineering transfer enrollment data publicly.

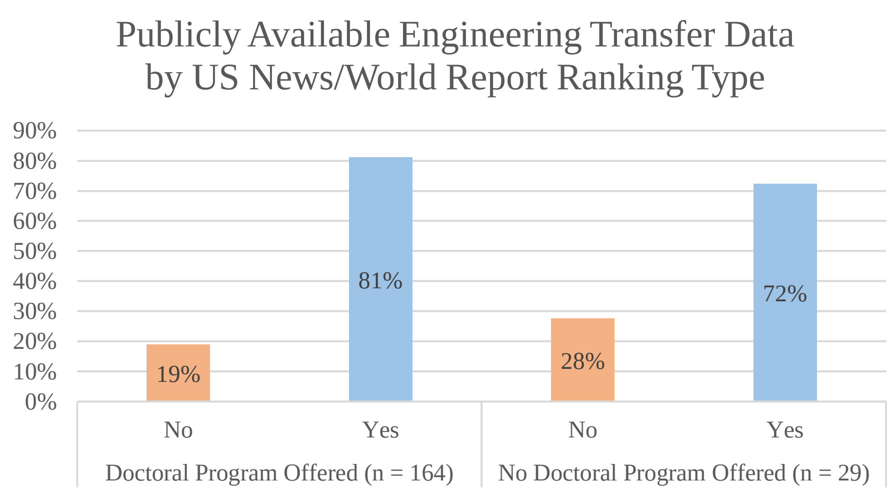
For private institutions, the medians for two of the student cost variables were similar for institutions that provided publicly available engineering enrollment data and those that did not, including: tuition and fees, and total price for in-state students living off campus (Appendix MS2-E). However, unlike for public institutions, private institutions reporting engineering transfer enrollment data publicly had a higher median net price for students receiving grants and scholarships ($\tilde{X}$ = $31,820.12) relative to private institutions in the sample that did not ($\tilde{X}$ = $27,185.81). As is evident in Appendix MS2-B8 the minimum net price for private institutions that provided engineering transfer enrollment data exceeded $20,000, whereas nearly 25% of institutions not reporting transfer enrollments had a net price below $20,000. It could be that these low-cost private institutions lack sufficient resources for public reporting of enrollment by college and admit type. The other institutional finance data metric – endowment assets – was similar for both groups (Appendix MS2-E).

3.4.1.2.6 Descriptive Comparison by Engineering Program Rank

Focusing on college-level variables, I compared the availability of engineering transfer data by types of engineering programs in the *U.S. News and World Report* Rankings (Figure MS2-11). A larger percentage of institutions with doctoral engineering programs (n = 164; 85%) had publicly available engineering transfer enrollment data compared to institutions with no doctoral engineering programs (n = 29; 15%).

Figure MS2-11

Comparing Engineering Transfer Enrollment Data by US News/World Report Ranking Type



Rankings also seemed to relate to whether institutions had publicly available engineering transfer data for institutions with doctoral engineering programs. When examining the distribution of undergraduate engineering program ranks for institutions with doctoral engineering programs by the availability of transfer engineering enrollment data, median rankings for institutions that did not have publicly available engineering transfer enrollment data was considerably lower ($\tilde{X}$ = 54) than for institutions with publicly available engineering transfer enrollment data ($\tilde{X}$ = 93). Captured visually in Appendix MS2-B9, institutions with doctoral engineering programs that did not report transfer enrollment data were, in general, more highly ranked (1 is highest rank) than institutions that provided engineering transfer enrollment data. The relationship for institutions that did not offer doctoral engineering programs was distributed differently (Appendix MS2-B10). The median for undergraduate engineering program rank for institutions that did not report engineering transfer enrollment data ($\tilde{X}$ = 38) was the same as the median ranking for institutions that did report data ($\tilde{X}$ = 38).

An important consideration of these findings is how institutional control plays a role as a confounding variable that explains some of the differences observed between programs that do offer doctoral degrees in engineering. To understand the role that institutional control plays in the relationship between public availability of engineering transfer enrollment data, I generated boxplots for public and private institutions separately. In the case of rankings, institutional control was a significant factor in the relationship between undergraduate engineering program ranking and availability of enrollment data. As evidenced in Appendix MS2-B11, when comparing only public institutions, there is no meaningful difference in engineering program rankings between institutions that did provide publicly available engineering transfer enrollment data ($\tilde{X}$ = 93) than those that did not ($\tilde{X}$ = 101).

In comparing only private institutions, however, there was a substantial difference between the engineering program ranking for private institutions that did not provide enrollment data publicly and those that did (Appendix MS2-B12), with the former having a considerably higher median ranking ($\tilde{X}$ = 29) than the latter ($\tilde{X}$ = 61). In fact, the median ranking for institutions with publicly available data was lower than the 25^{th} percentile ranking (Q1 = 52) for institutions not providing data publicly. Thus, the differences in engineering program ranking between institutions with publicly available engineering transfer enrollment data and those without is conflated with institutional control.

In summary, the *U.S. News and World Report* rankings for undergraduate engineering programs related to the public availability of engineering transfer data primarily for private institutions that offer doctoral programs in engineering, but not for public institutions and not for institutions that do not offer doctoral programs in engineering, regardless of institutional control. For private institutions that offer engineering doctoral programs, higher ranked programs generally provided publicly available engineering transfer enrollment data less frequently than institutions with lower ranked engineering programs. Because that pattern is not evident for institutions without doctoral engineering programs, the finding may point to differences between these groups of institutions in terms of transfer receptivity.

3.4.1.2.7 Descriptive Comparison by Undergraduate Class Characteristics

Next, I examined the relationship of undergraduate class size and number of entering transfer students on whether institutions provide publicly available engineering transfer enrollment data. For institutions that provided publicly available engineering transfer enrollment data, the median total enrollment of undergraduate students ($\tilde{X}$ = 5,475) was over 2,500 higher than institutions that did not ($\tilde{X}$ = 2,803) (Appendix MS2-B13). A similar pattern was observed for the median average of institutions' total number of entering transfer students: institutions that did have publicly available transfer enrollment data had more entering transfer students ($\tilde{X}$ = 1,346) than institutions that did not ($\tilde{X}$ = 408) (Appendix MS2-B14).

To understand the proportion of new undergraduate students at an institution that were transfer students, I derived an institution-wide transfer composition variable using IPEDS data. The transfer composition of institutions with publicly available engineering transfer enrollment data was higher ($\tilde{X}$ = 24.8%) than institutions that did not ($\tilde{X}$ = 14.8%) (Appendix MS2-B15). Thus, it seems that total undergraduate enrollment and transfer enrollments related to institutions' reporting of engineering transfer enrollment data publicly. Institutions enrolling more undergraduate students, more total transfer students, and higher proportions of transfer students in their incoming class more frequently provide publicly available engineering transfer enrollment data. These results are intuitive—institutions that enroll more transfer students are probably more motivated to disaggregate enrollment reports for transfer students, having reached an enrollment threshold to be a sub-group warranting attention through detailed reporting.

3.4.1.2.8 Descriptive Comparison of Student Demographic Characteristics

I also compared the institution-wide student demographics and demographics of students in engineering for institutions with publicly available engineering transfer enrollment data relative to institutions that do not. More specifically, I examined differences between the two groups in the proportion of enrollments of Black/African American, Hispanic/Latinx, Racially/Ethnically Minoritized, and Women students at the institution level as well as in engineering. The Minoritized Race/Ethnicity variable combines the aforementioned race/ethnicities with American Indian/Alaska Native, Native Hawaiian/Pacific Islander and excludes Asian students, which are considered a majority Race/Ethnicity within STEM fields.

Based on results from descriptive analyses, there are no meaningful differences between the groups in medians for Black/African American enrollments (Appendix MS2-E) at the institution level ($\tilde{X}_{\text{YesData}}$ = 5%; $\tilde{X}_{\text{NoData}}$ = 5%) or in engineering ($\tilde{X}_{\text{YesData}}$ = 3.2%; $\tilde{X}_{\text{NoData}}$ = 4.3%). The same is true for Hispanic/Latinx enrollments (Appendix MS2-E) at the institution level ($\tilde{X}_{\text{YesData}}$ = 6.6%; $\tilde{X}_{\text{NoData}}$ = 6.8%) and in engineering ($\tilde{X}_{\text{YesData}}$ = 5.9%; $\tilde{X}_{\text{NoData}}$ = 7.1%).

The results of descriptive analyses comparing Minoritized enrollments for institutions that publicly report engineering transfer enrollment data with those that do not are fairly similar to those for Black/African American and Hispanic/Latinx race/ethnicity groups. Institutions with publicly available engineering transfer enrollment data have slightly higher minoritized student enrollments at the institution ($\tilde{X}$ = 14.2%) than institutions that do not report data ($\tilde{X}$ = 12.9%). The opposite is true in engineering: institutions that do report engineering transfer enrollment data enroll slightly smaller proportions of minoritized students in engineering ($\tilde{X}$ = 11.5%) compared with those that did not ($\tilde{X}$ = 12.5%), although in both cases the differences are small. In examining the distributions visually (Appendix MS2-B17), the range for institution-wide minoritized enrollments in the upper quartiles is more than double (~30%) for institutions that did report engineering transfer enrollment data than the fairly narrow range of upper quartile values (~12.5%) for institutions that did not report data. In contrast, the distributions for minoritized enrollments in engineering are much more similar for both groups (Appendix MS2-E). In summary, it seems that institution-wide and engineering minoritized student enrollments did not vary considerably between institutions that reported engineering transfer enrollment data publicly and those that did not.

There were clearer distinctions between institutions that did and did not report engineering transfer enrollment data publicly in terms of enrollment of women, both at the institution-level (Appendix MS2-B18) and in engineering programs (Appendix MS2-B19). Institutions that reported engineering transfer enrollment data enrolled higher proportions of women at the institution-level ($\tilde{X}$ = 51.2%) compared to institutions that did not report engineering transfer enrollment data ($\tilde{X}$ = 47.9%). The opposite was true in engineering (Appendix MS2-B19); institutions that reported engineering transfer enrollment data enrolled lower proportions of women ($\tilde{X}$ = 19.2%) compared to institutions that did not report data ($\tilde{X}$ = 22.3%).

3.4.1.2.9 Descriptive Comparison by Student Success Metrics

Finally, I examined the relationship between institution-wide undergraduate student retention metrics and whether or not institutions provided publicly available engineering transfer enrollment data. Graduation rates were excluded from these analyses as there is no logical linkage between public availability of enrollment data and graduation outcomes, and any findings are probably conflated with other variables. The median retention rate for institutions that reported publicly available engineering enrollment data was lower ($\tilde{X}$ = 85.4%) than for institutions that did not ($\tilde{X}$ = 91.6%), although over 75% of the institutions in both groups retained more than 80% of students (Appendix MS2-B20).

Thus, although the large majority (75%) of institutions that reported engineering transfer enrollment data publicly retain 80% or more of their FTIC students after their first year, the median retention rate remains considerably below the median retention rate for institutions that did not report data publicly. This finding suggests that retention of FTIC students may be related to the public availability of transfer enrollment data. One possible explanation is that institutions with higher attrition of FTIC students prioritize enrollment of transfer students to replace them, and as a result, more frequently report transfer enrollment data publicly. Conversely, institutions with higher retention of FTIC students may prioritize less enrollment of transfer students, and may in doing so may be less transfer receptive. Additionally, it could be that retention rate conflates with selectivity and institutional prestige, with more selective institutions retaining FTIC students at higher rates and enrolling fewer transfer students.

3.4.1.3 Predicting Institutions With/Without Engineering Transfer Enrollment Data

I used the findings from the descriptive analyses to select variables for inclusion in a logistic regression model to examine their relative relationship on the likelihood that institutions provide publicly available engineering transfer enrollment data. Any variable where the median for one group that fell outside of the notch, or 95% confidence interval, of the other group, was included in the initial logistic regression models. Table MS2-5 provides a list of predictor variables that were initially included in the model. The model included all institutions in the sample (n = 193).

Table MS2-5

Predictor Variables in Logit Regressions Predicting Publicly Available Enrollment Data

Initial List of All Predictor Variables to be Assessed for Model Fit
Control of institution (HD2013)
US News Ranking - Program Type
US News World Report Best Undergrad Engineering Schools 2019 Ranking (All)
Avg. SAT Math 75th Percentile (2010-2018)
Avg. Total entering students at the undergraduate level fall (2010-2018)
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)
Avg. IPEDS UG Transfer Composition All Entering Students
Avg. Full-time retention rate (2010-2018)
Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)
Avg. State Appropriations (2010-2018)
Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)
Avg. Percent of total enrollment that are women (2010-2018)
Avg. % of All UG EGR Enrollments - Women

Table MS2-6 provides summary statistics for the model of best fit (AIC = 164.37) including variance explained by the model and coefficients, odds ratios, and confidence intervals for predictor variables. Several variables did not have a significant relationship with the dependent variable and were dropped from the final model: US News and World Report

Engineering Program Types and Rankings, Avg. IPEDS UG Transfer Composition for All Entering Students, Avg. Full-Time Retention Rates, and Avg. State Appropriations. The overall model is statistically significant ($R^2 = .20$, χ^2 (6) = 38.4, $p < .001$). Institutional Control and the Average Enrollments of Entering Transfer Students were both significant predictors of whether or not institutions in the sample reported engineering transfer enrollment data publicly.

Table MS2-6

Summary Results from Model 1 – Logistic Regression Predicting Availability of Enrollment Data

	β (SE)	Pr(>|z|)	OR	2.5%	97.5%
(Intercept)	1.14	0.719	3.12	0.01	1836.49
`Control of institution (HD2013)`Public	2.09	0.005**	8.10	1.88	40.22
`Adjusted Avg. SAT Math 75th Percentile (2010-2018)`	-0.06	0.200	0.94	0.85	1.03
`Adjusted Avg. Total entering students at the undergraduate level fall (2010-2018)`	-0.01	0.380	0.99	0.98	1.01
`Adjusted Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)`	0.01	0.029**	1.03	1.01	1.06
`Adjusted Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)`	0.11	0.113	1.12	0.98	1.30
`Adjusted Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)`	0.07	0.097	1.07	0.99	1.16

Note: R2 = .20 (Hosmer-Memeshow), Model χ2(6) = 38.4, p < .001.*** *p < .05, **p<.01, ***p<.001

Public institutions were over 8 times as likely to provide publicly available engineering enrollment data relative to private institutions ($p < .01$) (Table MS2-6). Also under the assumptions of this model, the odds that an institution provided publicly available engineering transfer data increased as the total undergraduate enrollment of transfer students increased ($p < .05$). Neither result is particularly surprising. By receiving funding from state taxpayers, public institutions are, in general, required to be more transparent in sharing information about the institution than private institutions. Additionally, it makes sense that institutions that enroll more transfer students would be more likely to report enrollment data of those students publicly. However, this finding has important implications for transfer receptivity. It could be that the provision of this data publicly is drawing in more transfer students. Institutions with more transfer students may also feel obligated to disaggregate enrollment reports for transfer students, or may be proud of their commitment to embrace the transfer pathway and, in doing so, want to make these data public. Conversely, is the lack of reporting of transfer student enrollments a blind spot for institutions that serve fewer transfer students, or perhaps indicative of efforts to conceal the lack of transfer as a viable pathway at their institution? These findings indicate that institutions with more transfer students are more likely to disaggregate enrollment reports by admit type and college and provide them publicly, and may be more transfer receptive. Although a number of other variables emerged in descriptive analyses as being related to whether or not institutions provided engineering transfer enrollment data publicly, none emerged as predictive when controlling for other variables in the logistic regression model.

3.4.1.4 Engineering Transfer Graduation Data Collection

Having explored in detail the availability of enrollment data for engineering transfer students, I shift focus to the availability of graduation data for these students. In this subsection, I detail findings from collection of graduation rate data for transfer students in engineering across institutions in the sample. Much like the process for collecting enrollment data, I describe and categorize the types of engineering reporting tools available publicly for engineering transfer students. I then describe and categorize the types of graduation data that is available across institutions in the sample. Following similar procedures to collection of enrollment data, I began with a Google search that included "[institution name] institutional research graduation rates" which usually directed me to a landing page for institutional reporting of graduation rates typically authored by IR offices. Then, I scoured the available graduation data for a report or table or dashboard that provided graduation rates by college and admit type. The prevalence of publicly available reports that provided graduation rates by college or admit type was considerably less (Table MS2-7) than was available for enrollment data. Additionally, among the institutions providing data, there was considerable variability in what types of graduation rates were provided for engineering transfer students.

Table MS2-7

Counts of Institutions by Publicly Available Graduation Rate Data

Publicly Available Graduation Rate Data	Count
No	161
Yes	32

With so many institutions lacking publicly available graduation rate data and such variability in the data that was reported, I decided against collecting engineering transfer graduation rate data via email for institutions that did not report them publicly and instead conducted analyses about the types of graduation rate data and tools available across sample institutions. As I located graduation rate data for each institution, I first catalogued the set of students who were included in the reported graduation rates, focusing specifically on whether or not institutions provided graduation rates for transfer students or first-time, full-time cohorts and then if those reports were broken down by college/major. Then, for the 32 institutions that had publicly available graduation data for transfer students in engineering, I also documented the tool that was used to report those graduation rates. After collecting data for all sample institutions, I collated and categorized each into groups by type of graduation rates available publicly (Table XX) and types of reporting tools used to report engineering transfer graduation rates.

3.4.1.4.1 Types of Graduation Data Available

The types of graduation rate data available across the sample varied substantially with some institutions providing detailed graduation rates for both first-time, full-time (FTFT) and transfer cohorts by entering college/major, whereas others referred to an external reporting tool like IPEDS or the Common Data Set for the aggregated graduation rates for FTFT students required by the Student Right to Know Act (Student Right-to-Know and Campus Security Act, 1990), First-time, full-time (FTFT) students are specified by the Student Right to Know Act as cohorts of FTIC students whom are attending a postsecondary institution for the first time and attend the 4-year institution full-time and are usually organized by Fall semester of entry. This distinction is important as it allows institutions to track a subset of FTIC students that, given their "traditional" entry and enrollment statuses that align well with the institution's plans of study, are best positioned to achieve timely graduation. Table MS2-8 provides summary counts of the types of graduation rate data made available publicly by institutions in the sample, grouped by the lowest level of disaggregation available. The two levels of disaggregation of interest were admit type and college/major. For example, institutions that only reported graduation rates for FTFT student cohorts aggregated at the institution level were classified as 'First-Time Full Time (FTFT) All' (n = 72) and represent the least nuanced type of graduation rate reporting across the sample. All of the remaining institutions in the sample, except those that did not provide any graduation data at all (n = 8) or referred users to external reports like IPEDS of College Navigator (n = 7), reported, at a minimum, graduation rates for FTFT cohorts at the institution-level. However, these institutions also reported graduation rate data at additional levels of disaggregation, including admit type, college, or both and were categorized accordingly.

I was unable to locate any graduation rate data or a referral/link to external data for seven institutions (4%) in the sample. For four institutions (2%), graduation rates seemed to include all students, one of which was disaggregated by college (1%), aggregating all undergraduates into one cohort rate, or did not specify which cohort was represented in the graduation rates that were published. Not having data or aggregating reports for all student admit types were the least sophisticated way to publicize graduation data in the sample.

Table MS2-8

Summary Count of Types of Graduation Rate Data Publicly Available by Institution

Graduation Data Type	Count	% of Total
No Grad Data	7	4%
Aggregated for All Admit Types	4	2%
All Students	3	2%
All Students by College	1	1%
FTFT Cohorts Only	111	58%
Referral to External Report (i.e., IPEDS, Common Data Set)	8	4%
FTFT All	71	37%
FTFT by College	32	17%
Reports Available for Transfer Students	71	37%
Transfer All	37	19%
FTFT by College & Transfer All	4	2%
Transfer by College	30	16%
Total	193	100%

One-hundred-and-eleven institutions met the minimum standard set by the Student Right to Know Act and reported graduation rates for FTFT student cohorts. Eight of those institutions (4%) did not have graduation data available on their institution's website, instead referring users to external reports like IPEDS, College Navigator, and Common Data Set. The largest proportion of institutions (37%) reported graduation rates for FTFT student cohorts aggregated at the institution level (n = 72). For many of these institutions, these data were located on a webpage dedicated specifically for meeting external reporting requirements set by the Student Right to Know Act. A smaller group of institutions, although still lacking any reports for transfer students, provided a bit more nuanced graduation data for FTFT cohorts, disaggregating rates by college and/or major (n = 32; 17%). More often than not these consisted of more advanced data reports or dashboard tools with some flexibility to customize the data but lacked a filter for admit type to examine rates beyond those for FTFT cohorts.

A total of 70 institutions in the sample (36%) provided graduation rates publicly for transfer students. Of those, 36 reported graduation rates for all transfer students at the institution (19%), and four institutions (2%) disaggregated graduation rates for FTFT cohorts by college but did not for transfer students. The remaining 30 institutions were the most advanced in reporting graduation for transfer students and disaggregated rates by college (16%). The types of tools used to report graduation rates for transfer students disaggregated by college are discussed in the next sub-section.

Looking across institutions in the sample, the extent to which institutions disaggregated *graduation rates* by admit type and college (i.e., reporting rates for transfer student cohorts in engineering, n = 29; 15%) lags well behind such nuanced and detailed reporting of their *enrollments* (n = 113; 59%). It may be that these types of nuanced reports of transfer student graduation in engineering exist and that a majority of institutions have extensive reporting available internally to monitor graduation of transfer cohorts by college. It is also plausible that tracking and reporting of graduation rates for transfer cohorts, particularly disaggregated by college, may not be common across institutions in the sample. Advances in public reporting for FTFT cohorts of students, probably in response to external demands for transparency, seem to have not had the same impact on reporting of graduation for transfer students.

3.4.1.4.2 Types of Engineering Transfer Graduation Data and Reporting Tools

A majority of the institutions in the sample did not have any publicly available reports or dashboard tools (n = 161) to report graduation rates for transfer students in engineering (Table

MS2-9), accounting for 83% of the sample. 32 institutions (17%) provided graduation data for engineering transfer students through a public report, study, or dashboard.

Table MS2-9

Summary Counts of Types of Transfer Graduation Data Tools

Transfer Graduation Data Tool	Count	% of Total
None	161	83%
PDF Transfer Graduation Report/Study	10	5%
Graduation Dashboard, Filter by College & Admit Type	19	10%
Transfer Graduation Dashboard, Filter by College	3	2%
Total	193	100%

Ten institutions that provided graduation data for transfer students in engineering did so through static PDF reports. Figure MS2-11 provides one example of a report that detailed graduation rates for both transfer and FTFT students disaggregated by college. These reports provide users the ability to compare graduation rates of transfer students with FTFT students in the same college and also compare student success for transfers across disciplines. Although less sophisticated than an interactive dashboard, institutions with these reports can gain some insights into the success metrics for transfer students across disciplines and, as a result, may be better able to maintain or improve graduation rates for transfer students, indicative of transfer receptivity.

Among institutions that provided engineering graduation rate data publicly for transfer students, interactive graduation dashboards that included filters for college and admit type were most common (n = 19). For some institutions, the number of ways to drill-down and compare graduation rates for cohorts was extensive. For example, the dashboard shown in Figure MS2-12 enabled users to compare graduation rates of certain subgroups of FTFT and transfer students, students' academic plans, and different versions of admissions entry exams.

Figure MS2-12

Example of a PDF Transfer Graduation Report

Table 6: Engineering

Entering Fall Class	First Fall Term	First Spring Term	Second Fall Term	Second Spring Term	Third Fall Term	Third Spring Term	Fourth Fall Term	Fourth Spring Term	Fifth Fall Term	Fifth Spring Term	Sixth Fall Term	Sixth Spring Term
2007	94	0 0.0%	0 0.0%	4 4.3%	15 16.0%	31 33.0%	35 37.2%	49 52.1%	50 53.2%	54 57.4%	54 57.4%	55 58.5%
2008	104	0 0.0%	0 0.0%	5 4.8%	15 14.4%	30 28.8%	42 40.4%	55 52.9%	59 56.7%	67 64.4%	69 66.3%	71 68.3%
2009	104	0 0.0%	0 0.0%	6 5.8%	9 8.7%	27 26.0%	35 33.7%	54 51.9%	57 54.8%	63 60.6%	64 61.5%	64 61.5%
2010	113	0 0.0%	0 0.0%	12 10.6%	31 27.4%	43 38.1%	48 42.5%	65 57.5%	67 59.3%	73 64.6%	75 66.4%	78 69.0%
2011	146	1 0.7%	1 0.7%	7 4.8%	19 13.0%	54 37.0%	71 48.6%	87 59.6%	91 62.3%	98 67.1%	99 67.8%	99 67.8%
2012	118	0 0.0%	1 0.8%	11 9.3%	22 18.6%	45 38.1%	56 47.5%	73 61.9%	82 69.5%	85 72.0%	86 72.9%	88 74.6%
2013	132	1 0.8%	1 0.8%	3 2.3%	18 13.6%	34 25.8%	48 36.4%	71 53.8%	75 56.8%	81 61.4%	82 62.1%	
2014	134	0 0.0%	0 0.0%	8 6.0%	20 14.9%	49 36.6%	60 44.8%	80 59.7%	86 64.2%			
2015	122	0 0.0%	0 0.0%	11 9.0%	22 18.0%	58 47.5%	70 57.4%					
2016	130	0 0.0%	1 0.8%	10 7.7%	39 30.0%							
2017	151	0 0.0%	0 0.0%									
Weighted Average:				**6.4%**		**37.0%**		**57.6%**		**65.1%**		**67.0%**

(Tennessee Technological University, https://www.tntech.edu/ir/pdf/graduation_rates/grad_rates_transfer_by_unit_jun_10_2019.pdf)

As was the case for enrollment reporting tools, a few institutions (n = 3), had graduation dashboards specifically dedicated to transfer students, as in Figures MS2-13 and MS2-14. Customized for incoming transfer students, these reports seemed to be more advanced in the types of variables available to understand graduation rates for transfer students including major, demographic characteristics, and student financial aid and income information. These advanced graduation dashboards may help institutions better track and improve student success for transfer students in engineering, and thus may be indicative of a more transfer receptive institution. As was the case for both example figures, half of institutions with a graduation dashboard (n = 11), either transfer-specific or with filters for college and admit type, were located in California. Institutions seeking to advance their reporting efforts for transfer student success might look to the California system for advice and guidance.

Figure MS2-13

Example of a Graduation Dashboard with Filters by College and Admit Type

Student Level:	College:	Department:	Plan:	Outcome:	Within:	SAT scale:
CA Community College Transfers	Engr, CS & Tec...	(All)	(All)	Graduation Rate	Retained/Graduate...	New

How are plans defined? What're these rates? What does "Within" .. Note on SAT scale

Graduation rate

Last Updated: 1/28/2020 3:25:52 PM

Starting Year

Year	Number of Students	Avg. Entry GPA	Avg. SAT	Avg. EI	1 Year	2 Year	3 Year	4 Year	5 Year	6 Year
2007	99				0.0%	13.1%	32.3%	58.6%	65.7%	69.7%
2008	91				0.0%	12.1%	30.8%	41.8%	47.3%	51.6%
2009	99				0.0%	10.1%	35.4%	45.5%	58.6%	65.7%
2010	174				0.0%	19.0%	44.3%	62.6%	73.0%	75.3%
2011	164				0.0%	17.7%	48.2%	65.2%	71.3%	76.8%
2012	181				0.0%	11.6%	37.6%	57.5%	63.5%	67.4%
2013	303				0.3%	13.9%	46.2%	61.4%	67.0%	70.6%
2014	263				0.0%	20.2%	41.4%	57.4%	65.4%	
2015	317				0.3%	10.7%	43.5%	64.7%		
2016	347				0.0%	13.3%	46.1%			
2017	312				0.0%	17.6%				
2018	255				0.0%					
2019	259									

(California State University – Los Angeles, http://www.calstatela.edu/InstitutionalEffectiveness/retention-and-graduation-initiative-2025)

Figure MS2-14

Example of a Transfer-Specific Graduation Dashboard

Transfer Retention and Graduation Rates

Customize this display:

Selection of Parameter: Overall

Time: 2009-2018

Rate Type: Within College

College: All

Major: All

Gender: All

IPEDS Race/Ethnicity: All

Financial Aid Status: All

First Generation: All

CA Community College: All

Low Income

Transfer Retention and Graduation Rate - Overall

Selectiom	Fall 2018 Cohort	Fall 2017 Cohort	Fall 2016 Cohort	Fall 2015 Cohort	Fall 2014 Cohort	Fall 2013 Cohort	Fall 2012 Cohort	Fall 2011 Cohort	Fall 2010 Cohort	Fall 2009 Cohort
Total	1,867	1,325	1,209	1,250	1,264	1,279	1,201	1,379	1,140	908
Year 1 Graduated	0.3%	0.1%	0.4%	0.4%	0.8%	0.4%	0.6%	0.6%	1.0%	0.8%
Year 2 Graduated		55.8%	58.6%	56.2%	60.3%	59.3%	49.7%	56.6%	52.5%	45.0%
Year 3 Graduated			78.6%	78.7%	82.4%	81.5%	76.6%	79.5%	75.7%	69.8%
Year 4 Graduated				82.2%	85.8%	84.9%	80.6%	83.3%	79.2%	75.2%
Year 1 Retained	87.6%	86.9%	88.9%	88.4%	91.2%	91.9%	89.0%	90.4%	85.6%	82.8%
Year 2 Retained		25.8%	23.5%	26.1%	24.6%	26.8%	31.7%	27.6%	27.5%	31.3%
Year 3 Retained			3.4%	3.5%	2.8%	3.5%	3.2%	4.3%	4.1%	5.4%
Year 4 Retained				0.6%	0.2%	0.8%	0.8%	1.3%	1.4%	1.8%
Year 1 Total Success	87.8%	87.0%	89.3%	88.8%	92.0%	92.3%	89.6%	90.9%	86.6%	83.6%
Year 2 Total Success		81.6%	82.1%	82.3%	84.9%	86.2%	81.4%	84.2%	80.0%	76.3%
Year 3 Total Success			82.0%	82.2%	85.3%	85.1%	79.9%	83.8%	79.8%	75.2%
Year 4 Total Success				82.9%	85.9%	85.7%	81.4%	84.6%	80.6%	77.0%

(University of California – Riverside, https://ir.ucr.edu/stats/outcomes/transfer)

3.4.1.5 Comparing Institutions with and without Publicly Available Graduation Data

Having contextualized the types of data and reporting tools available publicly that detail graduation rates for engineering transfer students, I then completed a descriptive analysis comparing institutions that provided publicly available graduation data for engineering transfer students with institutions that did not, identifying variables that may relate to provision of publicly available graduation data by college and admit type. As I did for findings from analyses of enrollment data, I first present findings related to institutional control. Then, I organize the rest of the findings moving from macro-level variables to micro-level variables beginning with differences at the state level and with state-level transfer policies. Then I focused at the institution level by examining differences between groups in their institutional characteristics, institutional selectivity, and institutional finance variables. Finally, I compared groups at the micro-level—student information—including enrollment data for undergraduates.

Table MS2-10 provides summary data about the medians for continuous variables in which there were significant differences between institutions with publicly available engineering transfer enrollment data and those not reporting data publicly. These findings are detailed in the proceeding sections, and boxplots used to compare the distribution of these variables are available in Appendix MS2-C.

Table MS2-10

Summary of Significant Results – Comparing Institutions with and without Graduation Data

Variable	Median - Publicly Available Enrollment Data	Median - No Publicly Available Enrollment Data	Difference	Medians Significan Different (95% CI)
Avg. SAT Math 75th Percentile (2010-2018)	633	657	-24	No
Avg. State Appropriations (2010-2018)	$ 203,151,774	$ 130,235,597	$72,916,177	Yes
Avg. Total entering students at the undergraduate level fall (2010-2018)	6838	4553	2285	Yes
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)	1346	408	938	Yes
Avg. IPEDS UG Transfer Composition % - All Entering Students	28.7%	21.2%	7.5%	Yes
Transfer Composition (Average) (2010-2018)	21.3%	15.9%	5.4%	No

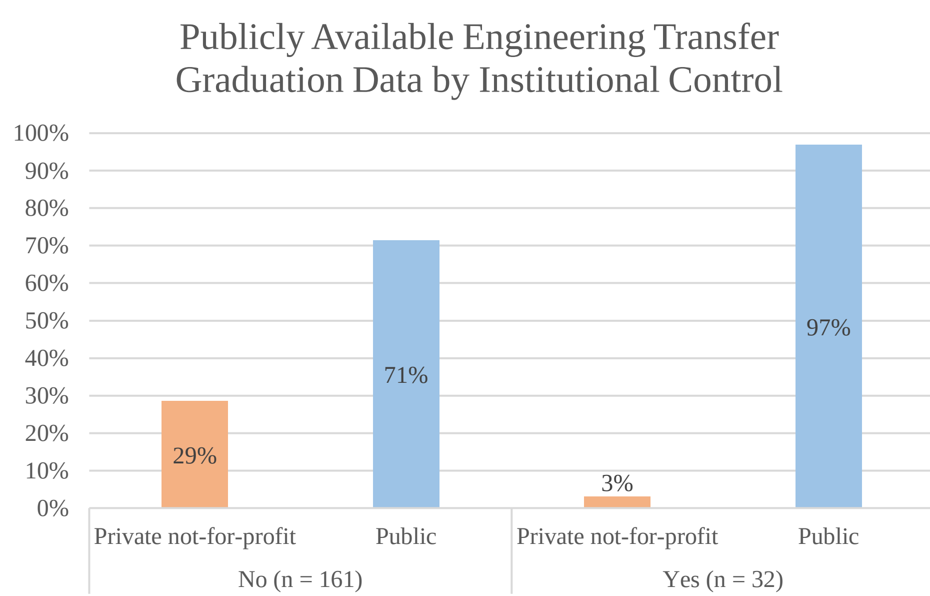
Boxplots are provided for non-significant results in Appendix MS2-F. No meaningful differences were apparent between institutions that reported graduation rates for transfer students in engineering and those that did not for the following groups of independent variables: *U.S. News and World Report* Engineering Program Ranking, student success metrics, and student cost variables (Appendix MS2-F). Although substantial differences were apparent between the student demographics of institutions that reported graduation data and those that did not (Appendix MS2-F), with so few institutions in the former group, differences are probably because of regional differences in demographics and thus are not included in this results section.

3.4.1.5.1 Descriptive Comparison of Graduation Data by Institutional Control

Comparing institutions that provided engineering transfer graduation data publicly with those that did not based on institutional control may shed some light on how public and private institutions manage reporting of graduation data for engineering transfer students. Private institutions less frequently reported engineering transfer graduation rates publicly; only one of the 32 institutions (3%) that reported graduation data was a private institution (Figure MS2-15). This finding aligns with descriptive analyses for public availability of transfer enrollment data. If private institutions are less likely than public institutions to provide enrollment data, it makes sense that private institutions would less frequently report graduation data publicly, particularly at the level of disaggregation needed to capture rates for transfer students in engineering.

Figure MS2-15

Comparing Engineering Transfer Graduation Data by Control of Institution

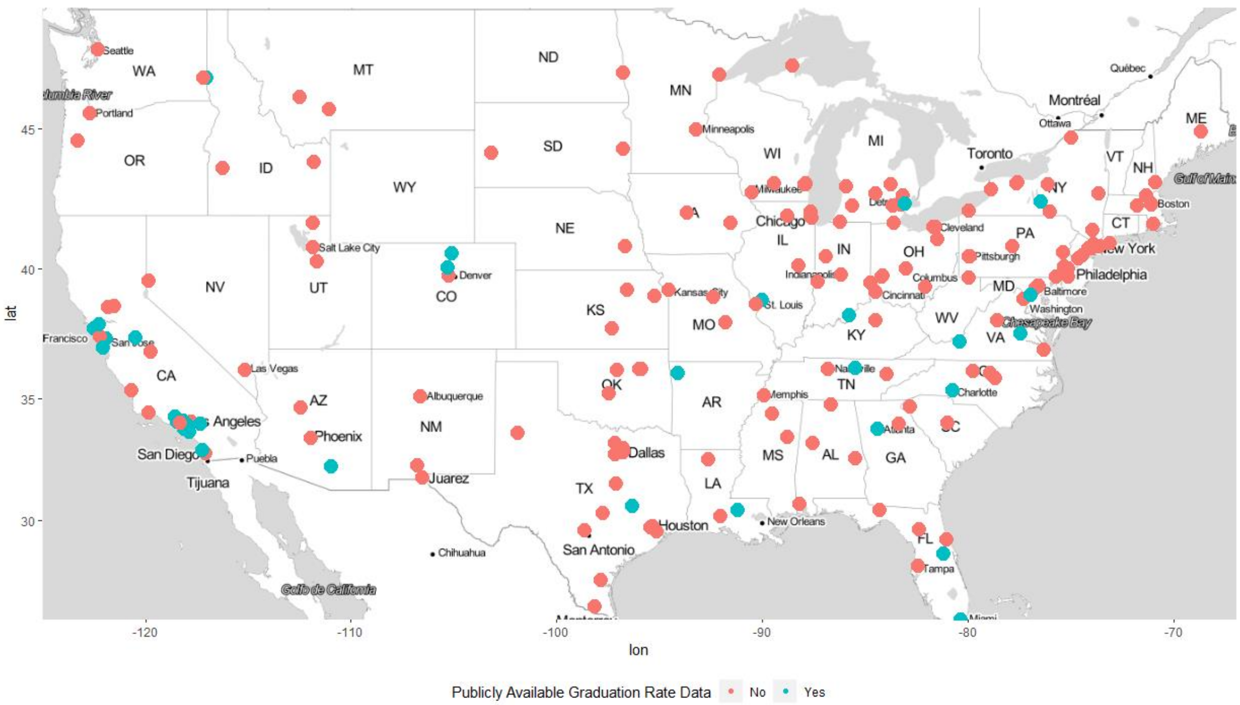


3.4.1.5.2 Descriptive Comparison of Graduation Data by State

To understand differences by state in public reporting of graduation rate data disaggregated for engineering transfer students, I mapped the data (Figure MS2-16). The most obvious finding was the prevalence of institutions located in California (n =13) that provided engineering transfer graduation data publicly. Also of note, although accounting for a smaller number of institutions in the sample, two of the institutions in Colorado (n = 3) provided graduation data publicly. California and Colorado may serve as exemplars for understanding how the public availability of enrollment and graduation data can influence transfer receptivity.

Figure MS2-16

Map of Sample Institutions by Publicly Available Engineering Transfer Graduation Data



3.4.1.5.3 Descriptive Comparison of Graduation Data by State-Level Transfer Policies

I next compared the prevalence of state-level transfer policies for institutions that reported engineering transfer graduation rates publicly with those that did not. Private institutions were excluded from these analyses as they are not mandated to comply with state policies. There were substantial differences across groups for three of the four state-level transfer variables examined, with no meaningful differences between groups for the statewide guaranteed transfer of an associate degree variable (Appendix MS2-F). Table MS2-10 provides a count of publicly available graduation rate data for engineering transfer students by state—an important consideration when interpreting these results is that 13 of the 32 (40%) institutions reporting graduation rate data are located in California, so the state-specific policies in California are most prominent in these analyses.

Table MS2-10

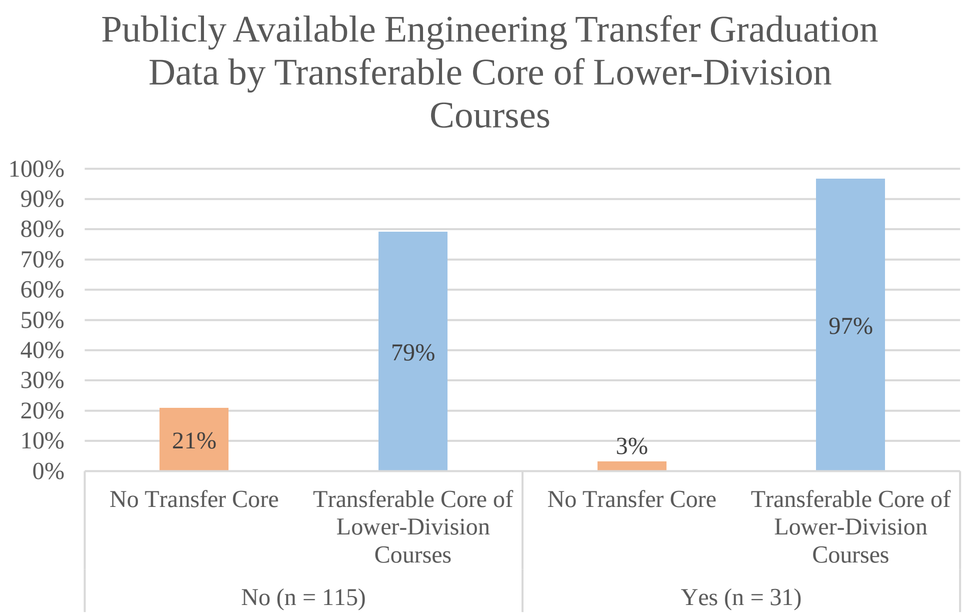
Counts of Institutions with Publicly Available Transfer Graduation Data by State

State	Count of Institutions with Publicly Available Graduation Data
AR	1
AZ	1
CA	13
CO	2
FL	2
GA	1
ID	1
IL	1
KY	1
LA	1
MD	1
MI	1
NC	1
NY	1
TN	1
TX	1
VA	2

Nearly all of the institutions (97%) that reported graduation outcomes for engineering transfer students were in states with a statewide transferable core of lower-division courses, with only one institution (3%) in a state without a transferable core policy (Figure MS2-17). I observed a similar relationship for the statewide common course numbering systems variable (Figure MS2-18). Institutions with common course numbering systems accounted for a greater proportion (48%) of institutions that reported engineering transfer graduation rates than institutions that did not (36%). These results are intuitive as the purpose of these statewide transfer policies is to streamline transfer, and public 4-year institutions in states with these policies may be more apt to report graduation rate data for transfer students.

Figure MS2-17

Comparing EGR Transfer Graduation Data by Transferable Core of Lower-Division Courses



Surprisingly then, I observed the opposite relationship for the final statewide transfer variable, reverse transfer (Figure MS2-19). Institutions in states with statewide transfer policies accounted for a smaller percentage of institutions reporting graduation data publicly for engineering transfer students (26%) than for institutions that did not report graduation data publicly (39%). This counter-intuitive finding warrants further exploration in future research – what is different about this policy compared to other statewide transfer policies that a different relationship emerges with public availability of graduation rates for engineering transfer students?

Figure MS2-18

Comparing EGR Transfer Graduation Data by Statewide Common Course Numbering System

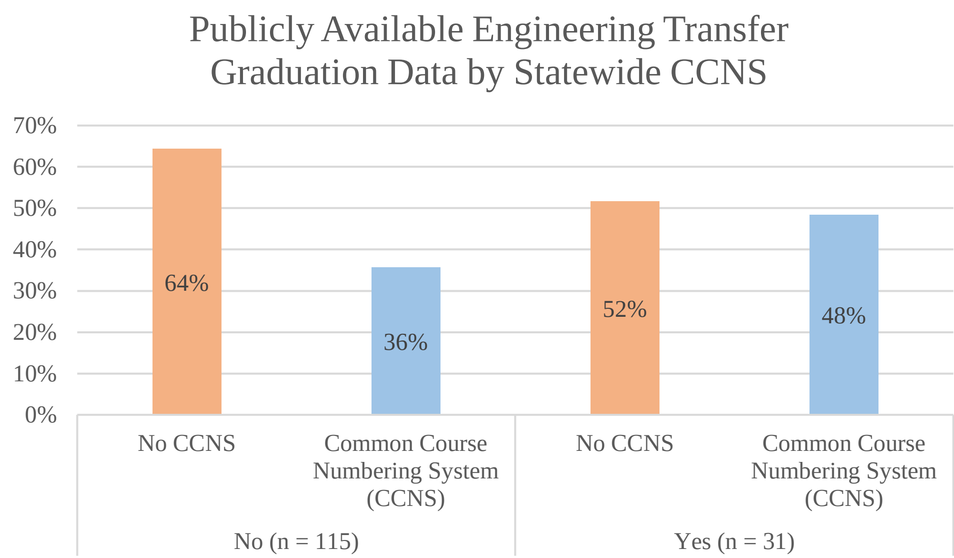
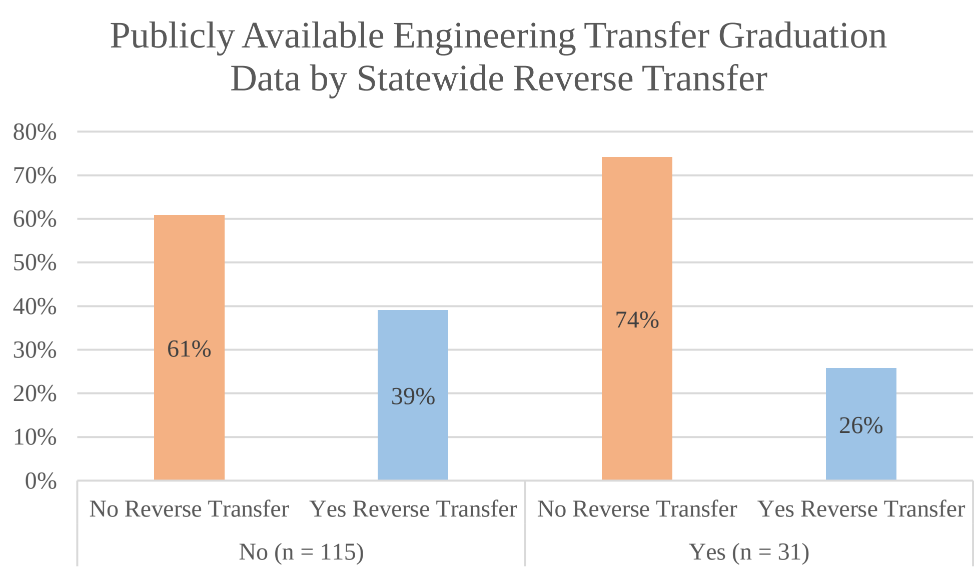


Figure MS2-19

Comparing Engineering Transfer Graduation Data by Statewide Reverse Transfer



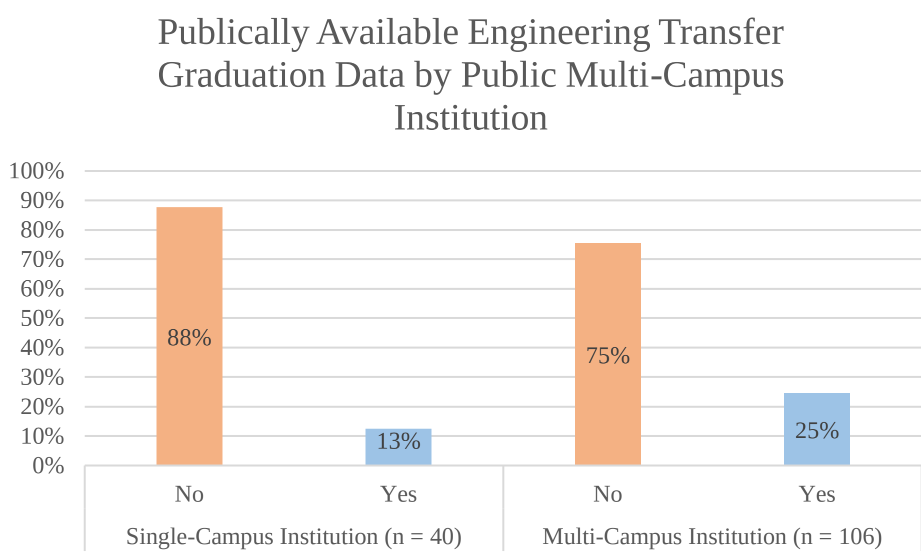
3.4.1.5.4 Descriptive Comparison of Graduation Data by Institutional Characteristics

Beyond institutional control, the only other meaningful findings from descriptive analyses of institutional characteristics was for the multi-institution campus variable and for

Hispanic Serving Institutions. In for case of the former, as done previously when examining the public availability of enrollment data, I removed private institutions because they are all single-campus institutions and examined only public institutions. Multi-campus public institutions more frequently reported graduation rates disaggregated for transfer students in engineering than single-campus public institutions (Figure MS2-20). Even after accounting for institutional control, institutions with multiple campuses reported graduation rates more frequently than single-campus public institutions and may indicate differences in transfer receptivity.

Figure MS2-20

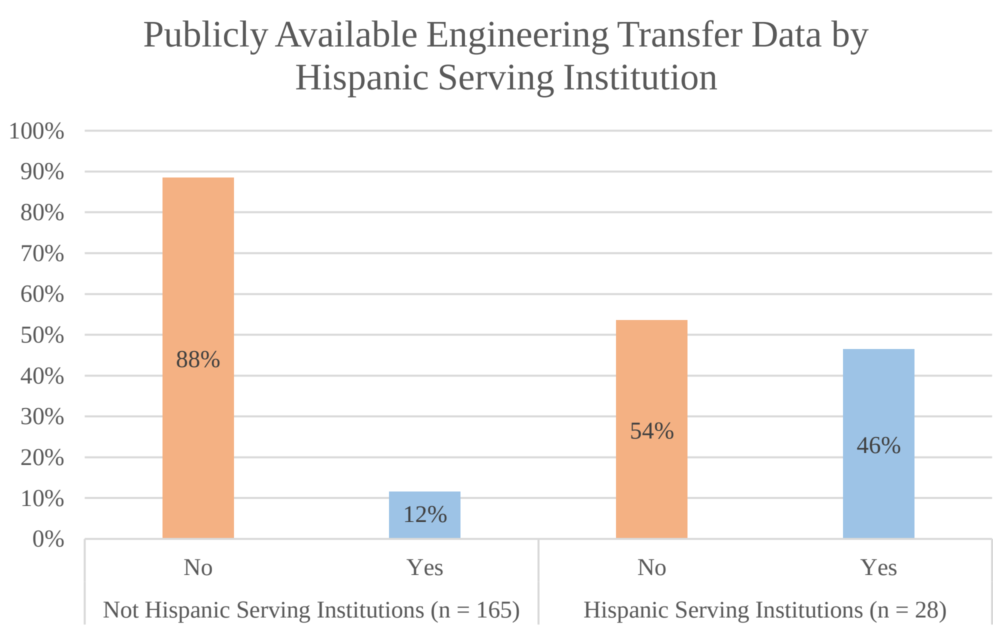
Comparing Engineering Transfer Graduation Data by Multi-Campus Institution



In comparing HSI's with non-HSI institutions in the availability of graduation data for engineering transfer students (MS2-21), I found that 54% of HSI's (n = 28) reported graduation data publicly for their engineering transfer students compared with only 12% of non-HSI institutions (n = 165). This finding is in some way conflated with state as many of the HSI's in the sample are located in California. However, it is encouraging from the perspectives of transfer receptivity and broadening participation in engineering that more than half of the HSI institutions in the sample reported graduation data for engineering transfer students publicly. I did not find meaningful differences between groups for several institutional characteristics: Land Grant Status, Degree of Urbanization, and of the Carnegie Classification variables (Appendix MS2-F).

Figure MS2-21

Comparing Engineering Transfer Graduation Data by Hispanic Serving Institution



3.4.1.5.5 Descriptive Comparison of Graduation Data by Institutional Selectivity Metrics

As was the case when comparing the prevalence of engineering transfer enrollment data with institutional selectivity metrics, there were no meaningful differences between the groups based on institutions' median admit rate (Appendix MS2-F), but I did observe differences for average 75th percentile SAT Math scores. Appendix MS2-C1 compares the distribution of average 75th percentile SAT Math scores for entering FTIC students for institutions that reported graduation rate data for engineering transfer students with institutions that did not. The median for institutions that reported data publicly ($\tilde{X}$ = 633) was lower than for institutions that did not ($\tilde{X}$ = 657). Reporting transfer graduation data may be related to institutional selectivity. Less selective institutions may be more likely to report transfer graduation data by college than more selective institutions.

3.4.1.5.6 Descriptive Comparison of Graduation Data by Student Cost & Finance Data

None of the student cost variables – average published tuition and fees, average net price for students receiving grant or scholarship aid, and average total price for in-state students living off campus (not with family) – meaningfully differentiated between institutions that reported graduation data publicly and those that did not, when accounting for institutional control (Appendix MS2-F). Similarly, endowment assets, one of the institutional finance variables included in descriptive analyses, was not significantly different between the two groups (Appendix MS2-F).

In contrast, the other institutional finance variable – state appropriations – meaningfully differentiated between institutions that reported graduation data publicly and those that did not. The median state appropriations received by institutions that reported graduation rates publicly for transfer students in engineering ($\tilde{X}$ = \$203,151,774) was considerably more than the median received by institutions that did not report graduation rates publicly ($\tilde{X}$ = \$130,235,597). In fact, more than 75% of institutions that reported graduation data received more state appropriations than the median received by institutions not reporting data (Appendix MS2-C2). This finding indicates that reporting of graduation rates may be more nuanced and include further disaggregation in states that provide more public funding to their 4-year institutions. States seeking to increase transfer receptivity, at least in terms of establishing sustainable systems to assess and evaluate transfer pathways, may benefit from increased public funding funneled to public 4-year institutions. Institutions that seek to do the same may benefit from advocating at the state level for increased public monies. It is important to acknowledge that viewing state appropriations as a lump sum, rather than as a percentage of an overall institutional budget, does not account for differences in base budgets—institutions where state appropriations account for large portions of the overall budget will be more dramatically impacted by increased monies than institutions where it accounts for a much smaller percentage of revenues.

3.4.1.5.7 Descriptive Comparison of Graduation Data by UG Class Characteristics

Findings from descriptive analyses indicate that several undergraduate class characteristics related to whether or not institutions reported engineering transfer graduation data. The only undergraduate class characteristic that did not meaningfully differ between institutions that reported graduation rates for engineering transfer students and those that did not was the percentage of entering transfer students who attended full-time (Appendix MS2-F).

First, the median undergraduate class size for institutions that reported engineering transfer graduation data publicly ($\tilde{X}$ = 6,838) was considerably higher than for institutions not reporting transfer graduation data ($\tilde{X}$ = 4,553). As evidenced in Appendix MS2-C3, all institutions falling within the top 75% of the distribution for institutions reporting data publicly enroll more total undergraduates than the median for institutions that did not. Larger institutions more frequently reported graduation data for transfer students by college than smaller institutions. A similar relationship was apparent between publicly available engineering transfer graduation data and the average total of entering undergraduate transfer students for institutions in the sample. Institutions that reported engineering transfer graduation rates ($\tilde{X}$ = 1,346) enrolled nearly 1000 more transfer students on average than institutions that did not report graduation data publicly ($\tilde{X}$ = 408). Like the distribution for total entering undergraduates, all institutions falling within the top 75% of the distribution for institutions reporting data publicly enroll more transfer students than the median for institutions that did not (Appendix MS2-C4). This result makes sense as institutions that enroll more transfer students would be more invested in disaggregating graduation metrics by admit type and reporting student success metrics for transfer students. Conversely, institutions enrolling fewer transfer students on average may not have reached a critical mass of transfer students to consider them a sub-group of students worthy of the time and costs required to routinely disaggregate reporting of student outcomes.

Finally, I examined differences between institutions that reported engineering transfer graduation rate data publicly with institutions that did not in both average IPEDS transfer composition, or the proportion of all incoming students that are transfer students, as well as the newly derived transfer composition variable for engineering programs specifically. Like the other two undergraduate class characteristics, there seem to be meaningful differences between the groups for both transfer composition variables, with institutions reporting data publicly having higher transfer composition than institutions who did not. The median transfer composition at the institution level for institutions providing publicly available graduation data ($\tilde{X}$ = 28.7%) was 7.6% higher than for institutions not reporting data publicly ($\tilde{X}$ = 21.2%) (Appendix MS2-C5). A similar relationship was apparent for transfer composition in engineering programs with a higher median for institutions reporting graduation data ($\tilde{X}$ = 21.3%) than those that did not ($\tilde{X}$ = 15.9%) (Appendix MS2-C6). Again, these results make sense given that institutions with higher proportions of transfer students in their undergraduate classes and in engineering programs would be more inclined to disaggregate student outcomes by admit type and college.

3.4.2 Results Part 2: Transfer Composition

Having explored the availability of enrollment and graduation data for engineering transfer students, I now shift to a more detailed analysis of engineering transfer enrollments through transfer composition. To present findings related to transfer composition, I begin by examining distributions of enrollments for FTIC and transfer students and then detail findings from descriptive analyses that examined the variance in transfer composition across sample institutions. Then I examined the relationships of transfer composition and a collection of independent variables. Finally, I provide results from regression analyses.

3.4.2.1 Examining Transfer Composition in Engineering Programs

Analyses of Average Transfer Composition were conducted from a sub-sample of institutions (n = 135) that had complete data for Fall new transfers and annual FTIC students in engineering for all academic years of interest (2010–2018) (Table MS2-11). Four institutions with full data for transfer students were omitted from these analyses because of partial, lack of, or inconsistencies in enrollment data provided in the ASEE database for FTIC students. Any institution providing no data (n = 40) or only partial data for transfer students (n = 14) or FTIC students (n = 2) were also omitted from analysis.

Figure MS2-22 provides a visual of the distribution of the average (2010-2018) number of 'New Transfer' enrollments in Fall semesters into engineering for the sub-sample. The majority of institutions, on average, enroll fewer than 250 new transfer students in engineering in Fall semesters, with almost all of the institutions in the sample enrolling fewer than 500 new transfer students in engineering. A few institutions in the sample are outliers and enroll more than 1000 new transfer students into engineering on average in Fall semesters, pulling the mean ($\bar{X}$ = 186) above the median ($\tilde{X}$ = 152). This value serves as the numerator in calculation of the Average Transfer Composition variable.

A notable limitation, as discussed in detail in the Limitation section of this manuscript, is the absence of Spring and Summer 'New Transfer' enrollments in the Average Transfer

Composition (2010-2018) variable—the metric underestimates the transfer composition from institutions that also enroll new transfers in Spring and Summer terms.

Table MS2-11

Counts of Sample Institutions by Available FTIC and Transfer Engineering Enrollment Data

FTIC EGR Enrollment Data	Transfer EGR Enrollment Data	Count
Complete	Complete	135
	No Data	32
	Partial	13
No Data	Complete	2
	No Data	4
	Partial	1
Partial	Complete	2
	No Data	4

Figure MS2-22

Distribution of Fall 'New Transfer' Students in Engineering for Sub-Sample

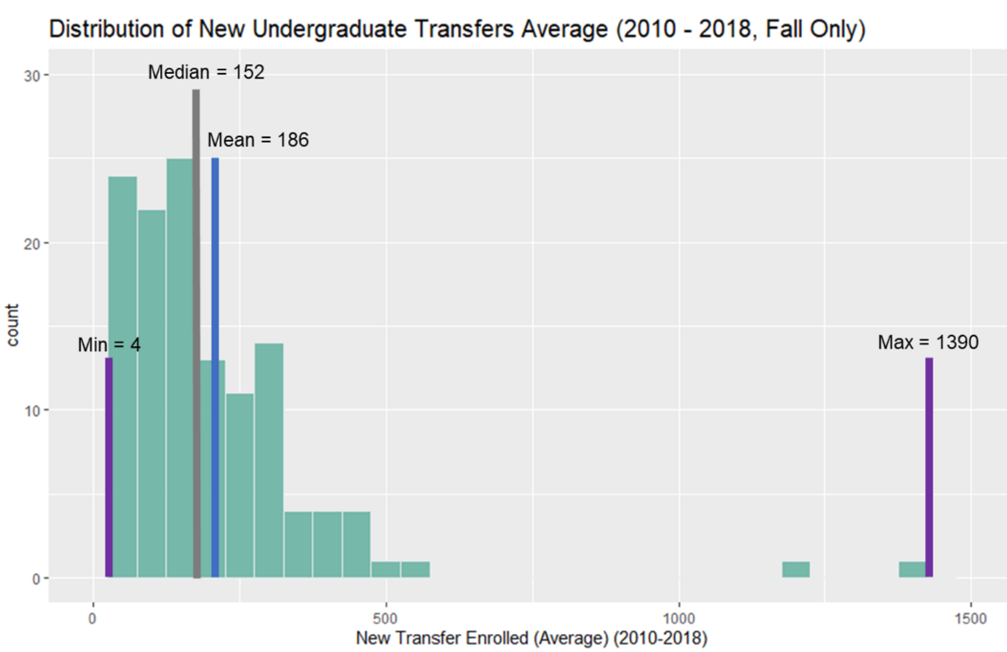
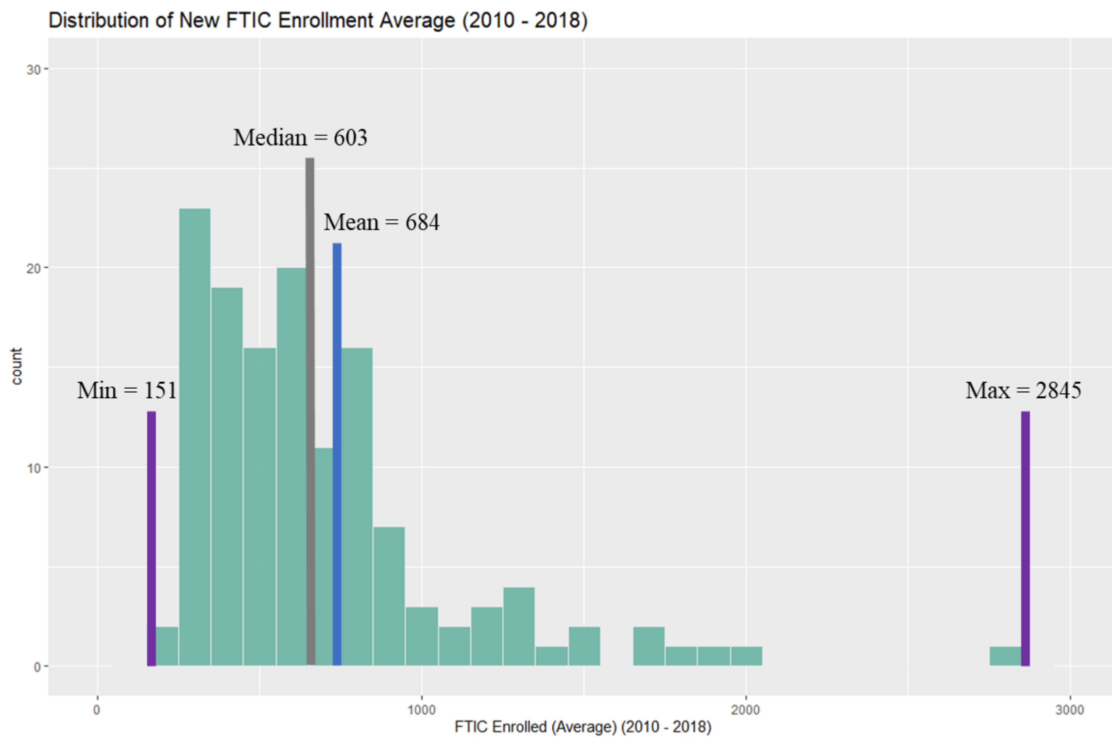


Figure MS2-23 visualizes the distribution of average new first-time-in-college (FTIC) enrollments annually for institutions in the sub-sample. The majority of institutions ($\bar{X}$ = 684;

$\tilde{X}$ = 603) enroll fewer than 1000 new FTICs per year, with a small sub-group of institutions enrolling between 1000 and 2000 new FTICs per year and one institution enrolling 2845 new FTICs on average per year. This value is summed with the Average Transfer Enrollments to create a Total New Enrollments value (Figure MS2-24) that serves as the denominator in the proportion calculation for Average Transfer Composition.

Figure MS2-23

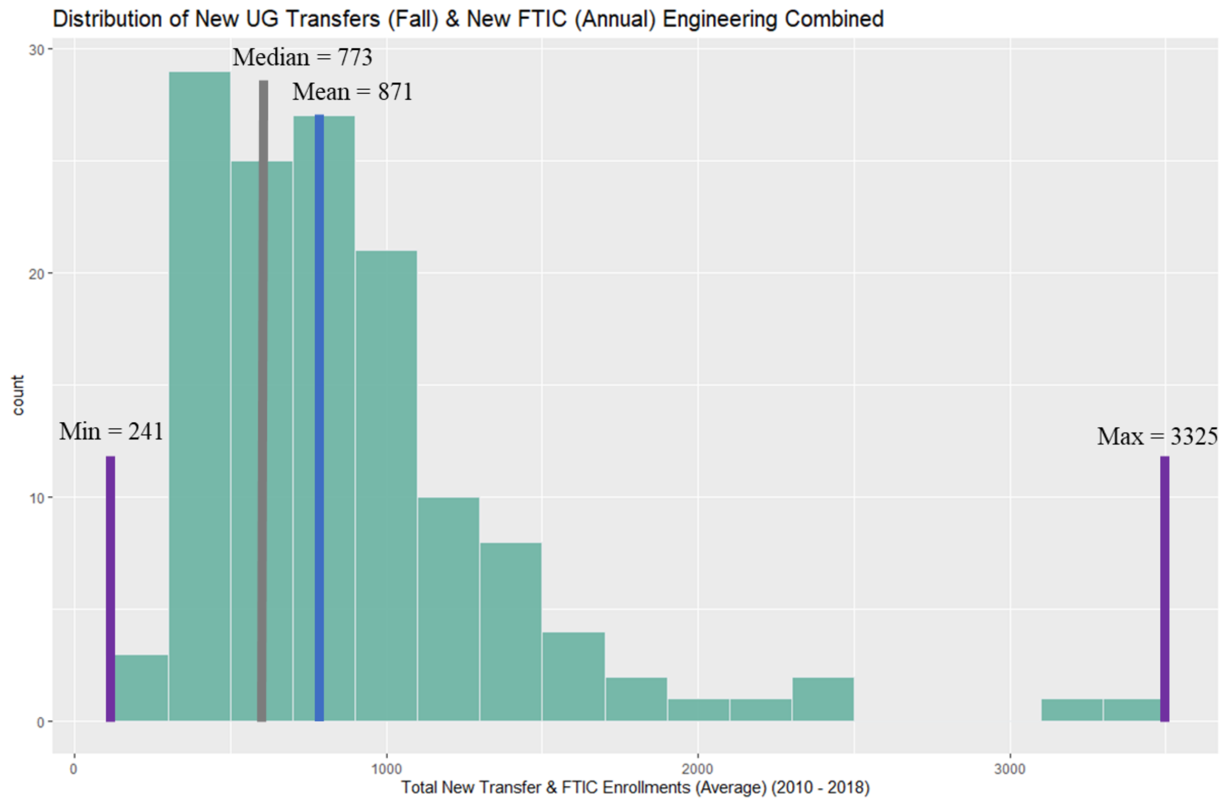
Distribution of Annual New Freshman (FTIC) Students in Engineering for Sub-Sample



The summed total of new transfers in the Fall term and new FTIC enrollments annually captures the majority of new enrollments in engineering per year. As was the case for the other enrollment variables, the distribution was positively skewed with the majority of institutions enrolling fewer than 1200 new students in engineering, and nearly all institutions enrolling 2500 or fewer new students. Two outlier institutions with total enrollments above 3000 cause the mean ($\bar{X}$ = 871) to be considerably higher than the median in the sample ($\tilde{X}$ = 773)**.**

Figure MS2-24

Distribution of Total Enrollments of New Transfer Students in Fall and Annual New FTIC Students in Engineering for Sub-Sample



Using the average enrollments of new transfer students in Fall term, I create a proportion measure, Average Transfer Composition (2010-2018), which compares these values with the summed total of new transfer and FTIC enrollments in engineering. Subsequent analyses in this section focused on the Average Transfer Composition composite variable, which is an average of transfer composition across the nine years of data (2010-2018) included in the study. Figure MS2-25 visualizes the distribution of Average Transfer Composition of institutions (n = 135) in the sub-sample. Transfer students accounted for as little as 1.1% to as much as 57.5% of institutions' new students entering engineering. The distribution is slightly positively skewed pulling the mean ($\bar{X}$ = 20.6%) slightly above the median ($\bar{X}$ = 18.5%).

With no naturally occurring breaks in the distribution, a useful way to examine the distribution is to split it into quartiles (Figure MS2-26). This approach also helped meaningfully compare transfer composition with nominal independent variables in sections that follow. For institutions in the lowest quartile of the sample, transfer students accounted for 11.6% or less of new students in engineering. Transfer composition for institutions in the middle lower quartile ranged from 11.6% to 17.5%, and from 18.2% to 27.8% for institutions in the middle upper quartile. The range of transfer composition for institutions in the highest quartile is larger than the other three quartiles (Figure MS2-26), ranging from 28.2% to 57.5%.

Figure MS2-25

Distribution of Transfer Composition in Engineering for Sub-Sample

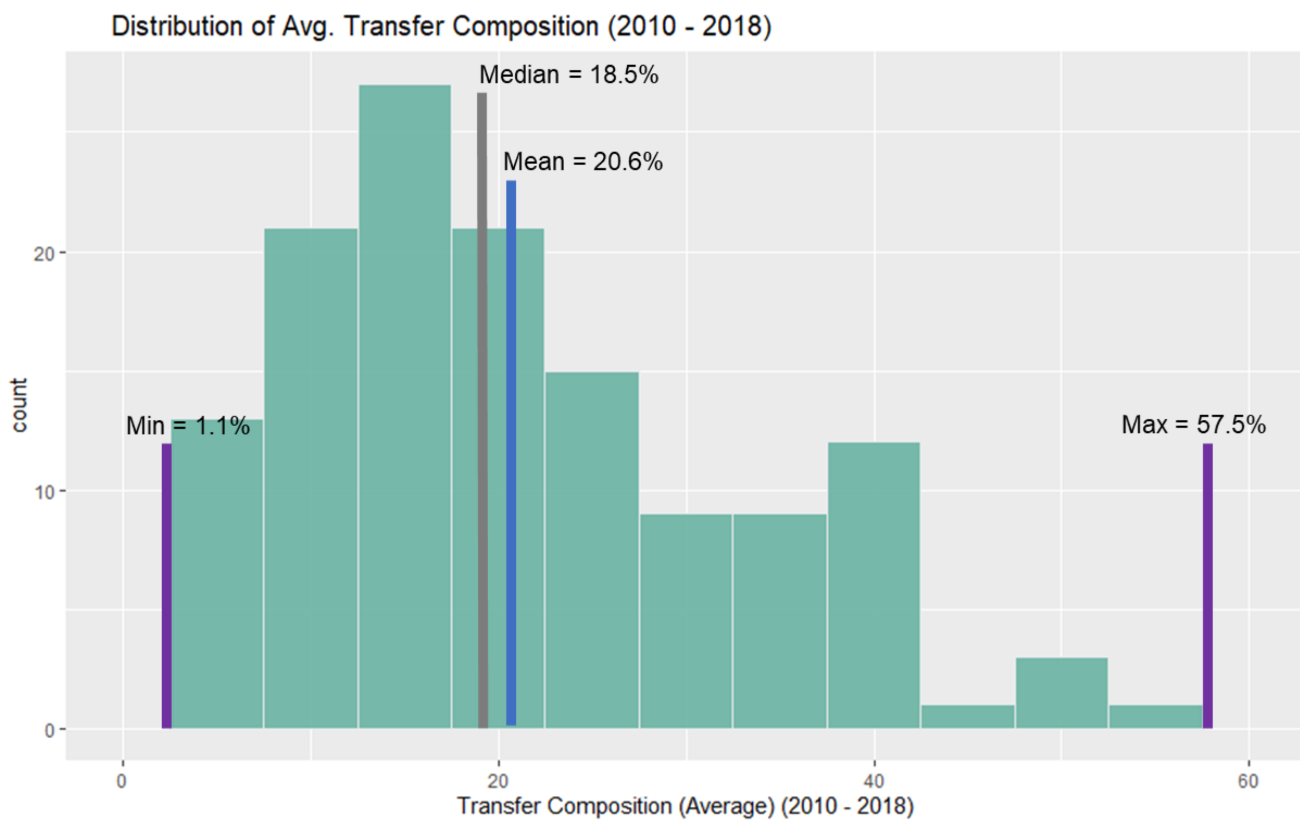
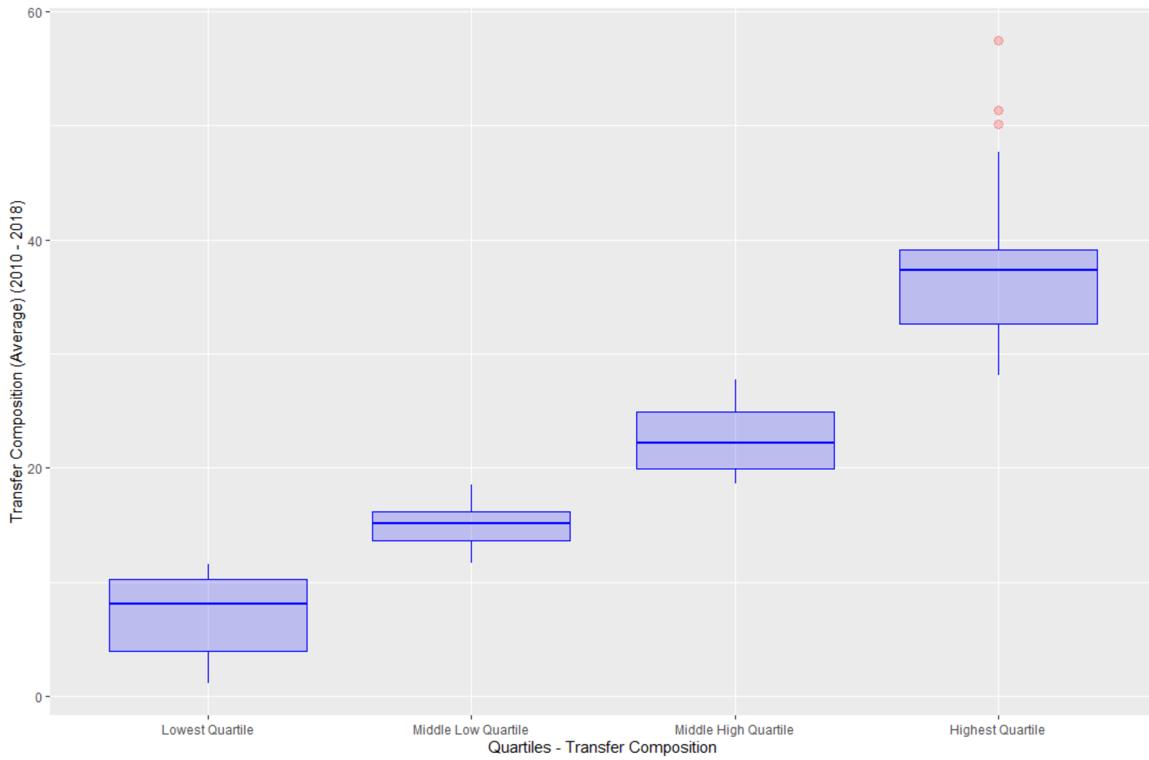


Figure MS2-26

Distribution of Avg. Transfer Composition Quartiles in Engineering for Sub-Sample



3.4.2.2. Descriptive Analyses Comparing Transfer Composition with Relevant Variables

Several descriptive analyses were conducted to examine the relationship between Average Transfer Composition and the independent variables in this study. Similar to previous sub-sections, I organize findings by groups of independent variables. First, I compared the distribution of average transfer composition into quartiles by institutional control. Then, I organize the rest of the findings moving from macro-level to micro-level variables beginning with differences at the state level and with state-level transfer policies. I then focus on institution-level variables, first comparing transfer composition with a series of categorical and continuous institutional characteristic variables. Next, I examined the relationship of institutional selectivity metrics and institutional finance and student cost variables with transfer composition. Then, I examined the relationship of several college-level variables and transfer composition, starting with engineering program rankings. I then analyzed the relationship between transfer composition and two college-level policy variables in engineering: minimum GPA for admissions consideration and minimum number of completed credits required before transfer. I also compared transfer composition with the types of college-level enrollment reporting tools available publicly for transfer students in engineering. I finish by zooming in on student-level variables, beginning by comparing institutions' undergraduate class characteristics with average transfer composition. Then, I examined the relationship between student demographics at the institution and in engineering programs and average transfer composition. Finally, I compared student success data with transfer composition.

These descriptive analyses informed my selection of variables to include in inferential regression analyses. Table MS2-11 provides a summary of correlation coefficients and significance values for continuous independent variables. Scatterplots for all variables that significantly correlated with transfer composition are provided in Appendix MS2-D. Scatterplots for all non-significant correlations with transfer composition are provided in Appendix MS2-G.

Table MS2-11

Summary of Significant Findings Related to Transfer Composition for Continuous Variables

Variable	*r*	*df*	*p*
Avg. SAT Math 75th Percentile (2010-2018)	-0.39	130	< .001***
Avg. Published In-State Tuition & Fees (2010-2018)	-0.25	115	0.006**
Avg. Published In-State Tuition & Fees (2010-2018) (Privates Only)	-0.69	16	< .001***
Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2018) (Publics Only)	-0.32	115	< .001***
Avg. Total price for in-state students living off campus (not with family) (2010-2018) (Privates Only)	-0.54	14	.03*
Avg. Endowment Assets (Publics Only)	-0.22	114	.02*
US News World Report Best Undergrad Engineering Schools 2019 Ranking (Doctorate Offered)	0.3	118	.001***
US News World Report Best Undergrad Engineering Schools 2019 Ranking (No Doctorate Offered)	0.38	13	.161
Minimum GPA for EGR Transfer	-0.19	99	0.06 .

Avg. Total entering students at the undergraduate level fall (2010-2018)	0.37	133	< .001***
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)	0.69	130	< .001***
Avg. IPEDS UG Transfer Composition % - All Entering Students	0.82	130	< .001***
Avg. Percentage Transfer-In Full Time (2010-2018)	0.45	133	< .001***
Avg. Percent of total enrollment that are Black-African American (2010-2018)	0.14	133	.09 .
Avg. % of All UG EGR Enrollments - African American	0.14	133	.10 .
Avg. Percent of total enrollment that are Hispanic/Latino (2010-2018)	0.29	133	< .001***
Avg. % of All UG EGR Enrollments - Hispanic	0.18	133	.03*
Avg. % of All UG EGR Enrollments - Minoritized	0.34	133	< .001***
Avg. Percent of total enrollment that are Minoritized Race or Ethnicity	0.25	133	.003**
Avg. Percent of total enrollment that are women (2010-2018)	0.25	133	.003**
Avg. % of All UG EGR Enrollments - Women	-0.46	133	< .001***
Avg. Full-time retention rate (2010-2018)	-0.35	133	< .001***
Avg. Graduation rate - Bachelor degree within 4 years total (2010-2018)	-0.53	133	< .001***
Avg. Graduation rate - Bachelor degree within 5 years total (2010-2018)	-0.53	133	< .001***
Avg. Graduation rate - Bachelor degree within 6 years total (2010-2018)	-0.49	133	< .001***

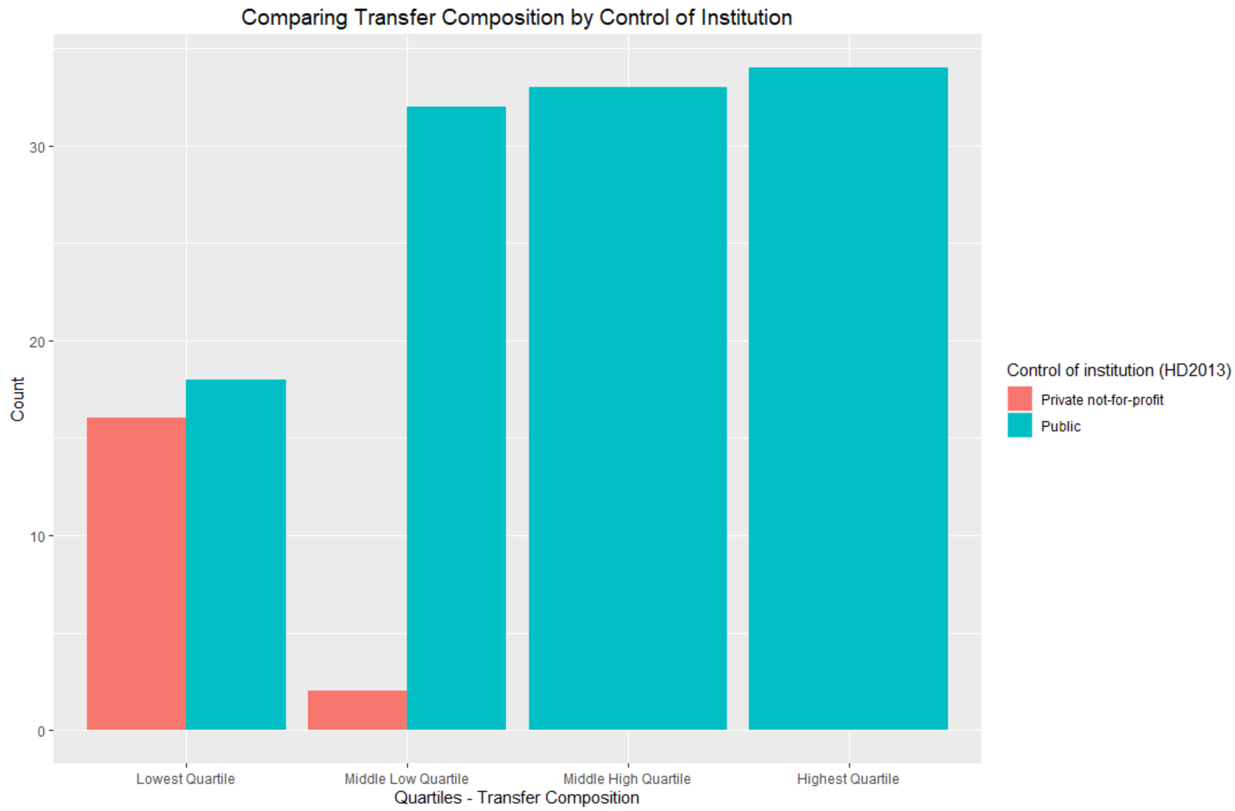
(Significance levels are denoted accordingly: . at .10; * at .05; ** at .01; *** at .001)

3.4.2.2.1 Examining Transfer Composition by Institutional Control

The distribution of average transfer composition in quartiles varied substantially by institutional control (Figure MS2-27). Transfer composition for public institutions was distributed fairly evenly across the highest three quartiles, with considerably fewer public institutions falling in the lowest quartile. Conversely, no private institutions had an average transfer composition in the highest two quartiles, with private institutions accounting for nearly half of the institutions in the lowest quartile of average transfer composition. Thus, among the sample institutions, transfer students accounted for a lower percentage of new students entering into engineering in private institutions, with transfer students being a more prominent part of new enrollments at public institutions. This finding is not particularly surprising as processes to streamline the transfer of credits through articulation agreements typically involve public institutions and exclude private institutions (O'Meara et al., 2007). Nonetheless, these findings suggest that the prominence of access for transfer students in engineering is, in aggregate, higher at public institutions than at private institutions.

Figure MS2-27

Distribution of Transfer Composition Quartiles by Institutional Control

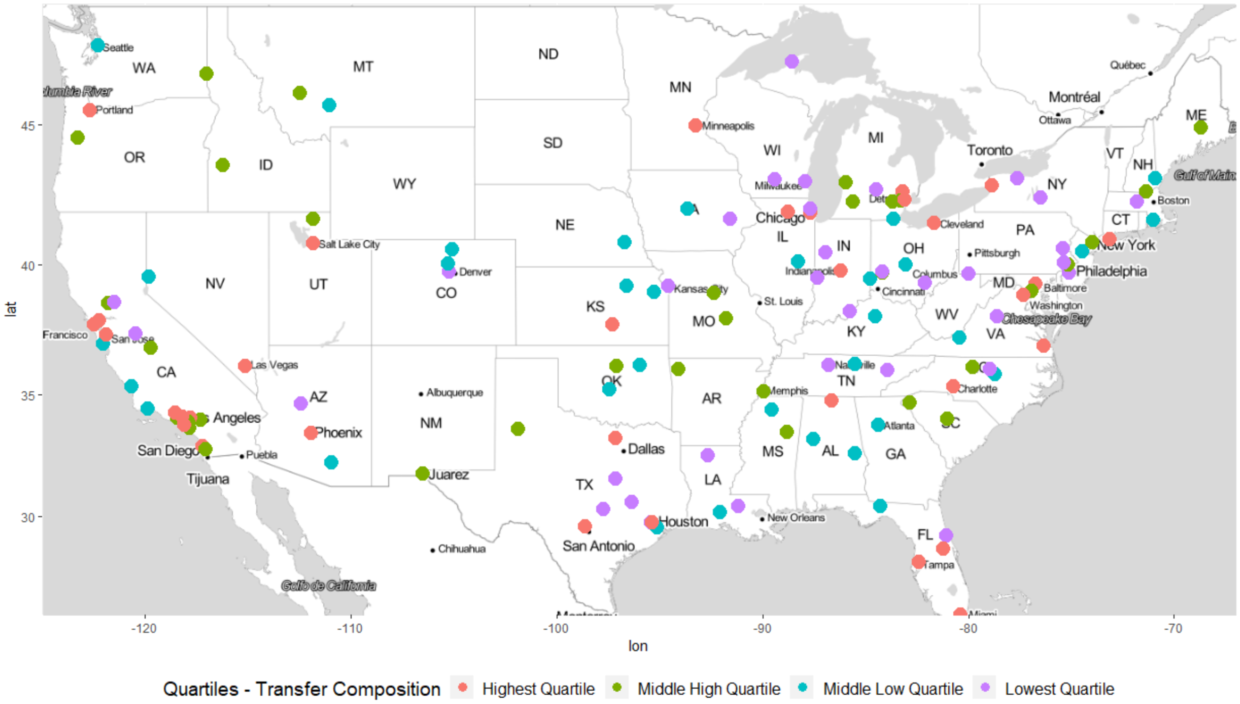


3.4.2.2.2 Examining Transfer Composition by State

To examine variance in transfer composition across states, I mapped transfer composition quartiles (Figure MS2-28) and did not observe major regional patterns. For states with only one or two institutions represented, some fell in upper quartiles of transfer composition (e.g., Oregon, Utah, Minnesota, Maine) whereas others fell into the lower quartiles of transfer composition (e.g., Colorado, Nebraska, Iowa, Louisiana, Wisconsin), and the rest were split, with some institutions falling on each side of the distribution (e.g., Washington, Nevada, Kansas, Mississippi, South Carolina). For states with a larger number (e.g., 5 or more) of institutions in the sample, the institutions were distributed across at least three if not all four quartiles of the distribution (e.g., Michigan, Texas, California, Ohio). As such, looking at transfer composition as an aggregated measure across institutions within a state may not be particularly useful, with differences between institutions in each state bringing the average to the middle of the distribution.

Figure MS2-28

Map of Sample Institutions by Transfer Composition Quartiles

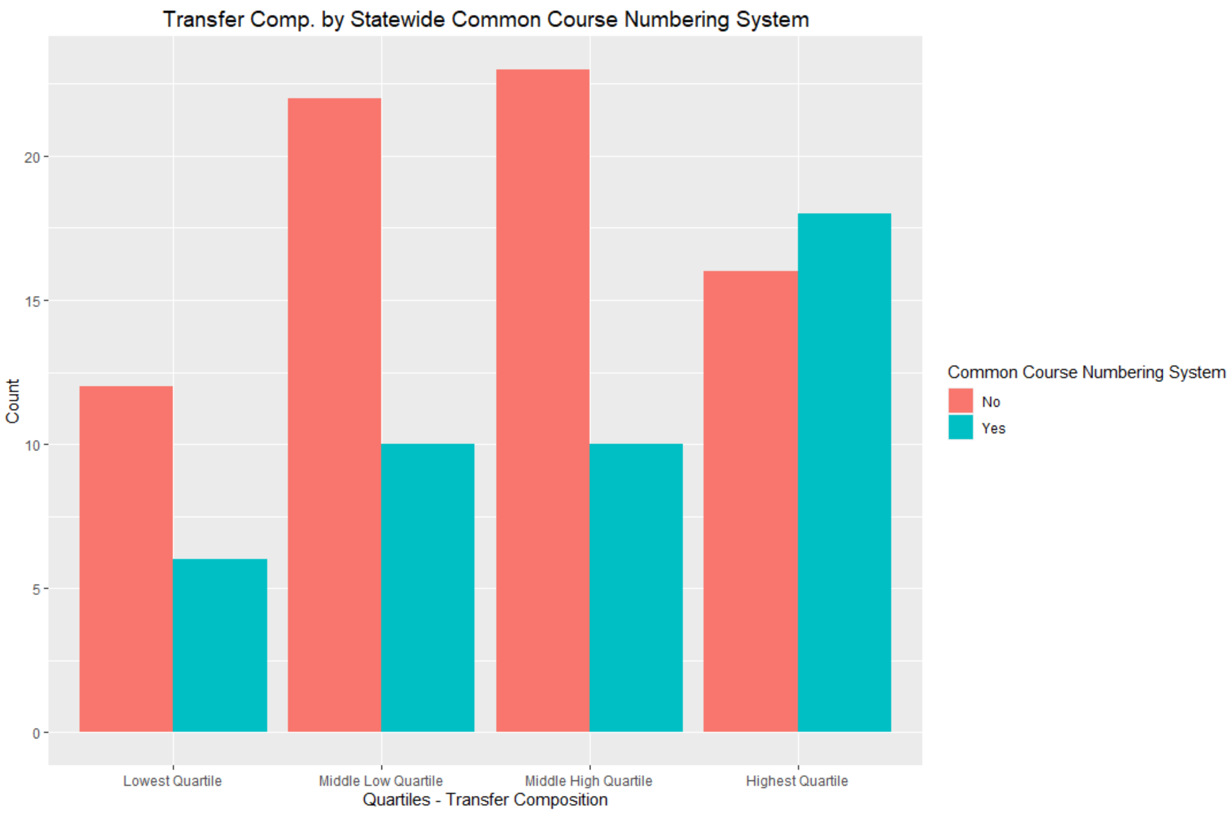


3.4.2.2.3 Examining Transfer Composition by State-Level Transfer Policy

This sub-section details findings from descriptive analyses of transfer composition and state-level transfer policies. Private institutions were excluded from this analysis as state-level policies apply only to public institutions. Descriptive analyses examined the relationship between engineering transfer composition, distributed into quartiles, and four statewide transfer policies: Common Course Numbering System, Guaranteed Transfer of an Associate's Degree, Reverse Transfer, and a Transferable Core of Lower-Division Courses. The distribution of institutions by transfer composition quartile was similar for three of the policy variables: Guaranteed Transfer of an Associate's Degree, Reverse Transfer, and Transferable Core of Lower-Division Courses (Appendix MS2-G); I observed no apparent differences based on these state-level policies. However, in examining the distribution of public institutions by engineering transfer composition quartile and whether or not they were in a state with a Common Course Numbering System, substantially more institutions in the highest quartile were in states that did have one (Figure MS2-29). This finding may indicate that establishment of a Common Course Numbering System at the state-level may increase transfer composition in engineering programs.

Figure MS2-29

Distribution of Transfer Composition Quartiles by Statewide Common Course Numbering



The lack of meaningful differences in the distribution of engineering transfer composition for the other three state-level transfer policy variables may indicate a lack of impact of those policies on the prevalence of transfer, at least within engineering. Alternatively, examining policies in aggregate at the state level may not capture interactions of these policies with other institution and college level policies that influence access for transfer students in 4-year engineering programs.

3.4.2.2.4 Examining Transfer Composition by Other Institutional Characteristics

I conducted analyses comparing transfer composition with a collection of other institutional characteristics. First, I examined the relationship between transfer composition and two ways to group institutions via the Carnegie classification system: basic and undergraduate profile. The basic Carnegie classification helps differentiate institutions based primarily on the highest level degree offering, although doctoral universities are further distinguished based on their levels of research activity. Figure MS2-30 visualizes the distribution of transfer composition quartiles by basic Carnegie classification for institutions in the sample.

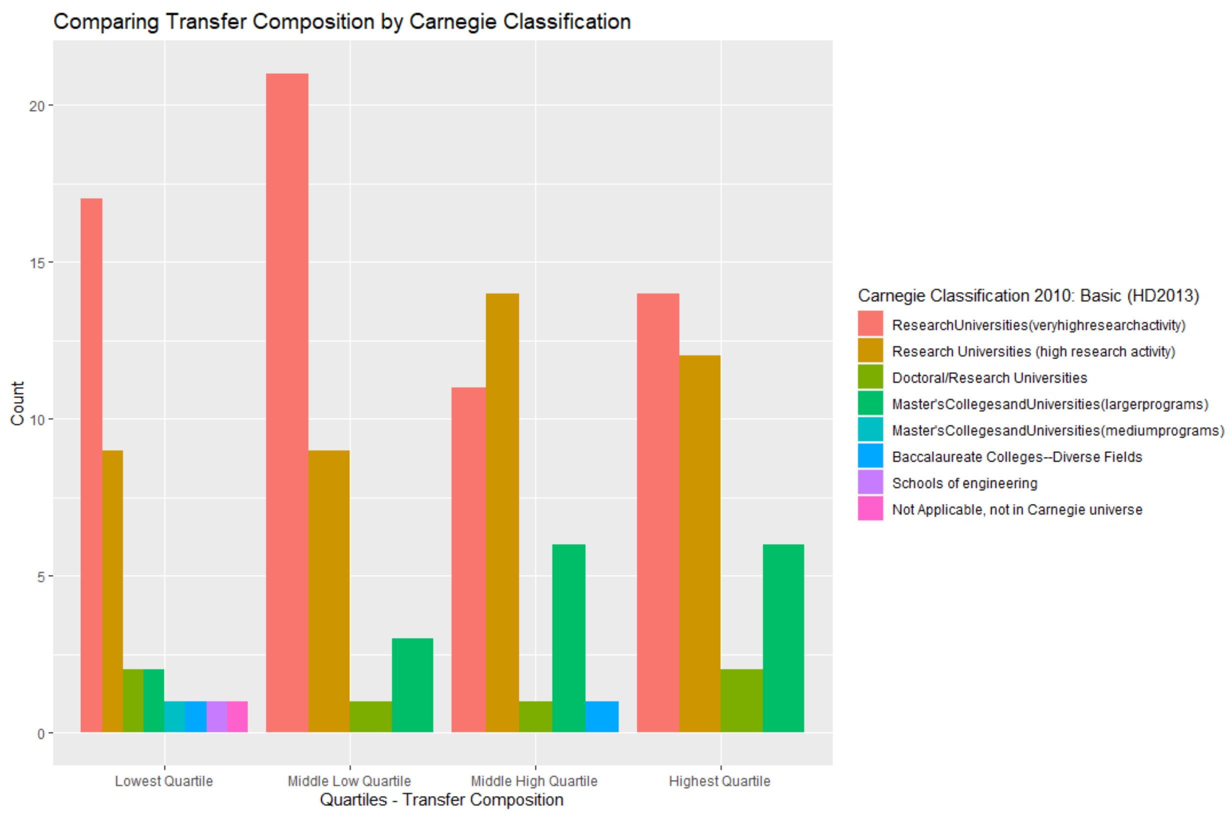
Although the majority of institutions in the sample are categorized as research universities, institutions with very high research activity were more prevalent in the lower two quartiles of transfer composition than those with only high research activity. Additionally, large Master's colleges were more prevalent in the higher two quartiles of transfer composition. Thus, there seem to be meaningful differences between Carnegie classification groups and transfer composition; the prevalence of transfer pathways in engineering at the top-tier research universities is less than at other research universities as well as Master's colleges. Further investigation into these groupings of institutions may advance our understanding of the landscape of access to engineering transfer pathways and, thus, transfer receptivity.

The second Carnegie classification compared with transfer composition was the undergraduate profile. This variable incorporates the enrollment status (i.e., full- vs. part-time), selectivity, and prevalence of transfer students in institutions' undergraduate student population.

As evidenced in Figure MS2-31, institutions classified as medium full time (i.e., 60-79% of entering students enroll full-time), selective, and higher transfer-in (i.e., at least 20% of all entering undergraduates are transfers) accounted for almost half of all the institutions in the highest quartile, with the remaining of these institutions falling in the middle high quartile.

Figure MS2-30

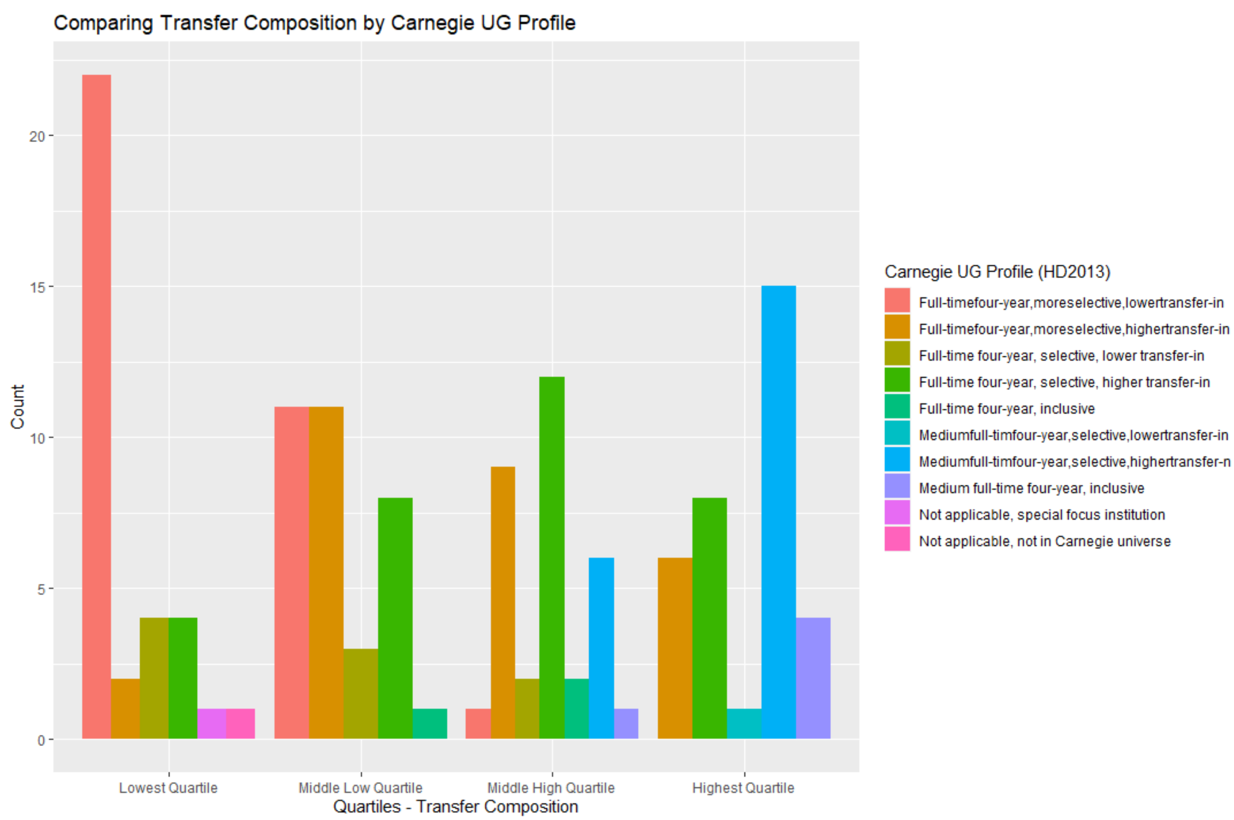
Distribution of Transfer Composition Quartiles by Carnegie Classification (Basic)



One might assume this finding is an effect of the higher transfer-in measure. However, two other groups are also classified as higher transfer-in: full-time more selective and full-time selective. The distribution of the full-time more selective group is spread across the four quartiles with the highest frequency of institutions falling in the middle-low quartile of transfer composition. The full-time selective group was more similar to medium full-time, selective, higher transfer-in institutions, with the majority of institutions falling into the higher two quartiles in transfer composition. However, a number of institutions still fell within the lower two quartiles, whereas none of the medium full-time, selective, higher transfer-in institutions did. The intersection of these measures, including a higher prevalence of part-time students and transfer students, with somewhat selective admissions standards signal that an institution may be uniquely positioned to enroll higher percentages of transfer students in engineering.

Figure MS2-31

Distribution of Transfer Composition Quartiles by Carnegie Undergraduate Profile



Similarly, despite fewer of these institutions in the sample, all of the medium full-time inclusive and medium full-time, selective, lower transfer-in institutions fell into the top two quartiles of transfer composition. Examining these groups of institutions more closely may highlight how institutions provide broader access to engineering programs via transfer and may be more transfer receptive.

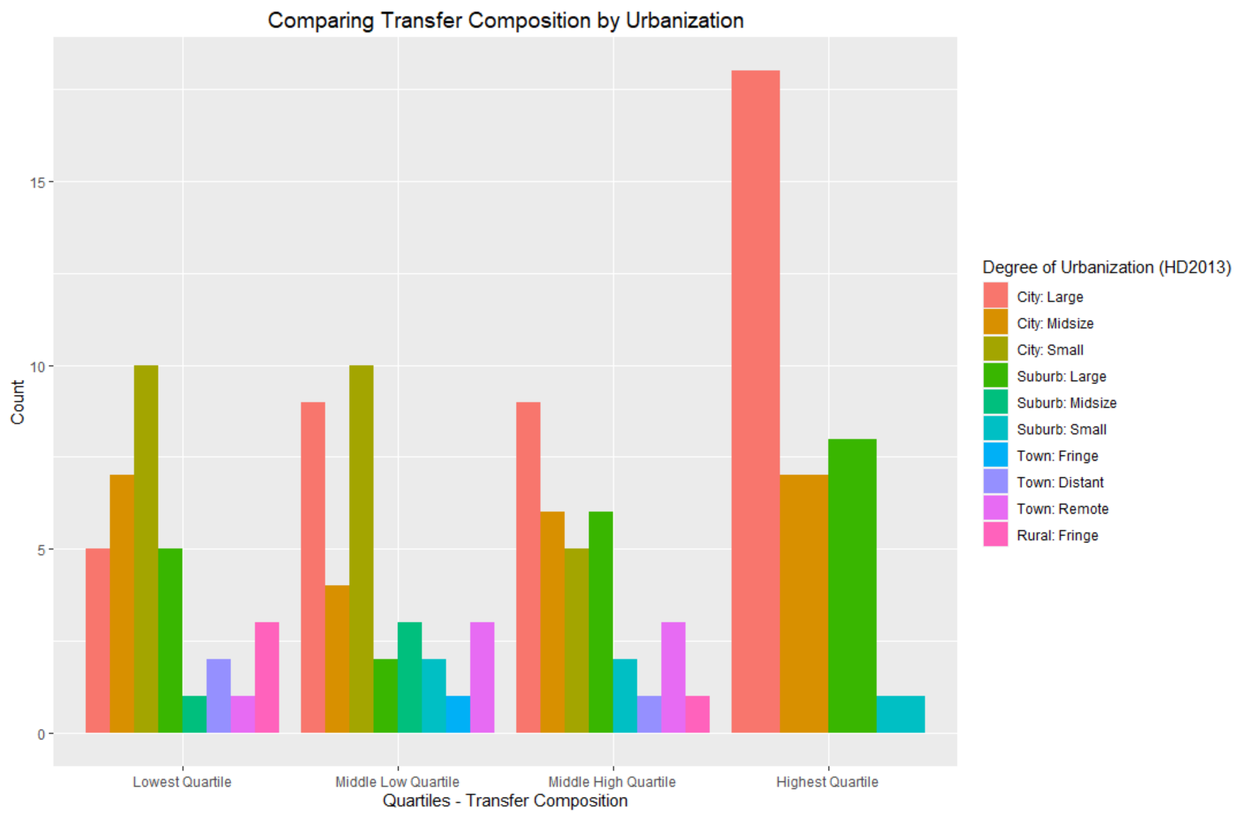
Conversely, full-time, more selective, lower transfer-in institutions were the most prominent group of institutions in the lower two quartiles of transfer composition, with almost none falling in the upper two quartiles. The combination of more selective admissions, enrolling fewer part-time and fewer transfer students overall seems to be related to lower transfer composition in engineering. Considered collectively, the Carnegie undergraduate profile may be a useful predictor of variance in transfer composition in engineering.

Another variable that may be useful in explaining variance in transfer composition in engineering is degree of urbanization, which groups institutions together based on the size of the population where the institution in located. Groups are distinguished based on whether the institution is located in a city, suburb, town or rural area, and the relative size (i.e., large, midsize, small) or proximity (i.e., distant, fringe, remote) to other municipalities. The clearest finding in Figure MS2-32 is that institutions located in large cities account for more than half of the institutions in the highest quartile of transfer composition. In contrast, the largest sub-group of institutions falling in the lower two quartiles of transfer composition were located in small cities, with none of these institutions falling in the highest quartile. Similarly, no institutions located in towns or in rural areas fell in the highest quartile, and in general were more prevalent in the lower two quartiles of transfer composition.

The transfer composition of suburban institutions varied depending on size, with those in large suburban areas more often falling into the highest two quartiles and those in smaller and midsize suburban areas falling most frequently in the middle two quartiles. These findings are intuitive as 4-year institutions in large cities and suburbs are proximally closer to larger networks of urban and suburban community colleges that enroll more students than community colleges in towns and rural municipalities. Their location also lends itself more easily to commuter transfer students who wish to continue living at home or off-campus while attending the 4-year institution.

Figure MS2-32

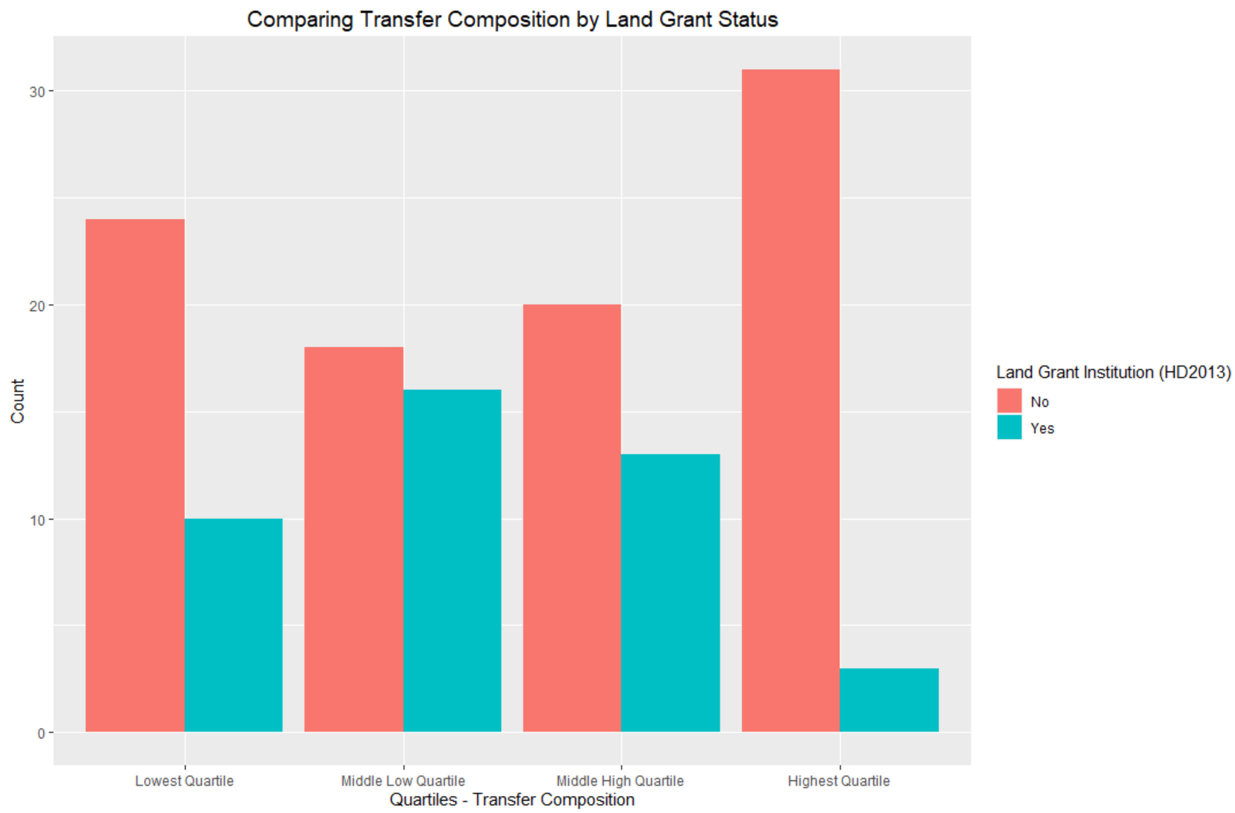
Distribution of Transfer Composition Quartiles by Degree of Urbanization



I also compared the distribution of transfer composition for land-grant institutions with institutions that are not land grants (Figure MS2-33). Given the explicit mission of land-grant institutions to serve students from their local and state communities, it was surprising to find that the overwhelming majority of institutions in the highest quartile of transfer composition were not land-grant institutions. Instead, the majority of land grant institutions fell into the middle two quartiles of transfer composition. Thus, although transfer composition in engineering for the majority of land-grant institutions falls around the average for all institutions in the sample, few seem to be prioritizing transfer pathways in engineering relative to the FTIC pathway. The opposite is true when examining transfer composition for non-land-grant institutions which fell more frequently at either end of the distribution. More nuance is needed to distinguish the characteristics of non-land grant institutions with higher transfer composition from those that fall in the lowest quartile.

Figure MS2-33

Distribution of Transfer Composition Quartiles by Land Grant Status



To examine the relationship of multi-institution/campus organization and transfer composition, I excluded private institutions, all of which are single campus institutions. In examining the distribution of public institutions by transfer composition quartile (Figure MS2-34), single campus institutions were distributed across the quartiles whereas far fewer multi-institution/campus organizations fell into the lowest quartile of transfer composition, falling instead across the other three quartiles. Thus, few multi-campus public institutions enrolled very small proportions of transfer students in engineering; increased representation of transfer students in engineering at public institutions with multiple campuses or that are part of a system may be indicative of increased transfer receptivity.

Finally, 23 of the 28 institutions in the sample that are Hispanic-serving institutions (HSIs) were included in the following comparison with transfer composition quartiles. Evidenced in Figure MS2-35, there is a relationship between HSI status and transfer composition. The majority of HSI institutions in the sample fell into the top two quartiles for transfer composition—institutions that served larger proportions of Hispanic/Latinx students also enrolled larger proportions of transfer students in engineering.

Figure MS2-34

Distribution of Transfer Composition Quartiles by Multi-Institution Campus for Publics

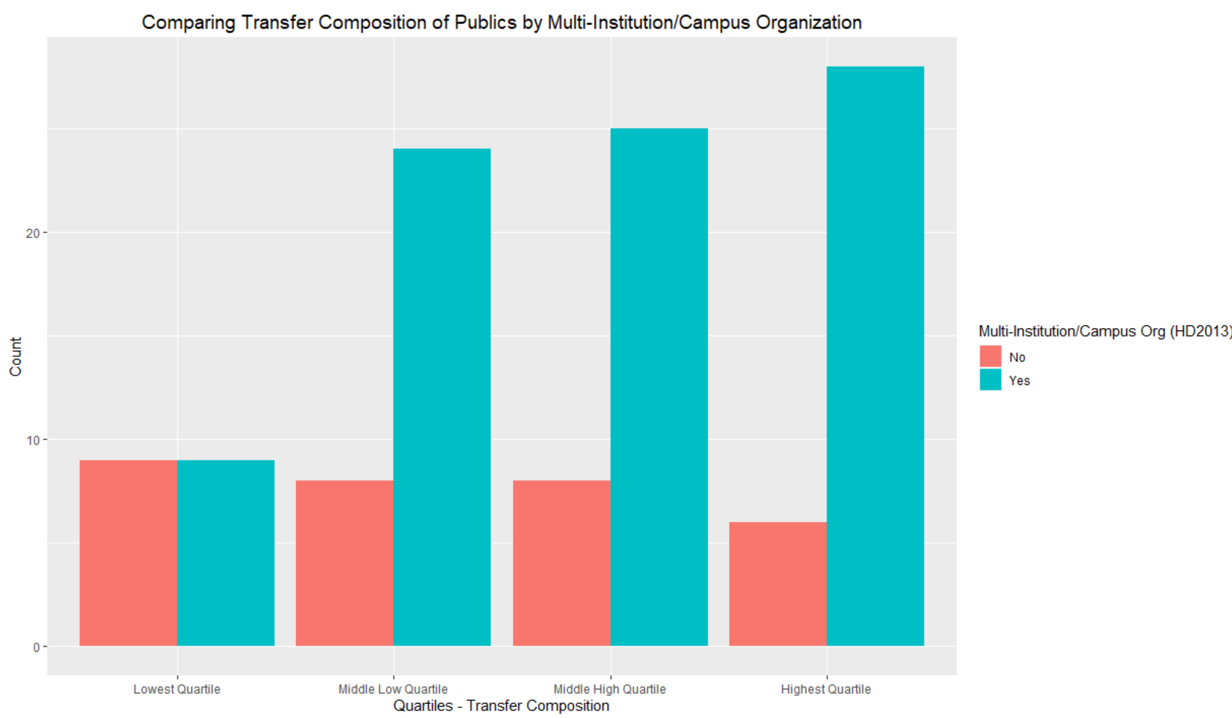
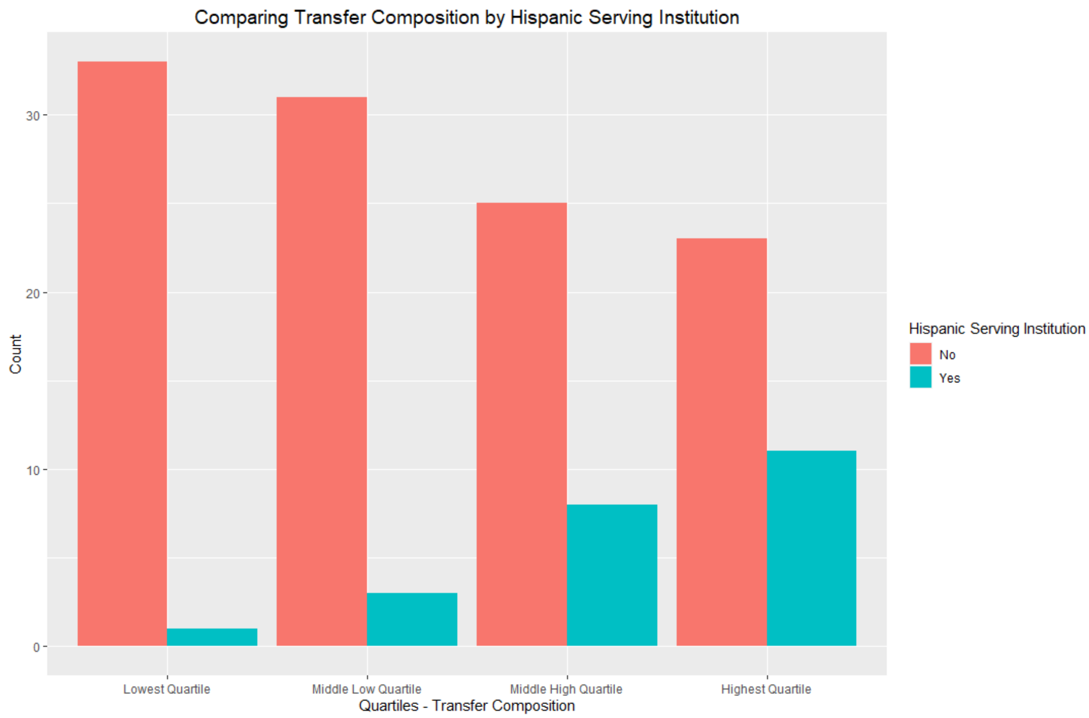


Figure MS2-35

Distribution of Transfer Composition Quartiles by Hispanic Serving Institution



3.4.2.2.5 Examining Transfer Composition by Institutional Selectivity

I compared transfer composition of institutions with two measures of institutional selectivity collected at the institutional level for all incoming undergraduates: Average 75th Percentile SAT Math Scores and Admit Rates. As evident in Appendix MS2-D1, the Average 75th percentile score for entering students on SAT Math significantly negatively correlated ($r_{(130)} = -0.39$, $p < .001$) with transfer composition. Institutions with higher average SAT Math scores for entering undergraduates generally had lower transfer composition in engineering. This inverse relationship may suggest that more selective institutions generally enroll fewer transfer students in engineering, and less selective institutions generally enroll more transfer students. This finding aligns with findings from the distribution of transfer composition into quartiles by institutions' Carnegie classification variables.

Alternatively, in examining the relationship between a second measure of institutional selectivity, admit rate, and institutions' transfer composition in engineering, there was no significant correlation (Appendix MS2-G). This finding seems to be anomalous, however, as the results from descriptive analyses of Carnegie classifications for selectivity as well as average SAT Math scores indicate a significant negative relationship between selectivity and transfer composition in engineering.

3.4.2.2.6 Examining Transfer Composition by Student Cost & Institutional Finance Data

Descriptive analyses comparing engineering transfer composition with student cost and institutional finance measures are most useful when disaggregating these measures by institutional control. As such, analyses were done separately for public and private institutions in the sample for the following student cost and finance variables: published in-state tuition and fees, net price for students awarded grant or scholarship aid, total price for in-state students living off campus not with family, state appropriations, and endowment assets. All cost and finance variables are composite averages across 2010-2018 fiscal years. The following variables had non-significant correlational relationships with transfer composition for public institutions: total price for in-state students living off campus not with family and state appropriations (Appendix MS2-G). The same was true for net price for students awarded grant or scholarship aid for private institutions (Appendix MS2-G).

Published in-state tuition and fees significantly negatively correlated ($r_{(115)} = -0.25$, $p = .006$) with engineering transfer composition for public institutions (Appendix MS2-D2). The negative correlation was even stronger ($r_{(16)} = -0.69$, $p < .001$) between the variables for private institutions (Appendix MS2-D3). In both cases, institutions with lower tuition and fees had higher transfer composition in engineering, which is intuitive because many students who pursue a bachelor's degree via the transfer pathway at public institutions do so to reduce the overall cost to attend college.

In contrast, transfer students, particularly those from community colleges, may negate the financial gains of attending community colleges when choosing to transfer to a private institution given the average tuition and fees in this sample is more than double that of public institutions. It is important to note some limitations of this finding for private institutions. Although a significant relationship exists, the sub-sample size of private institutions is relatively small (n = 18), and the transfer composition for all but two of these institutions still falls in the lowest quartile for transfer composition. So, although private institutions with lower published tuition and fees enroll larger proportions of transfer students in engineering relative to other private institutions with higher sticker prices, those institutions still enroll lower proportions of transfer students in engineering compared to the full sample of institutions. However, the slight uptick in transfer enrollments at private institutions with lower tuition and fees may be a finding that private institutions might consider if they seek to grow transfer student enrollment.

Tuition and fees provides a "sticker price" value for students and families to consider when selecting a college or university to attend, however two other student cost metrics used in this study are more nuanced in depicting students' costs to attend an institution. The first, net price, is the average cost for students to attend the institution considering how institutions subsidize students through financial aid. The average net price for public institutions significantly negatively correlated ($r_{(115)} = -0.32$, $p < .001$) with transfer composition in engineering (Appendix MS2-D4), but was not significantly correlated ($r_{(16)} = .20$, $p = .43$) for private institutions (Appendix MS2-G). Even after accounting for scholarship and grant aid given to students at public institutions in the sample, the same negative relationship was apparent between student cost and transfer composition. Public institutions with lower average net price also enrolled higher proportions of transfer students in engineering on average across the sample. Conversely, public institutions with a higher net price to attend generally enrolled lower proportions of transfer students in engineering. Again, students pursuing a bachelor's degree through the transfer pathway may be more sensitive to cost, even at public 4-year institutions, and are enrolling at higher rates at lower cost institutions.

A second nuanced student cost metric used for analyses in this study is average total price for in-state students living off campus not with family. Unlike the prior two cost variables, this variable accounts for students' living costs. I selected this variable specifically as it might best represent the student costs encountered by a "typical" community college transfer student who chooses to transfer in-state to a public 4-year institution and does not have access to or chooses not to live on campus. Unlike for the other two student cost variables, the relationship between this variable and engineering transfer composition was non-significant for public institutions ($r_{(113)}$ = -0.10, p = .28) (Appendix MS2-G) but was significant for private institutions ($r_{(14)}$ = -0.54, p = .03) (Appendix MS2-D5). This finding indicates that when accounting for costs to live off campus, there is no significant difference in the transfer composition of engineering programs for public institutions. The contrasting findings of descriptive analyses of transfer composition in engineering by student cost variables for public and private institutions warrants attention in future studies examining transfer enrollments and student costs. Collectively, student costs need to be considered in greater detail to understand complex relationships with transfer enrollments.

Finally, I explored the relationship between two institutional finance metrics, state appropriations and endowment assets, and engineering transfer composition. There was no significant relationship between state appropriations and engineering transfer composition for public institutions ($r_{(115)}$ = -0.03, p = .76) (Appendix MS2-G). Endowment assets, however, significantly negatively correlated with transfer composition for public ($r_{(114)}$ = -0.22, p = .02) institutions, even after removing outlier institutions, and did not significantly correlate for private institutions ($r_{(16)}$ = -0.45, p = .06) (Appendix MS2-D6). This could indicate that public flagship institutions with large endowments are enrolling fewer transfer students in engineering than other public institutions with smaller endowments. This finding is similar to other findings related to institutional prestige, ranking, and selectivity.

3.4.2.2.7 Examining Transfer Composition by Engineering Program Rank

Next, I examined several college-level variables in engineering beginning with the relationship between transfer composition and institutions' *U.S. News and World Report* Engineering Program Rankings (Appendix MS2-D7). Transfer composition positively correlated with engineering program rankings for institutions that offer doctoral engineering programs ($r_{(118)}$ = .30, p < .001) but is not significantly correlated for institutions not offering doctoral engineering programs ($r_{(13)}$ = .38, p = .161). The latter non-significant result may be an effect of small sample size. As institutions' engineering program ranking increased (i.e., 1 is the highest ranked program), their transfer composition in engineering decreased. As an example (Appendix MS2-D7), of the seven institutions with higher than 40% transfer composition, only one ranked in the top 50 engineering programs, two in the top 100, and four ranked outside the top 150 engineering undergraduate programs. Another way to examine this figure is to identify institutions that are exceptions to this trend and maintain both high engineering program rankings and transfer composition. Closely examining the four institutions that cluster around 40% transfer composition and rank within the top 50 engineering programs may highlight best practices for institutions that seek to provide prevalent access to engineering programs for transfer students while simultaneously maintaining high program rankings.

3.4.2.2.8 Examining Transfer Composition by Engineering Transfer Policy

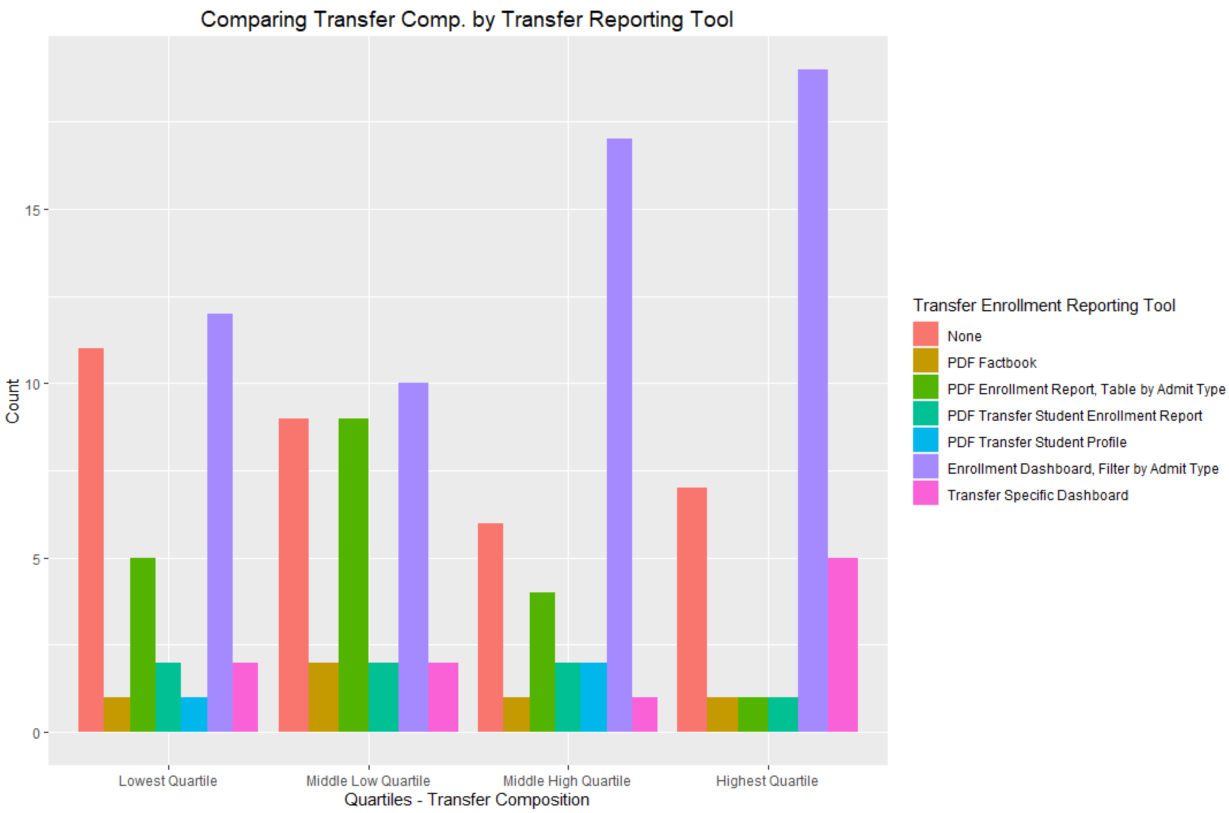
I next examined how two other college-specific policy variables relate to transfer composition in engineering—minimum transfer GPA for admissions consideration and minimum required credits to be completed before applying for transfer admissions. Not all institutions in the sub-sample of institutions with transfer enrollment data (n = 135) provided a minimum GPA for transfer admissions or a minimum number of credits to be completed before consideration for transfer admissions (n = 49). The relationship between transfer composition and the latter variable – minimum number of credits required for admissions consideration—was non-significant ($r_{(47)} = .22$, p = .13) (Appendix MS2-G). However, when comparing engineering transfer composition with minimum GPA for transfer admissions in engineering (n = 102), I found a significant negative correlation at the $p = 0.1$ level ($r_{(99)} = -0.19$, p = .06) (Appendix MS2-D8); as the minimum GPA for admissions consideration was lower across institutions in the sample, transfer composition was higher. The minimum GPA required for admissions consideration for engineering programs across the sample ranged from 2.0 to 3.7, but many institutions recommended that transfer students should have substantially higher GPA's than the minimum required.

3.4.2.2.9 Examining Transfer Composition by Transfer Enrollment Data Tools

To understand the relationship between college-level reporting of enrollment data for transfer students, I examined the relationship between transfer composition in engineering and the types of publicly available data tools used by institutions to track enrollments of engineering transfer students (Figure MS2-36). First, I compared the distribution of institutions into transfer composition quartiles by transfer reporting tool. The most prominent finding was that institutions with enrollment dashboards that could be filtered by admit type (i.e., FTIC vs. New Transfer) encompassed a large proportion of institutions in the highest and middle high quartiles of transfer composition.

Figure MS2-36

Distribution of Transfer Composition Quartiles by EGR Transfer Enrollment Reporting Tool



Similarly, the majority of institutions with transfer-specific interactive dashboards were most prominent in the highest quartile of transfer composition. In contrast, institutions with no publicly available engineering transfer enrollment tool and those with static PDF enrollment reports that included a table of enrollments broken down by admit type and college were more prevalent in the lower two quartiles of engineering transfer composition.

3.4.2.2.10 Examining Transfer Composition by Undergraduate Class Characteristics

More granular analyses compared student-level variables with transfer composition. First, I compared transfer composition with several institution-level undergraduate class characteristics including: average total entering undergraduates, total average transfer-in degree seeking students, average IPEDS undergraduate transfer composition of all entering students, and average percentage of transfer students who attend 4-year institution full-time. All of these variables significantly correlated with transfer composition in engineering for sample institutions (Appendix MS2D9 – MS2-D12). First, as the total number of entering undergraduates increased, so did transfer composition in engineering ($r_{(133)} = .37$, $p < .001$). Institutions enrolling more new undergraduate students also enrolled higher percentages of transfer students in engineering, on average (MS2-D9). In addition to providing increased access for more entering FTIC students, this finding suggests that larger institutions provide more prevalent access for transfer students into engineering, which could be indicative of being more transfer receptive.

Next, I compared transfer composition of sample institutions with their average number of entering transfer-in degree/certificate-seeking undergraduates (Appendix MS2-D10) and found them to be significantly positively correlated ($r_{(130)} = .69$, $p < .001$). As institutions enrolled more transfer students generally, their transfer composition in engineering also increased. This finding is encouraging from the perspective of transfer receptivity in engineering, as it indicates that institution-wide efforts to increase transfer enrollments may permeate into specific fields like engineering.

A similar but slightly more nuanced correlation analysis compared transfer composition in engineering with a composite IPEDS transfer composition variable for all undergraduates at all institutions in the sample. As described previously, to understand what proportion of new undergraduate students at an institution are transfer students, I derived an institution-wide transfer composition variable using IPEDS data that compares the proportion of new students at an institution that are transfer students with FTIC entrants. Transfer composition in engineering significantly positively correlated ($r_{(130)} = .82$, $p < .001$) with the institution-wide transfer composition variable derived from IPEDS, although not all institutions fell on the 1:1 line, suggesting some differences across disciplines at some institutions (Appendix MS2-D11).

This finding aligned with and extended analyses of the relationship of Carnegie undergraduate profile and the distribution of institutions into quartiles based on their engineering transfer composition; institutions classified as higher transfer-in (i.e., at least 20% of all entering undergraduates are transfer) were more likely to fall into the higher two quartiles of engineering transfer composition. A closer look at transfer composition beyond a dichotomous categorization of low and high transfer-in highlights the magnitude of the correlation between institution-wide transfer composition and transfer composition in engineering. These findings are also encouraging from the perspective of transfer receptivity in engineering; efforts by institutions to enroll not just more transfer students on aggregate, but targeting increased proportions of transfer students in their undergraduate classes are likely to increase transfer composition in engineering as well.

Finally, I examined the relationship between the enrollment status of all entering transfer students at an institution with their transfer composition in engineering. In contrast to the other undergraduate class characteristics, these variables significantly negatively correlated ($r_{(133)} = -0.45$, $p < .001$). These findings indicate that institutions with more transfer students enrolling part-time may also have higher transfer composition in engineering. As evidenced in Appendix MS2-D12, the vast majority of institutions in the lowest quartile for transfer composition in engineering had more than 90% of their transfer students enrolled full-time. In contrast, the majority of institutions in the highest quartile of engineering transfer composition had less than 90% of transfer students enrolled full-time, with several falling between 60–80%. Thus, institutions with higher proportions of transfer students enrolling part-time also had, on average, higher transfer composition within engineering. As was evident in prior analyses examining the distribution of institutions into quartiles by transfer composition and Carnegie undergraduate profile, institutions that allow more part-time enrollments for undergraduates may also provide more prevalent access for transfer students in engineering and be more transfer receptive.

3.4.2.2.11 Examining Transfer Composition by Student Demographics

Next, I examined the relationship between transfer composition and demographic characteristics of all students at each institution as well as the student demographics of students in engineering programs. Because this study seeks to understand how transfer pathways may enable access for minoritized student populations to bachelor's degrees in engineering, I included the following race/ethnicities and gender characteristics in descriptive analyses, both at the institution-level and those specific to engineering programs: Black/African American, Hispanic/Latinx, Minoritized Race/Ethnicities, and Women. The Minoritized Race/Ethnicity category includes Black/African American, Hispanic/Latinx, Native American/American Indian or Alaska Native, and Native Hawaiian or Pacific Islander.

Transfer composition significantly positively correlated with enrollments of Black/African American students at the $p < .1$ level for enrollments at the institution-level ($r_{(133)} = .14$, $p = .09$) and in engineering ($r_{(132)} = .14$, $p = .10$) (Appendix MS2-D13; Appendix MS2-D14). This finding may indicate that improving the transfer pathway in engineering is increasing access for Black/African American students at a greater rate than other race/ethnic groups into engineering programs. Similarly, Hispanic/Latinx enrollments at both the institution-level ($r_{(133)}$ = .29, p < .001) and in engineering ($r_{(133)}$ = .18, p = .03) significantly positively correlated with transfer composition in engineering programs. This result indicates that as enrollments of Hispanic/Latinx students increased across the sample of institutions (Appendix MS2-D15), so too did the proportion of transfer students in engineering programs. The same pattern held for enrollments of Hispanic/Latinx students in engineering (Appendix MS2-D16). Bolstering the transfer pathway in engineering may be especially important for broadening participation for Black/African American and Hispanic/Latinx students in engineering.

Similarly, transfer composition of engineering programs significantly positively correlated with enrollment of Minoritized students at the institution ($r_{(133)}$ = .34, p < .001) and in engineering programs ($r_{(133)}$ = .25, p = .003). Increases in transfer composition coincided with increases in Minoritized enrollments across the whole institution (Appendix MS2-D17) and in engineering programs (Appendix MS2-D18). Without knowing the directionality of the relationship between the variables, we do not know for certain whether increased transfer leads to increased minoritized enrollments or vice versa, but they are related and efforts to increase one may lead to increases in the other. Regardless, from the perspective of transfer receptivity in engineering, these results are encouraging signs that efforts to improve transfer pathways in engineering may broaden participation for minoritized students in engineering.

The relationship between institution-wide enrollment of women and engineering transfer composition ($r_{(133)}$ = .25, p = .003) was similar to the other race/ethnicity variables. As enrollments of women was greater at institutions in the sample, engineering transfer composition was also greater (Appendix MS2-D19). In contrast, transfer composition in engineering significantly negatively correlated with enrollment of women in engineering programs ($r_{(133)}$ = -

0.46, $p < .001$). As engineering transfer composition was greater across the institutions in the sample, the enrollment of women in engineering was lower (Appendix MS2-D20). Expanding the transfer pathway to engineering degrees may not help broaden participation for women in engineering, which is a challenging contrast for practitioners and policy-makers to manage as they simultaneously seek to broaden participation for minoritized race/ethnic groups and women in engineering.

3.4.2.2.12 Examining Transfer Composition by Student Success Metrics

Finally, to understand the relationship between transfer composition and institution-level student success, I compared engineering transfer composition with institutions' average full-time retention rates for FTIC students as well as IPEDS graduation rates for first-time, full-time undergraduate cohorts seeking completion of bachelor's degrees at 4-year, 5-year, and 6-year time intervals. The retention rate used was an average across 2010-2018 academic years, and the graduation rates were averages across 2008-2018. Engineering Transfer Composition significantly negatively correlated with FTIC retention rates ($r_{(133)} = -0.35$, $p < .001$) and with graduation rates at 4-year ($r_{(133)} = -0.53$, $p < .001$), 5-year ($r_{(133)} = -0.53$, $p < .001$), and 6-year ($r_{(133)} = -0.49$, $p < .001$) time intervals. As engineering transfer composition increased, both FTIC retention and graduation rates decreased, on average, across institutions in the sample (Appendix MS2-D21 – Appendix MS2-D24).

These findings may suggest that institutions enrolling more transfer students could be backfilling enrollments lost because of attrition of FTIC students. Confirming this, however, would require a more direct comparison of engineering transfer enrollment with graduation rates in engineering programs, not the institution-wide graduation rates for all first-time full-time student cohorts provided by IPEDS. Nonetheless, it seems that institutions with lower retention and graduation rates for FTIC students are more likely to enroll higher proportions of transfer in engineering, and possibly across all disciplines at the institution.

3.4.2.3 Modeling Transfer Composition of 4-Year UG Engineering Programs

Relying on findings from descriptive analyses that examined the relationship between engineering transfer composition and a number of relevant independent variables, I selected a subset of variables for a multiple linear regression analysis with engineering transfer composition as the dependent variable. Table MS2-12 provides a list of variables that were included in the initial model.

Table MS2-12

Initial List of Predictor Variables Considered for Inclusion in Regression Analysis

Initial List of Potential Predictor Variables
Control of institution (HD2013)
Carnegie Classification 2010: Basic (HD2013)
Carnegie Classification 2010: Undergraduate Profile (HD2013)
Degree of urbanization (Urban-centric locale) (HD2013)
Statewide Common Course Numbering System
Transfer Enrollment Reporting Tool
US News World Report Best Undergrad Engineering Schools 2019 Ranking (All)
Avg. SAT Math 75th Percentile (2010-2018)
Avg. Total entering students at the undergraduate level fall (2010-2018)
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)
Avg. IPEDS UG Transfer Composition All Entering Students
Avg. Percentage Transfer-In Full Time (2010-2018)
Avg. Full-time retention rate (2010-2018)
Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)
Avg. Published In-State Tuition & Fees (2010-2018)
Avg. Total price for in-state students living off campus (not with family) (2010-2018)
Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)
Avg. Endowment Assets (All Combined)
Avg. % of All UG EGR Enrollments - Minoritized
Avg. % of All UG EGR Enrollments - Women
Minimum GPA for EGR Transfer

Three variables were removed because of multicollinearity with other predictor variables (Table MS2-13). Additionally, the Avg. IPEDS UG Transfer Composition for All Entering Students variable, which dominated the model, was removed. Given the similarities between how this independent variable and the dependent variable are operationalized, these values represented the same measure at different levels of the institution. As such, transfer composition in engineering is a derivative of transfer composition at the institution as a whole, and so I excluded it from the model. Several other variables were non-significant predictors of transfer composition and were removed from the final model (Table MS2-13).

Table MS2-13

Predictor Variables Removed from Final Model

Variables Removed from Final Model	Reason for Removal
Avg. IPEDS UG Transfer Composition All Entering Students	Aggregated Measure of Dependent Variable
Avg. Full-time retention rate (2010-2018)	Multicollinear with Other Predictors
Avg. Published In-State Tuition & Fees (2010-2018)	Multicollinear with Other Predictors
Avg. Total price for in-state students living off campus (not with family) (2010-2018)	Multicollinear with Other Predictors
Carnegie Classification 2010: Undergraduate Profile (HD2013)	Non-significance
Statewide Common Course Numbering System	Non-significance
US News World Report Best Undergrad Engineering Schools 2019 Ranking (All)	Non-significance
Avg. Total entering students at the undergraduate level fall (2010-2018)	Non-significance
Avg. Percentage Transfer-In Full Time (2010-2018)	Non-significance
Avg. Endowment Assets (All Combined)	Non-significance
Avg. % of All UG EGR Enrollments - Women	Non-significance

The final model predicting transfer composition included three categorical predictor variables (Control of Institution, Degree of Urbanization, and Transfer Enrollment Reporting

Tool) and four continuous predictors (Avg. 75th Percentile SAT Math Score, Avg. 4-Year Graduation Rate, Avg. Net Price for Students Awarded Grant or Scholarship Aid, and Minimum GPA for Admissions Consideration in Engineering Programs). I selected public institutions as the reference group for institutional control as it was the largest sub-group. Small cities were selected as the reference group for the urbanization variable, as institutions in this category were overwhelmingly located on the low end of the distribution for transfer composition. Finally, I selected “none” as the reference group for the transfer enrollment reporting tool category as it was the largest sub-group and fell on the low end of the distribution for transfer composition.

The overall model was significant ($R^2 = .50$, $F_{(15, 83)} = 7.54$, $p < .001$) and explained 50% of the variance in average transfer composition in engineering (Table MS2-14). Two variables were not significant predictors of transfer composition in engineering in the final model: Minimum GPA for Admissions Consideration in Engineering and Control of Institution. The latter result indicates that, when controlling for other variables in the model, institutional control does not significantly predict variance in transfer composition in engineering. Several other variables were significant predictors of variance in transfer composition. First, both midsize cities ($\beta = 8.76$, $t = 3.38$, $p =.001$) and large suburbs ($\beta = 10.4$, $t = 3.67$, $p < .001$) were significant predictors of transfer composition in engineering. The model showed that average transfer composition in engineering for institutions located in midsize cities would be 8.7% higher than at institutions located in small cities, and 10.4% higher at institutions located in large suburbs when compared with those in small cities.

The type of transfer enrollment reporting tool available publicly used by institutions to report engineering transfer enrollment data significantly related to transfer composition in engineering programs. Specifically, institutions with enrollment dashboards that included a filter by admit type (β = 7.02, *t* = 3.17, *p* =.002) and institutions with a transfer-specific dashboard (β = 10.97, *t* = 2.81, *p* =.006) significantly related to higher transfer composition in engineering compared to the reference group of institutions that did not have any publicly available enrollment reporting tool for engineering transfers. The coefficients in the model demonstrate that by having an enrollment dashboard with a filter by admit type, institutions had a 7% higher transfer composition compared to not having a reporting tool at all. Similarly, the model demonstrates that institutions with transfer-specific dashboards had a nearly 11% greater transfer composition compared to institutions that did not have a reporting tool.

Table MS2-14

Summary of Results from Final Regression Model for Transfer Composition

	B	*SE B*	β	*p*
(Intercept)	-6.44	15.07		0.670
\`Control of institution (HD2013)\`Private not-for-profit	6.17	5.99	0.15	0.307
\`Degree of urbanization (Urban-centric locale) (HD2013)\`City: Large	4.56	2.77	0.68	0.103
\`Degree of urbanization (Urban-centric locale) (HD2013)\`City: Midsize	8.76	2.59	1.14	0.001**
\`Degree of urbanization (Urban-centric locale) (HD2013)\`Suburb: Large	10.40	2.83	52.24	0.000***
\`Degree of urbanization (Urban-centric locale) (HD2013)\`Suburb: Small or Midsize	3.14	4.49	5.28	0.486
\`Degree of urbanization (Urban-centric locale) (HD2013)\`Town or Rural	-0.43	2.98	-221.84	0.886
\`Transfer Enrollment Reporting Tool\`Enrollment Dashboard, Filter by Admit Type	7.02	2.22	0.27	0.002**
\`Transfer Enrollment Reporting Tool\`PDF Enrollment Report, Table by Admit Type	2.68	3.10	0.07	0.390
\`Transfer Enrollment Reporting Tool\`PDF Factbook	-4.06	4.54	-0.60	0.374
\`Transfer Enrollment Reporting Tool\`PDF Transfer Student Enrollment Report	1.95	3.36	0.25	0.563
\`Transfer Enrollment Reporting Tool\`Transfer Specific Dashboard	10.97	3.90	55.10	0.006**
\`Avg. SAT Math 75th Percentile (2010-2018)\`	0.08	0.03	0.14	0.002**
\`Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)\`	-0.35	0.08	-180.45	0.000***
\`Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)\`	0.00	0.00	0.00	0.007**
\`Minimum GPA for EGR Transfer\`	-3.57	2.63	-0.09	0.178

One other predictor variable significantly positively related to engineering transfer composition – Avg. 75^{th} Percentile SAT Math scores. SAT Math scores were significantly positively related to transfer composition (β = .08, t = 3.08, p =.003). The coefficients of this predictor variable indicate that for each 10-point increase in 75^{th} percentile SAT Math scores, transfer composition increased on average by 0.8%, when controlling for all other predictor variables in the model. This is counter-intuitive given the descriptive analyses presented earlier in this manuscript, and given other research on institutional selectivity and prevalence of transfer, and may be an effect of multiple relationships going on between variables in this model.

Two other variables in the model, average 4-year graduation rates (β = -0.20 , t = -2.85, p =.005) and average net price for students awarded grant or scholarship aid (β = -0.00, t = -2.24, p =.03), significantly negatively relate to transfer composition in engineering. As an institution's graduation rate increases by 10%, the engineering transfer composition decreased on average by 2%. Similarly, as the average net price for a student to attend an institution increases by $10,000, transfer composition in engineering decreased by 7%, even after controlling for institutional control. These results indicate that both institutions' graduation rates for FTFT students and average cost for students to attend who are subsidized by grant or scholarship aid inversely relate to transfer composition. The former result may be indicative that institutions that experience attrition of FTIC students before degree completion are replacing those enrollments with transfer students in engineering. Institutions that are graduating the majority of their FTIC students have less need to replace lost FTIC enrollments with transfers. The latter result also aligns with prior research that suggests transfer students are particularly price sensitive and pursue a bachelor's degree via the transfer pathway to reduce costs.

In summary, although a bit oversimplified, generally institutions that could be characterized as having higher transfer composition are larger, moderately selective regional comprehensive public institutions in urban or suburban locales. These institutions also enroll larger undergraduate and new transfer classes and are lower cost, less prestigious, and have lower ranked engineering programs. By comparison, generally institutions with average transfer composition tend to be more selective, moderate to higher ranked land grant public institutions with average total undergraduate enrollments and transfer student enrollments. Finally, the least transfer receptive institutions, or institutions with the lowest transfer composition were generally private institutions and the most selective, most highly ranked flagship public institutions. These institutions tended to have smaller undergraduate enrollments with fewer entering transfer students and less racial and ethnic diversity.

3.4.3 Results Part 3: Graduation Data

The final component of transfer receptivity explored in this paper is graduation of transfer students. At the outset of this study, I had sought to conduct comparative analyses of graduation rates for transfer students in engineering across institutions in the sample, much like I had done for transfer enrollments through transfer composition. Unfortunately, in addition to having a small sub-sample of institutions with publicly available graduation data, institutions that did provide data reported graduation rates in a variety of different ways that make meaningful comparisons impossible. For example, a few institutions reported graduation rates only for transfer students from in-state community colleges, excluding any other community college transfer students. Other institutions aggregated all types of transfer students into graduation rates by college, including both vertical and lateral transfer pathways. Thus, comparing across institutions in these two groups would be problematic. As another example, some institutions provided graduation rates at 2-year, 4-year, and 6-year time intervals, whereas others reported 3-year and 4-year rates and others still only 6-year and 8-year rates. Even when institutions reported graduation data for engineering transfer students at comparable time intervals, some institutions reported rates that students graduated in-college, whereas others reported rates for students based on their graduation from the institution, regardless of the college. Finally, many institutions reported rates by entering cohort year, but others reported an aggregated average for several cohort years (see Figure MS2-37, for example), making it difficult to be confident when drawing conclusions from comparisons across institutions.

Collectively, these findings highlight the stark lack of data collection and public reporting of graduation rates for transfer students. Finding publicly available graduation rates for transfer students disaggregated by college was even more challenging, and inconsistencies in how graduation rates are operationalized, what years and cohorts are reported, and what transfer students are included or excluded muddied any attempts to contextualize and compare graduation rates across institutions.

Figure MS2-37

Example of a PDF Transfer Graduation Report with Grad Rates Aggregated Across Cohorts

ACADEMIC INDICATORS AND CAMPUS EXPERIENCES

Graduation rates by academic indicators and campus experiences

	Overall		% graduated within		
	Count	%	2 years	2.5 years	3 years
Total	8,758		60%	77%	87%
Units attempted in the first term					
< 13	624	7%	38%	56%	73%
13 – 14.5	5,358	61%	61%	78%	88%
15 or greater	2,774	32%	63%	79%	88%
First-term GPA / first-year Probation					
< 2.00 or Academic Probation	647	7%	23%	36%	50%
First-term GPA <2.00	480	--	--	--	--
First-year Probation	557	--	--	--	--
C to C+ (2.00 – 2.69)	942	11%	51%	71%	84%
B average (2.70 – 3.69)	4,979	57%	64%	82%	91%
A average (3.70 or greater)	2,093	24%	66%	81%	93%
Declared first major					
After second term	659	8%	18%	30%	46%
By the end of the second term	8,099	92%	63%	80%	90%
First declared major*					
Chemistry	266	3%	44%	74%	88%
Engineering	769	9%	39%	80%	88%
Environmental Design	262	3%	81%	87%	92%
Natural Resources	452	5%	71%	82%	91%
Haas	366	4%	89%	93%	96%
Letters & Science	6,466	75%	61%	77%	88%
Administered Programs	526	*6%*	59%	78%	88%
Arts & Humanities	1,615	*19%*	62%	77%	88%
Bio Sciences	371	*4%*	64%	82%	93%
Math & Phys Sci	541	*6%*	47%	76%	86%
Social Sciences	2,364	*28%*	65%	78%	89%
Undergraduate Division	1,049	*12%*	59%	73%	86%

(University of California – Berkeley, January 2017, https://opa.berkeley.edu/sites/default/files/reporttransfer_19jan2017.pdf)

It seems that institutions may have a better grasp on the matriculation of transfer students into colleges in comparison to the success of those students based on analysis of publicly available data. Alternatively, in effort to be strategic in reporting student success metrics, institutions may be less willing to publicize graduation rates of transfer students if the outcomes are relatively poor. In either case, this study highlights the relative lack of data available to track stable graduation for transfer students in engineering – although a small selection of institutions, particularly in the California system, may serve as exemplars for institutions that seek to improve the graduation component of the transfer receptivity framework.

3.5 Discussion

The results of this study contribute in a number of ways to prior research on transfer pathways, effective transfer partnerships, and transfer receptivity. The organization of the results of this study around three key considerations of the transfer receptivity – data systems and tools to assess and evaluate transfer pathways, the landscape of access for transfer students to engineering, and the landscape of graduation for transfer students in engineering – lends well to framing the discussion. Collectively this manuscript heeds the call by Jain et al. (2011) to advance our understanding of the role 4-year institutions play in realizing vertical transfer pathways and highlights myriad ways institutions can be more transfer receptive.

3.5.1 Advancing Understanding of Tools to Assess/Evaluate Engineering Transfer

One of the most unique and important contributions of this study was a close-up examination of the data and tools institutions had publicly available to report on, assess and evaluate transfer enrollment and graduation in engineering. Jain et al. (2011) suggest that institutions that are transfer receptive make the transfer of students central to the mission of the institution. The quality of and extent to which institutions report transfer data may serve as evidence for how central transfer students are to institutions' missions.

Wyner, Jenkins, and Fink (2017), in examining six highly effective transfer partnerships, found that institutional reporting disaggregated for transfer students was critical to the sustained success of those institutions in supporting students in the transfer pathway. Findings from my study align with their research. Institutions with publicly available interactive enrollment dashboards with filters by admit type or customized entirely for transfer students had higher transfer composition within engineering. It seems that institutions in this study with expansive and customizable reporting tools for transfer students, like those institutions in highly effective transfer partnerships, better monitored student progress through matriculation to the 4-year institution. Wyner, Jenkins and Fink (2016) suggested that the highly effective partners shared data between 2-year and 4-year partners – I find that institutions with higher transfer composition in engineering allowed more public access to the dashboards. Other institutions with static pdf enrollment reports or factbooks as well as institutions reporting data only via email request had lower transfer composition on average. Although I cannot affirm the directionality of the relationship between transfer enrollment reporting tools and transfer composition, it is clear that a relationship exists between them. Institutions seeking to increase the proportion of transfer students in engineering would likely only benefit from robust reporting tools to track their progress from matriculation to graduation.

Two other important findings are based on the descriptive analyses of publicly available graduation data for engineering transfer students. First, half of the 22 institutions with publicly available graduation dashboards, either with a filter by admit type or one customized exclusively for transfer students, were located in California. The California system is often looked to for best practices in facilitating vertical transfer pathways across disciplines (Bers, 2007; Dowd, 2007) and in engineering (Cal-Pass; Blash). My findings suggest that institutions seeking to learn how to improve reporting of student outcomes for engineering transfer students might benefit from investigating current systems being implemented in California 4-year institutions. Another finding that is likely related to this first finding was that state appropriations significantly related to whether or not an institution in the sample provided graduation data for engineering transfer students publicly. Institutions that had publicly available data received more state appropriation funds on average than those that did not report graduation rates publicly. Prior research suggests that declines in state appropriations have forced public 4-year institutions to seek out alternative revenue sources, like enrolling more out-of-state and international students (Cheslock & Gianneschi, 2008) and thus may enroll fewer transfer students and be less inclined to report student success metrics for them. Conversely, states that seek to bolster transfer may benefit from increasing state appropriations and requesting public 4-year institutions to maintain more detailed, nuanced and transparent reporting of student success in return.

3.5.2 Advancing Understanding of Access for Transfers in Engineering

Jain et al. (2011) highlighted the importance of access when constructing the transfer receptivity framework. This study advances our understanding of the landscape of access for transfer students in engineering through transfer composition–a new metric to quantify and contextualize transfer enrollments as a proportion of all new students in engineering. Previous studies have examined transfer enrollments in engineering and STEM (Shealy et al., 2013; Sullivan et al., 2012; Terenzini et al., 2014), compared demographic characteristics of transfer students with FTIC students (Blash et al., 2012; Cortez et al., 2015; Knight et al., 2014), and spotlighted institutions that enroll large numbers of transfer students across the institution (Wyner et al., 2016). Transfer composition goes a step further, serving as a proxy measure for the extent to which transfer students are represented as a proportion of total enrollments in engineering. To my knowledge, no previous study has conceptualized transfer enrollments in this way. Carnegie has used a dichotomous form of this measure in deriving the Undergraduate Profile variable, which includes lower transfer-in (i.e., less than 20% of an institutions' undergraduate enrollment are transfer students) and higher transfer-in (i.e., more than 20% of an institutions' undergraduate enrollment are transfer students) as one of its sub-measures to categorize institutions. My study expands that dichotomous categorization into a continuous measure that can provide a more nuanced understanding of the landscape of access for transfer students. Using available data from IPEDS, transfer composition can be readily compared at the institution-level without requiring the data collection that occurred for this study for engineering. The novel dataset generated for this research affords more nuanced comparisons within institutions' colleges of engineering.

My findings demonstrate that the landscape of access for transfer students into engineering programs, as operationalized through transfer composition, is not uniform across institutions. In this sample, transfer students represented as little as 1% and as much as 57% of all new engineering students across institutions. Given the prominence of articulation agreements that have emerged at state, system, and institutional levels (Hodara et al., 2017), it seems logical to assume that transfer would be more prevalent at public institutions than at privates. Although findings from descriptive analyses in this study support this assumption, transfer composition was not uniformly distributed across public institutions, and several other factors seemed to play a more important role in transfer composition in engineering. Student costs to attend college, for example, negatively related to transfer composition, even when controlling for institutional control. This finding aligns with evidence from other research that flagship institutions are becoming cost prohibitive for low-income and even some middle-income students (Mugglestone, Dancy, Voight, 2019). The majority of transfer students fall into these low- and middle-income categories (Community College Research Center, 2019), tend to be more price sensitive than FTIC students (Cheslock, 2005b), and choose the community college transfer pathway in engineering for affordability reasons (Ogilvie & Knight, 2018).

A counter-intuitive finding from this study is the dearth of land grant institutions in the highest quartile of transfer composition. It may be that land grant status is interacting with flagship status in certain states. The pursuit of program rankings, prestige amongst peers, and increased out-of-state and international enrollments may be shifting the focus of land grants away from in-state transfer initiatives (O'meara, 2007; Stocum, 2013). A substantial portion of institutions falling in the highest quartile of transfer composition in the sample are regional comprehensive institutions that, as a result of shifts in priorities for state land grants and flagships, appear to be serving as a prominent pathway for transfer students in engineering.

Relatedly, findings from descriptive analyses indicate that *U.S. News and World Report* Engineering Program Rankings and institutional selectivity both negatively correlated with transfer composition in engineering. This finding is not surprising considering institutional selectivity is a prominent metric in calculating rankings, which subsequently works toward diminishing access (Glynn, 2019; Hossler, 2004; Pusser & Marginson, 2013). However, there were a few institutions in the sample that were exceptions with highly ranked (i.e., top 50) undergraduate engineering programs or high average 75th SAT Math scores for FTIC students that also maintained transfer composition in the highest quartile of the sample. Spotlighting the policies, practices and cultures of these institutions may provide insight into how prestige and access for transfer students can be pursued simultaneously akin to the *New York Times* (NYT) Access Index (Leonhardt, 2017; "Top Colleges Doing the Most for the American Dream," 2017) which rewards institutions that graduate students at rates above 75% and enroll higher proportions of lower and middle-income students at lower costs. In fact, several of the institutions in the top 10 in the NYT Access Index also fell into the top two quartiles for transfer composition in this study. Even though the access index is based on Pell Grant eligibility of FTIC enrollments, enhancing access for FTIC and transfer students while simultaneously maintaining institutional prestige may be possible. Accordingly, following the lead of the NYT Access Index, perhaps we ought to consider a new way to think about ranking engineering programs that incorporates access. Then, tying funding to that ranking system could act as a policy lever to encourage institutions to prioritize increased access to engineering programs through vertical transfer from community colleges.

Institutions in this study with higher transfer composition seem to be broadening participation in engineering for Hispanic/Latinx and other Minoritized students, marginally so for Black/African American students, and not at all for Women. These divergent findings align with the mixed findings from prior research on the demographic composition of community college transfer students in engineering. Some studies have found that Minoritized students are substantially more prevalent in STEM pathways at community colleges than FTIC pathways directly out of high school (Gibbons et al., 2011; Knight et al., 2014; Yoon et al., 2015). Others have found that transfer students who successfully matriculate to 4-year institutions experience attrition of students from Minoritized backgrounds resulting in the transfer students who do successfully transfer looking a lot like students in FTIC pathways (Bahr et al., 2017; Blash et al., 2012; Perez et al., 2016). My study finds similar contrasts, with institutions that have higher transfer composition also having higher percentages of enrollments of Hispanic/Latinx students and Minoritized students. Certainly a few states in particular, namely California, Texas and Florida, are probably playing a role in this finding as they tend to prioritize vertical transfer more than most states (Garcia Falconetti, 2009; Moore et al., 2009; Smith & Miller, 2009; Wellman, 2002) and have high Hispanic/Latinx populations. Higher transfer composition, however was associated with only slight increases in Black/African American student enrollments in engineering and was negatively correlated with women enrollments, suggesting transfer pathways are not broadening participation in engineering for women and are marginally effective to improve Black/African American enrollments.

Institutions' location and the presence of certain state-level transfer policies both related to transfer composition in engineering. For example, institutions in large urban and suburban communities seem to be better positioned to facilitate transfer pathways in engineering compared to small cities, towns and rural communities. This finding may be explained by the proximity of universities to urban and suburban community colleges. Previous research has indicated proximity to home as one of the prominent reasons that students start their postsecondary pathways in engineering at a community college (Brawner & Mobley, 2014; Ogilvie & Knight, 2018), and students may seek to continue their postsecondary journey at 4-year institutions proximal to home and the community college they attended. The proximity of community colleges and 4-year institutions has been critical to the success of co-enrollment models in increasing viable transfer pathways (Cortez et al., 2015; National Academy of Engineering, 2015). With more community colleges that enroll more students located in urban and suburban locales, it makes sense that 4-year institutions nearby would have higher transfer composition.

In examining the influence of state-level articulation policy elements on transfer composition in engineering, only common course numbering systems (CCNS) related to transfer composition. Common course numbering systems are typical components of articulation agreements (Hodara et al., 2017; Wyner et al., 2016) and may be helping to streamline curricular pathways for engineering transfer students that are critical for successful progression in STEM transfer pathways (Bahr et al., 2017). This finding also affirms the work of Roksa and Keith (2008) who found that articulation policies are not aimed at increased transfer, but preservation of credits for students who do transfer. It could be that institutions in states with common course numbering systems are benefiting from the efforts to align courses and preserve credits. The other three components common in articulation policies examined in this study—guaranteed transfer of an associate’s degree, transferable core of lower-division courses, and reverse transfer—had little relationship with transfer composition in engineering. This finding aligns with prior research on the efficacy of transfer articulation policy, which is inconclusive, particularly at the state-level, in some part because of lack of consistency when they are operationalized by institutions and practitioners (Wang, 2020; Wang, 2020). These policies may not be sufficiently equity-minded and fall short of concrete equity-oriented transfer goals that explicitly increase student diversity at 4-year institutions and overcome persistent inequities for students at the margins (Wang, 2020).

Alternatively, admissions policies at the institution and college levels may be more influential than state-level policies in determining to what extent transfer students gain access to programs, particularly in engineering. For example, in this study I found that the minimum GPA required to be considered for transfer admission into colleges of engineering negatively correlated with transfer composition. Many institutions made clear that the real minimum GPA for successful admission into engineering far exceeded the posted minimum, particularly at institutions with lower transfer composition. Additionally, it was not uncommon for institutions to require higher GPA minimums for community college transfers compared with lateral transfers, and to use multiple GPA metrics, such as a Math and Science GPA, when making admissions decisions. The prevalence of nuanced GPA requirements for admissions, particularly those requiring higher thresholds for vertical transfers, may not be sufficiently equity-minded (Wang, 2020). Previous research has pointed to examples of institutions that do implement more equity-minded policy, such as allowing community college students to carry their GPA over to the 4-year institution (National Academies of Engineering, 2015). I did not find evidence of these types of admission policies in this study, at least from data collection through the ASEE profiles transfer admissions page. Future iterations of this study would benefit from more nuanced examination of articulation policies that exist and are executed at the institution and college-levels to better understand how these policies interact with access for transfer students to 4-year engineering programs.

Finally, I felt it important to critically reflect on one assumption of the transfer composition metric—the primary framing of this metric is that institutions with transfer students accounting for a larger share of new enrollments in engineering are probably more transfer receptive. An alternative view could suggest the opposite, and that prioritization of transfer student enrollments is necessitated only by attrition of FTIC students in engineering, with transfer students serving simply as an enrollment balancer. Adopting this perspective would suggest that a higher transfer composition does not necessarily reflect transfer students as more central to institutions' mission, a key consideration of transfer receptivity, but instead a solution to enrollment needs for the institution. Future analyses could explore if this is happening by examining trends of transfer composition over time and observing to what extent enrollments fluctuate year to year for FTIC and transfer students in engineering. Additionally, qualitative research at institutions with high transfer composition would be invaluable in helping illuminate if the assumptions of this study hold true, and that institutions with high transfer composition are in fact more transfer receptive and not simply relying on transfer students for enrollment balancing in engineering.

3.5.3 Advancing Understanding of Graduation for Transfers in Engineering

In addition to access, Jain et al. (2011) point to graduation of transfer students as critical to increasing transfer receptivity of 4-year institutions. The intention of this study at the outset was to examine the landscape of graduation rates for engineering transfer students and in doing so, give some context to graduation of transfers in engineering. Instead, the most prominent finding of this study is that we know comparatively little about graduation rates disaggregated by college and admit type compared to our understanding of transfer matriculation. Less than half (36%) of institutions in the sample publicly reported graduation rates for transfer students aggregated across all disciplines, with a mere 15% providing an additional level of detail by disaggregating by college. By comparison, including institutions that provided transfer enrollment data via email and those that only had enrollment data for some of the years in this study, 79% of the sample institutions had enrollment data disaggregated by college and admit type. Even when excluding those institutions that provided data by request via email, the percentage of institutions with publicly available enrollment data disaggregated by admit type and college (58%) far exceeded those providing graduation data. It is thus no surprise that the vast majority of prior research on transfer success (i.e., graduation) is aggregated at the institution-level (e.g., Glynn, 2019), whereas studies and reports on transfer enrollments specific to engineering disciplines is more common than transfer success (e.g., Sullivan et al., 2012; Zhang et al., 2003). The handful of previous studies that have examined graduation rates for engineering transfer students compare transfer students with FTIC students in engineering at the same institution (Shealy et al., 2013; Yoon et al., 2015; Zhang et al., 2004) or examine time-to-degree for transfer students (Blash et al., 2012). Analyses that compare graduation rates of transfer students across institutions are a notable area in need of future attention by scholars.

The dearth of graduation rate data is undoubtedly linked to the lack of reporting requirements from the U.S. Department of Education for student success outcomes for transfer students. Although considerable progress has been made to increase transparency of student success outcomes via public reporting of graduation rates, a result of the Student Right to Know act (Student Right-to-Know and Campus Security Act, 1990, institutions must only comply by providing a graduation rate for first-time, full-time student cohorts. Ninety-six percent of institutions in my sample provided this rate publicly on their websites or linked users to IPEDS or College Navigator websites to obtain that information. A consequence of requiring all public institutions to report these data publicly was the realization that using first-time full-time cohorts as the group of interest may not adequately capture the "typical student" for all types of institutions in the United States (Association for Institutional Research, 2020). For example, this metric did not work well for community colleges whose first-time, full-time student cohorts account for only a small percentage of students they enroll, excluding more prominent groups of students like those enrolled part-time, students who are transferring from another local community college, and students who transfer out of 4-year institutions. Additionally, the metric does not capture students who successfully transferred out of community colleges to 4-year institutions prior to completing an Associate's degree, which led to the emergence of reverse transfer policies and the Outcome Measure in IPEDS (Association for Institutional Research, 2020), which gives institutions the opportunity to report degree outcomes for non-first-time entering students (i.e., transfer-in students).

Reporting on this variable, however, is not required and may only be reported by institutions with high enrollments of students who are not first-time, full-time students. Perhaps the prevalence of reporting outcome measures disaggregated by students' pathways will become more prominent for 4-year institutions. In searching for graduation rate data for this study, however, a few alternative sources for collection of graduation data emerged. First, a few institutions in the sample participated in the Student Achievement Measure, which captures alternative outcomes for students other than graduation from the entering institution, like transfer and graduation from other 4-year institutions, and provides institutions the ability to disaggregate by admit type. Other institutions are members of the Consortium for Student Retention Data Exchange (CSRDE), which collects retention and graduation data of member institutions and shares de-identified reports of "peer institutions" for benchmarking. This organization brings to light an important consideration of this study: institutions may be reticent to share graduation rates publicly given its prominence in institutional rankings and prospective student decision making. Efforts like those in this study to contextualize and compare graduation for transfer students by college may be hindered by institutions' reticence to share these data publicly when institutions feel the stakes are higher and consequences harsher than they are for enrollment data.

In summary, given the dearth of graduation data disaggregated for transfer students in engineering and the variance in aggregating strategies for data by cohorts that are available, it is hard to judge the success of 4-year institutions in supporting graduation of transfer students, at least when also considering discipline. Jain et al (2011) contend that transfer receptive institutions will prioritize timely graduation of transfer students, akin to the work being done to support improved graduation for FTIC students (Zhang et al., 2004). Findings from this paper indicate that we have a long ways to go to heed the call to understand and prioritize graduation of transfer students, and focused attention to graduation by discipline is even further behind. By exploring the availability of graduation data that is discipline specific for transfer students, this paper echoes the call of Jain et al (2011) for more research, policy and practices at the institution and state level that help interrogate graduation outcomes for transfer students in engineering.

3.6 Implications

The implications of this research are extensive. I begin by highlighting an overarching implication related to funding that can be applied across implications for research, policy, and practice. Funding is particularly relevant given the prevalence of grant funds being funneled to STEM and to broadening participation in engineering by the National Science Foundation and other granting agencies.

3.6.1 Implications for Funding Engineering Transfer Research, Policy and Practice

Funding from the National Science Foundation for research related to engineering education is distributed inequitably, with 11 of 233 organizations receiving 56% of all engineering education grant funds (Reeping, Lyles, & Grote, 2020). The institutions receiving a majority of these funds are overwhelmingly Tier 1 research universities and private institutions with highly ranked engineering and STEM programs. Some of those grants are dedicated to improving transfer pathways in engineering, particularly those aimed at broadening participation in engineering. Based on findings from this study, funding that disproportionately goes to Tier 1 research universities and private institutions to improve engineering transfer pathways could have limited impacts, as transfer students account for a small proportion of engineering students at these institutions. In general, these tier 1 research institutions, flagship publics and land grant institutions are not the institutions enrolling higher proportions of transfer students, according to findings from this study. To realize expansion and enhancement of the transfer pathway in engineering, funding for research, practices and policies should place greater focus on regional comprehensive institutions, master's colleges and universities, and doctoral universities that emphasize teaching. Such institutions generally have engineering programs with higher transfer composition. Funding could go much farther, impact more transfer students in engineering, and showcase institutions that already prioritize transfer students as central to their mission within colleges of engineering. Considering shifts in allocations of NSF and other grant funds to these institutions could bolster transfer as a viable pathway to an engineering degree but also may move the needle for broadening participation in engineering.

3.6.2 Implications for Research on Engineering Transfer Pathways

I highlight several important implications for future research on engineering transfer. First, the data collected for this study combine enrollment and graduation rates for engineering transfers from IR websites for all 193 institutions in the sample with ASEE and IPEDS data for those institutions into a novel dataset that can be used for further engineering transfer research. Second, along the same lines as the implication for funding, this study gives some context to the landscape of access, graduation, and assessment and evaluation systems for transfer students in engineering. Most notably, by examining transfer enrollments in engineering through transfer composition, I have highlighted institutional and policy characteristics of institutions that are more common amongst institutions with higher engineering transfer composition. Future research could select institutions that have high engineering transfer composition and, adopting a similar approach to Wyner, Jenkins and Fink (2017) in creating of the Transfer Playbook, conduct extensive interviews and focus groups as well as document and policy analyses to understand what institutional transfer policies, practices, and cultural elements are common amongst such colleges of engineering. That work would further investigate the elements that Jain et al. (2011) identified as key indicators of transfer receptive institutions but would do so within the discipline-specific context of engineering.

Although my study aimed to provide more context for stable graduation of transfer students in engineering, the time required to overcome the lack of publicly available graduation data and inconsistencies in reporting for the limited data that do exist were not feasible for this study. However, future research could adopt a similar approach as I did for collection of enrollment data to capture graduation rates for engineering students for more institutions and then conduct analyses that compare average graduation rates across institutions and their characteristics. My study also highlights the value of examining how institutions report student enrollment and outcome data. Given the significant relationship between the tools used by institutions to report these data and engineering transfer composition, future studies should include and account for information availability when exploring and examining student success.

Finally, there is an opportunity to collect more nuanced articulation agreement and transfer admission policy information on institutions' websites that could be analyzed and categorized for comparative analyses with transfer composition. A limitation of this study, like many other studies before it, was the use of a limited few state-level articulation policies that are compared with transfer composition and may not capture the level of nuance to examine their impacts on access and graduation for engineering transfer students.

3.6.3 Implications for Transfer Policies to Improve Transfer in Engineering

This study highlights some important impacts of transfer policies as well as gaps that persist in bolstering it as a feasible pathway for engineering. First, given the positive relationship between the presence of common course numbering systems at the state level and institutions increased transfer composition, state and institution leaders seeking to make an impact on transfer pathways in engineering should investigate this particular element of articulation policies. It may be that, given the highly structured and sequential nature of engineering academic plans, systems that go beyond preservation of accepted credits but have a common course numbering system better facilitate vertical transfer.

A major finding of this study is that institutions high in transfer composition in engineering are, in general, not the highest ranked engineering programs. It is not reasonable to expect that all institutions should be transfer receptive and prioritize transfer student enrollments, particularly with public disinvestment in higher education that has led to increased competition for enrollments and dependence on tuition and fee revenues. However, it would be hard to argue that the current system is equitably structured, where students who begin at a community college, even if they perform well academically, have equitable access to "elite" engineering programs. The majority of highly ranked and highly selective institutions had less than 10% of their new enrollments typically filled by transfer students, and some (perhaps many) of those students are lateral transfers from other competitive 4-year institutions. Many of those institutions also had higher minimum GPA requirements for transfer admissions consideration and specified even higher minimums for community colleges students. The barriers to access these programs are compounding and may be prohibitive of community college pathways for low-income, minoritized, and first-generation students. If we are authentically interested in equity-minded transfer policy in engineering, states or federal policy mechanisms would be necessary to incentivize institutions to prioritize community college transfer pathways and reduce barriers to entry.

Finally, although the Student Right to Know Act of 1990 and the addition of the outcome measure in 2017 have made some progress in making graduation outcomes at institutions more transparent for the public, the availability of enrollment and graduation data disaggregated for transfer students remains lackluster, particularly compared to the information available for FTIC students. For example, nearly every institution, especially those with more competitive admissions for FTIC applicants, had extensive profiles that provided incredibly detailed information about entering classes including standardized test scores, high school class ranks, feeder high schools with counts of new students from each school, and non-academic accolades of entering FTIC students. Many institutions even had interactive maps with detailed enrollment counts of international undergraduate students by country of origin. Conversely, I attempted to find the largest feeder community college for transfer students for every institution in the sample and was only able to find that information for 46 institutions, less than a quarter of the sample. Policies that mandate or incentivize institutions to publicly report enrollment and graduation for transfer students may be necessary to improve the information available about transfer students. Further, the positive relationship between publicly available enrollment data with transfer composition may suggest that improvement in reporting will simultaneously improve institutions' and states' awareness of the efficacy of transfer pathways that reap increases in transfer student matriculation and graduation.

3.6.4 Implications for Practice to Better Support Transfer Pathways in Engineering

In terms of implications for practice, institutional leaders who seek to make transfer central to their mission, a key tenet of transfer receptivity and of highly effective transfer partnerships, could use transfer composition as a metric to understand the extent to which the institution and individual colleges and majors enroll transfer students. This inter-institutional dataset enables institutions to benchmark themselves to other institutions in transfer composition of engineering programs. Similarly, transfer support staff and advisors, which may serve as the primary advocate for transfer students on 4-year campuses, can leverage these metrics and findings to advocate for increased collection and dissemination of information about transfer student matriculation and success. Finally, I hope scholars, practitioners and policy makers find this information helpful in making more transparent what transfer access and graduation look like for students in engineering.

3.7 Conclusion

This manuscript advances prior research on transfer receptivity (Jain et al., 2011) by expanding our understanding of how 4-year institutions manage access and graduation of transfer students in engineering. I combined data from institution's IR websites, ASEE's database management system and IPEDS into a novel dataset to create a new enrollment composition metric – transfer composition – that captured the proportion of 4-year institutions' engineering enrollments comprised of transfer students and compared those values across institutions. I also explored the relationship between transfer composition and various institutional characteristics and transfer policies to understand what characteristics relate to lower or higher levels of transfer composition. Additionally, by collecting data from institutions' IR websites, I characterized the types of data and tools 4-year institutions had available publicly to assess and evaluate transfer pathways in engineering. Findings from this study contribute to our understanding of transfer receptivity by illuminating the variation in data and tools available for institutions to assess and evaluate transfer pathways in engineering as well as the landscape of enrollment and graduation of transfer students in engineering.

Chapter 4: Summary Discussion and Implications Across Manuscripts

4.1 Introduction

Looking across both manuscripts included in this study, several important overarching themes emerged. First, findings from this study suggest that, to examine and improve the efficacy of transfer pathways at 4-year institutions, investigation and improvement efforts should be discipline-specific. Next, streamlining vertical transfer at the institution, state, and national levels is challenged by competing institutional logics—access versus prestige—a consequence of vertical differentiation. This dissertation sheds some light on how states and institutions must manage these relatively incongruent aims in facilitating transfer partnerships between 2-year and 4-year institutions. Then, I identify a need for policy or ranking mechanisms that incentivize and reward 4-year institutions for increasing access through transfer paths that are tied to broadening participation in engineering. Next, I discuss the benefits of increased transparency of transfer policies and provision of transfer student data publicly, particularly for minoritized students. Additionally, my study highlights the need to broaden our focus from short-term matriculation to long-term success for transfer students. Finally, I suggest a few areas for future research that span across these manuscripts.

4.2 Understanding Transfer Receptivity that is Discipline-Specific

Although a few scholars have pointed to the need to make discipline-specific improvements to streamline transfer (Bahr et al., 2013; Wang, 2020), the bulk of research remains focused at the institution (Fink & Jenkins, 2017; Jain et al., 2011; Wyner et al., 2016) and state levels (Garcia Falconetti, 2009; Hodara et al., 2017). Findings from this study provide further evidence that specific attention should be paid to disciplinary nuances when designing policies and practices to improve vertical transfer. In Manuscript 2, I found that only one of the state-level transfer articulation policy elements—common course numbering system—related to transfer composition in engineering. This finding may be discipline-specific, as common course numbering systems, more than the other three state-level policies analyzed in the study, are designed to align lower-division courses between 2-year and 4-year institutions and thus should help institutions better align courses and plans of study. This policy may be particularly valuable for engineering given its highly sequential and rigid academic plan structure. Institutions in states with these policies will use the same numbering system for lower division engineering courses and may more easily align sequences of courses for engineering transfer students; said another way, common course numbering helps 2-year and 4-year institutions speak the same language when talking about courses. Additionally, the minimum GPA required for admissions consideration in engineering significantly correlated with transfer composition; discipline-specific admissions policies may very well influence access for transfer students and thus impact the transfer receptivity of an institution.

Manuscript 1 sheds light on the value of examining policies at the institution level that are discipline-specific and highlights challenges for effective transfer even when institutions have an articulation policy specific to a college of engineering. As a competitive-admissions college that houses a number of competitive-entry engineering disciplines, transfer students are subject to additional admissions scrutiny upon arrival to the receiving institution, even when they transfer via the articulation policy. The transfer receptivity of admissions policies at an institution, when examining those policies for transfer students at the institution as a whole, may not be indicative of transfer receptivity of policies within the college of engineering at that institution, or other competitive colleges and disciplines. Additionally, the enactment of exemptions that enable engineering transfer students having access to upper-level courses as well as admissions-conscious advising practices that enable students to meet admissions standards for entry into engineering disciplines serve as examples of transfer receptive policies and practices that are discipline-specific. Conversely, the emergence of rigor as a common justification for including engineering transfer students in the enrollment management process may spotlight a discipline-specific element of a receiving institution's culture that is less transfer receptive. In summary, at least in the case study described in Manuscript 1, to understand transfer receptive policies, practices and cultures requires a discipline-specific approach.

4.3 Managing the Access and Prestige Paradigms to Facilitate Transfer in Engineering

Both manuscripts also contribute to our understanding of how institutions manage competing interests to increase access for low-income, first-generation and minoritized students while maintaining prestige of academic disciplines, colleges, and at the institution as a whole. Manuscript 2 provides evidence that, in general, institutions that are more selective and have higher ranked engineering programs have lower transfer composition in engineering programs. Conversely, institutions that enroll more students, more transfer students, and admit students at higher rates generally enroll higher proportions of transfer students in engineering. However, there are a few institutions that seemed to break this trend and maintained relatively high transfer composition in engineering while being more selective in admissions and having highly ranked undergraduate engineering programs. The emergence of these institutions brings to light important questions. Are access and prestige truly diametrically opposed? Is it possible to increase the prestige of an undergraduate engineering program while simultaneously increasing enrollments for community college transfer students? What have these institutions done, in terms of transfer receptivity, to overcome transfer stigma and perceived concerns over a lack of rigor in community college engineering programs? Could the prestige and access paradigm in transfer be a fallacy altogether, with an unfounded perspective that community college transfer students are less prestigious, less academically prepared, and thus less successful than FTIC students in engineering? Findings from Manuscript 1 provide some evidence that transfer students actually outperform FTIC students in upper-division engineering courses. These questions warrant future investigation and may provide tremendous insights for increasing transfer receptivity in engineering without sacrificing pursuits of prestige or dispelling the myth that community college transfer students are less successful and thus less prestigious.

Findings from Manuscript 1 showcase how one institution balances access and prestige paradigms. In establishing an engineering transfer articulation agreement with the states' community college system, students are provided a pathway that makes explicit what requirements must be met to be guaranteed access into the institution. Simultaneously, by incorporating transfer students into enrollment management post-transfer, the institution can maintain some control over admissions into engineering disciplines and push students who do not meet the requirements into less competitive engineering disciplines or out of engineering entirely. As competitive admissions is one of the indicators of prestige, the most competitive disciplines can continue accruing prestige gained from competitive admissions for undergraduate engineers, while the college of engineering establishes access through the articulation agreement. The focus of Manuscript 1 was on the messiness that occurs when these two policies collide, but the existence of both may also be important levers for the institution and the college of engineering to simultaneously attend to access and prestige paradigms.

4.4 A Call for Policy Mechanisms that Incentivize and Reward Access Via Transfer Paths

Expanding on the previous theme, an important contribution of this pair of manuscripts is the emergent need for policy mechanisms that incentivize and reward access through transfer pathways in engineering. Manuscript 2 points to the relationship between higher transfer composition in engineering and increased representation of Minoritized students in engineering programs. Efforts to broaden participation in engineering have been going on for more than 40 years (National Academy of Engineering, 2015); despite those efforts, the proportion of enrollments nationally in engineering for Minoritized students lags behind their share of the population (*Digest of Education Statistics*, 2018, 2019). Given the findings of Manuscript 2, perhaps too little attention has been paid to the potential of the community college pathway to an engineering degree to serve as an important lever to broaden participation in engineering.

One finding from Manuscript 1 may be evidence for the lack of attention paid to community college pathways. Rigor was the most prevalent justification cited for inclusion of transfer students in the enrollment management process, despite the incongruence with the articulation agreement. Perhaps concerns about the rigor of engineering courses at community colleges outweigh the perceived benefits the pathway could provide to broaden participation in engineering. If we assume this imbalance, a need emerges for policy mechanisms that incentivize and reward 4-year institutions for embracing the community college transfer pathway for an engineering degree.

Wang (2020) identifies a need for more equity-minded transfer policy for institutions that are authentically interested in being more transfer receptive. Federal and state governments could get involved and reward institutions that establish more equity-minded transfer policies, or take punitive actions with holding back funding for those that do not, a performance-based funding approach commonly used in K-12 (Hanushek & Lindseth, 2009). However, with public disinvestment in higher education (Heller, 2001) and the academic capitalization of postsecondary institutions (Rhoades & Slaughter, 2004), the leverage of governments to shift institutions to be focused on access and equity dissipates (Leonhardt, 2017). Based on findings from my study, I suggest an alternative approach. US News and World Report rankings are among the prominent vehicles used by institutions to tout their prestige and the prestige of their academic programs (Merisotis & Sadlak, 2005; Sponsler, 2009). Increasing access for low-income, minoritized, and first-generation students is not often included among the levers for increasing an institution's rank. Instead, the opposite is true, as selective admissions and increased standardized test scores for incoming classes serve as important means to increase in rank (Pusser & Marginson, 2013). Within this ranking system, institutions are not rewarded for equity-minded policies, and activities that increase access do not increase institutions rank and prestige. Because rankings seem to play a more prominent role in how institutions behave, shifts to more equity-minded rankings systems may be a key to incentivize and reward institutions to increase access.

The New York Times Access Index provides one such example, where institutions are ranked based on the share of FTIC students who are Pell Grant eligible as well as the net price to attend the institution ("Top Colleges Doing the Most for the American Dream," 2017). Institutions receive a higher rank as their share of Pell eligible enrollments increase and the net price to attend decreases. Another requirement for being included in the ranking system is to graduate students at 75% or higher rates within 5 years, which excluded all but around 190 postsecondary institutions as of 2017. This ranking system is radically different from US News and World Report and other similar ranking systems that do not prioritize access. As mentioned in the Discussion section of Manuscript 2, I found that many of the institutions in the top 10 of this ranking system also fell into the upper quartiles of the distribution for transfer composition in engineering. Moving the needle for access for low-income FTIC students may have similarities to increasing access for community college transfer students, and the aforementioned institutions may be doing both well but are not currently rewarded for those efforts through a ranking system touting their prestigious work to improve access.

One potential remedy would be to make modifications to the US News and World Ranking system that incorporates access-oriented metrics. Alternatively, the New York Times Access Index could be expanded to include transfer students and incorporate more institutions by using a less stringent threshold for 5-year graduation rates, a variable that itself is conflated with institutional prestige and selectivity. Yet another possibility would be creation of an entirely separate, competing, ranking system that ranks institutions using metrics accounting for broadened access. No matter the approach, an important question remains: what is the incentive for changing the current ranking system to be more access oriented?

Accruing buy-in from institutions or from US News and World Report is almost certain to be a formidable challenge, particularly given how many 4-year institutions prioritize them and how often affluent students and families attend to these ranking systems in the college application process. From my perspective, the most logical approach would be punitive, increasing public awareness and scrutiny of inequalities in the higher education system that are perpetuated by ranking systems that reward restricted access. For example, public attention and criticism increase as the cost to attend college continues to rise forcing students and families to rely increasingly on student loans (Abel & Deitz, 2014; Akers & Chingos, 2014; Ehrenberg, 2000); simultaneously, institutions compete in an arms race for state-of-the-art recreation centers, expensive athletic facilities, and administrative staff to support campus operations (Enders, 2014; Frank, 2004; Leonhardt, 2017; Leslie & Rhoades, 1995). Public concern over inequities in admissions have expanded as a result of recent admissions scandals involving several institutions that fall in the upper echelons of these ranking systems (Jaschik, 2019b, 2019a)—undoubtedly these scandals are related to the pursuit of access to the prestige and rankings associated with these institutions. Additionally, although we do not yet know how Covid-19 will impact higher education institutions long term, the financial constraints that many students and families are sure to encounter will influence their decisions for postsecondary enrollment. To what extent should higher education institutions be socially responsible in reducing costs and increasing access for those students and families? Further, for the first time since the great recession in 2008, 4-year institutions may be financially motivated to broaden enrollment access, particularly to in-state residents, to overcome gaps in international and out-of-state student enrollments looming as a result of Covid-19. The convergence of these forces may provide an opportunity to propose an alternative ranking system that rewards institutions who prioritize access, and may be a critical step to make increasing access a prestigious endeavor.

4.5 Increased Transparency of Transfer Policies and Student Data Could Benefit Transfer

Both manuscripts in this study highlight how unwritten policies and unpublished data have the potential to influence decision making of transfer students. In Manuscript 1, the exemption that allows transfer students to take upper-level major courses during their first semester post-transfer is not written or publicized. The lack of transparency of this exemption influences transfer students differently based on their transfer student capital (TSC) (Laanan, 2004). Students who have accrued a wealth of TSC may reach out to advisors at the university to inquire about the policy and learn of the exemption and take advantage of that "insider" knowledge when making decisions to prepare for transfer. Conversely, students who lack TSC, as might be the case for first-generation students or students attending a community college with few transfer-centered resources, may not learn of the exemption and, lacking insider knowledge, make decisions to the detriment of successful matriculation and timely graduation from the 4-year institution in engineering.

Similarly, findings from Manuscript 2 suggest that the provision of engineering transfer student enrollment data publicly significantly related to the transfer composition of an institution in engineering. Institutions with more archaic forms to publish transfer enrollment data, or lacking publicly available data altogether, tended to enroll smaller proportions of transfer students into engineering. It could be that prospective engineering transfer students or their advisors or families, in researching the matriculation and graduation outcomes of current and past community college transfer students, are influenced by the availability of data when making decisions about where to apply. Institutions that are more transparent in sharing enrollment and graduation data for transfer students in engineering may be more transfer receptive and provision of data publicly will have tangible benefits for students and families seeking to make informed decisions about their specific transfer destination and how that may impact their successful matriculation and timely graduation.

Thus, both manuscripts point to the benefits for increased transparency of data and policies related to and influencing transfer students, and conversely, the consequences of concealing information. Consequently, I implore institutions that seek to improve the transfer pathway for community college transfer students to increase transparency of policies and data, particularly data that are specific to engineering.

4.6 Broadening Focus from Short-Term Matriculation to Long-Term Transfer Success

A final theme that emerged across both manuscripts was that our understanding of the short-term success (i.e., matriculation) of transfer students remains well ahead of the long-term success outcomes (i.e., graduation). In Manuscript 1, I described how advisors would act intentionally and strategically when advising courses for first semester transfer students in effort to balance their course loads and thus preserve their first term GPA to help students meet the requirements of the enrollment management policy and be admitted into a degree-granting major of their choice. This approach sometimes meant advising students to take courses that are not part of their degree plan or retaking courses they successfully completed at the community college. Other advisors shared a concern about the long-term implications of focusing on short-term entry into major including extended time-to-degree.

Findings from Manuscript 2 also spotlight the fissure in data availability between engineering transfer student enrollments and their graduation outcomes—the former were available publicly at 79% of institutions in the sample compared to only 15% for the latter. Although previous research shows that engineering is not reasonably considered a 2+2 pathway from community colleges (Ogilvie, 2014, 2017), focused efforts to improve our understanding of average time-to-degree for community college transfer students in engineering may also propel us to improve the pathway and decrease students' time-to-degree. Transfer students' delayed time-to-degree could, in part, be a result of complacency in tracking those outcomes. Improving the tracking of outcomes would be a good starting place to improve the transfer pathway in engineering.

4.7 Future research areas across manuscripts

One major area of future research prompted by the manuscripts in this study is understanding faculty and staff perceptions of the institutional logics that drive the behavior of the institutions that they serve. Specifically, I propose that the vertical transfer function is challenged by the opposing logics of access, which is central to community colleges (Cohen et al., 2014), and prestige, which is increasingly prominent in 4-year institutions across sectors, but particularly in research universities, flagship publics, and liberal arts institutions (O'Meara & Bloomgarden, 2011; Stocum, 2013). I rely on this theoretical concept for this study and support the claims with prior research, but I would be interested in asking institutional actors across postsecondary institutions about how they perceive institutional logics to play out at their institution. Further, I seek to understand perceptions of how institutional logics govern the behaviors of the institution and its actors, and how these logics diverge from or are similar to those relied upon by institutions in other levels of the higher education system. Future studies could test the theory that divergent institutional logics exist, particularly between 2-year and 4-year institutions, and whether those logics are causally linked with challenges to streamline vertical transfer.

Another important area of future research linked to these manuscripts is understanding the extent to which transfer policies are transfer receptive (Jain et al., 2011)and equity-minded (Bensimon et al., 2016). Both are critical theories that challenge our current way of thinking about policies, and as such, may be invaluable in helping us overcome the perpetual lack of, inconclusive, and mixed findings from studies examining the efficacy of articulation policy. Instead of re-working the traditional ways of assessing the efficacy of these policies, these critical approaches may be required to transform our paradigm completely about vertical transfer.

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Appendices

Appendix MS1-A: Interview Protocol (university and colleges blinded)

Protocol for Interviews with Advisors at University, and Community Colleges

The primary area of exploration for this interview is to better understand the transfer of coursework process for incoming transfer students into University's College of Engineering. More specifically, we seek to better understand:

1. How students receive information on transfer of coursework prior to transfer
2. The role of advisors in the course transfer process
3. The application of transfer articulation agreements in practice
4. Perceived (in)sufficiency of academic preparedness for incoming transfer students
5. How transfer of courses and student program choice impact transfer student retention, graduation rate, and time-to-degree completion

Demographic Data

Name, title, department and role within the institution

Experience with the Transfer of Coursework Process

1. [For 4yr schools] We want to learn more about the transfer of coursework process for incoming transfer students into University's College of Engineering.

- **How students receive transfer information**
  - What informational resources are available to students interested in transferring to University's College of Engineering?
  - How are students made aware of what courses they should take while at the sending institution? How are they made aware of what will and will not transfer from their sending institution?
- **Role of advising in transfer**
  - How does your advising office serve or interact with incoming transfer students?
  - How much contact do you have with prospective transfer students before they matriculate to University?
  - If you serve as an advisor for a specific engineering program at University, who are the key points of contact for students interested in your specific major/program prior to their matriculation into your program?
  - What advice would you give to transfer students on coursework that should be completed before they transfer to University?
- **Articulation agreements**
  - How familiar are you with the state's guaranteed transfer agreements for Engineering at University?

        - Based on your experience, how effective are articulation agreements in supporting student transfer to your institution?
        - For parts of articulation agreements that are ineffective, what improvements would you recommend?
        - What are the most common gaps in transfer student transcripts and course completion when they arrive to your program?
    - **Academic preparedness**
        - Based on your experience, how would you compare academic preparedness of transfer students with traditional freshman in upper division engineering coursework.
        - How well do you believe sending institutions prepare transfer students for upper division Engineering coursework at University?
        - Which courses have the greatest influence on levels of academic preparedness for incoming transfer students?
        - What courses are problematic courses for students in your program? These are sometimes called gatekeeper courses.
        - What academic preparation advice, tips, strategies would you give transfer students while attending the [SI] to best prepare for [RI]
    - **Impact on student success**
        - To the best of your knowledge, how do you believe transfer students compare with traditional freshman in retention, graduation rates and time-to-degree completion at [RI]?
        - Do you see patterns in coursework preparation for students who transfer to University and are academically successful?
        - Do you see patterns in coursework preparation for students who transfer to University and are not academically successful?

2. **[For 2yr schools]** We want to learn more about the transfer of coursework process for prospective engineering transfer students from your institution to another receiving institution.
    - **How students receive transfer information**
        - What informational resources are available to students interested in transferring to 4-year engineering programs?
        - How are students made aware of what courses they should take while at the sending institution? How are they made aware of what will and will not transfer from their sending institution?
        - How knowledgeable are faculty, staff and students at your institution on the course transfer process to partner 4-year institutions?
    - **Role of advising in transfer**
        - How does your advising office serve or interact with incoming transfer students?
        - How much contact do you have with prospective transfer students before they matriculate to a 4-year engineering program?

    - What advice would you give to transfer students on coursework that should be completed before they transfer?
- **Articulation agreements**
    - How familiar are you with the state's guaranteed transfer agreements for Engineering?
    - Based on your experience, how effective are articulation agreements in supporting student transfer from your institution to other 4-year engineering programs?
    - For parts of articulation agreements that are ineffective, what improvements would you recommend?
    - In your experience, which courses are students having the most trouble successfully transferring to their desired 4-year engineering programs?
    - How do articulation agreements impact students' completion of the Engineering Associate's Degree before transfer?
    - In terms of course requirements, how aligned are your institutions degree requirements with the articulation agreements for partner 4-year institutions?
- **Academic preparedness**
    - In your opinion, how would you compare academic preparedness of transfer students with traditional freshman in upper division engineering coursework?
    - How well do you believe your institution prepares transfer students for upper division Engineering coursework at 4-year institutions?
    - Which courses have the greatest influence on levels of academic preparedness for transfer students?
    - What courses are problematic courses for students in your program? These are sometimes called gatekeeper courses.
    - What academic preparation advice, tips, strategies do you give transfer students while attending your institution to best prepare for transfer?
- **Impact on student success**
    - To the best of your knowledge, how do you believe transfer students compare with traditional freshman in retention, graduation rates and time-to-degree completion at partner 4-year institutions?
    - Do you see patterns in coursework preparation for students who transfer to 4-year engineering programs and are academically successful?
    - Do you see patterns in coursework preparation for students who transfer to 4-year engineering programs and are not academically successful?
    - If you had the opportunity to make changes to the course transfer process for students starting at your institution and transferring to a 4-year engineering program, what changes would you make to the course transfer process and institutional partnerships to improve transfer student success?

Appendix MS2-A: Descriptive Statistics for All Variables

Table A1. Summary Descriptive Statistics – Continuous Variables

Variable	nbr.val	nbr.null	nbr.na	min	max	median	mean
Engineering Enrollment Continuous Variables							
Total UG Enrollment (2017)	193	0	0	1013	12995	2486	3175.0
New Transfer Enrolled (Average) (2010-2018)	154	0	39	4	1390	144	178.7
FTIC Enrolled (Average) (2010 - 2018)	193	3	0	0	2845	551	632.9
Total New Transfer & FTIC Enrollments (Average) (2010 - 2018)	193	2	0	0	3325	678	768.6
Transfer Composition (Average) (2010 - 2018)	152	0	41	1	57	18	20.1
Institution-Level Continuous Variables							
Avg. Percent Admitted (2010-2018)	193	0	0	6	100	64	60.3
Avg. SAT Math 75th Percentile (2010-2018)	188	0	5	500	800	652	660.3
Avg. Published In-State Tuition & Fees (2010-2018)	193	1	0	0	51187	10672	17399.6
Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)	192	0	1	3121	38935	15495	17811.2
Avg. Total price for in-state students living off campus (not with family) (2010-2018)	183	0	10	12235	76455	25692	32001.5
Avg. State Appropriations (2010-2018)	193	54	0	0	6.14E+08	1.06E+08	1.35E+08
Avg. Public (GASB) Value of Endowments End of Fiscal Year (2010-2018)	139	0	54	427264	9.06E+09	2.36E+08	6.40E+08
Avg. Private (FASB) Value of Endowments End of Fiscal Year (2010-2018)	51	0	142	3.18E+07	3.43E+10	1.15E+09	3.61E+09
College-Level Continuous Variables							
US News World Report Best Undergrad Engineering Schools 2019 Ranking (Doctorate Offered)	164	0	29	1	197	83	86.1
US News World Report Best Undergrad Engineering Schools 2019 Ranking (No Doctorate Offered)	29	0	164	1	110	38	40.4
Minimum GPA for EGR Transfer	137	1	56	0	4	3	2.6
Min Required Credits	63	0	130	1	60	24	29.3
Student-Level Continuous Variables							
Avg. Total entering students at the undergraduate level fall (2010-2018)	193	0	0	437	14247	4848	4944.4
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)	193	1	0	0	7534	1185	1331.2
Avg. IPEDS UG Transfer Composition % - All Entering Students	193	1	0	0	62	23	23.9

Avg. Percentage Transfer-In Full Time (2010-2018)	189	0	4	46	100	88	85.7
Avg. Percent of total enrollment that are Black or African American (2010-2018)	193	0	0	0	81	5	6.9
Avg. Percent of total enrollment that are Hispanic/Latino (2010-2018)	193	0	0	2	89	7	11.4
Avg. Percent of total enrollment that are Minoritized Race or Ethnicity	193	0	0	3	90	14	18.7
Avg. Percent of total enrollment that are American Indian or Alaska Native (2010-2018)	193	128	0	0	5	0	0.3
Avg. Percent of total enrollment that are Native Hawaiian or Other Pacific Islander (2010-2018)	193	169	0	0	4	0	0.1
Avg. Percent of total enrollment that are women (2010-2018)	193	0	0	18	61	51	48.5
Avg. % of All UG EGR Enrollments - African American (2010-2018)	188	0	5	0	76	3	4.9
Avg. % of All UG EGR Enrollments - Hispanic (2010-2018)	188	0	5	1	87	6	10.7
Avg. % of All UG EGR Enrollments - Minoritized (2010-2018)	191	3	2	0	88	12	16.0
Avg. % of All UG EGR Enrollments - Native American (2010-2018)	188	0	5	0	5	0	0.4
Avg. % of All UG EGR Enrollments - Native Hawaiian (2010-2018)	188	0	5	0	12	0	0.2
Avg. % of All UG EGR Enrollments - Women (2010-2018)	193	0	0	8	45	20	20.9
Avg. Full-time retention rate (2010-2018)	193	0	0	64	98	86	85.4
Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)	193	1	0	0	90	37	41.8
Avg. Graduation rate - Bachelor degree within 5 years total (2008-2018)	193	0	0	24	96	60	60.9
Avg. Graduation rate - Bachelor degree within 6 years total (2008-2018)	193	0	0	31	97	66	66.0

Table A1. [Continued]: Summary Descriptive Statistics – Continuous Variables

Variable	SE.mean	CI.mean.0.95	var	std.dev	coef.var
Engineering Enrollment Continuous Variables					
Total UG Enrollment (2017)	151.7	299.3	4443382.0	2107.93	0.66
New Transfer Enrolled (Average) (2010-2018)	14.2	28.1	31226.5	176.71	0.99
FTIC Enrolled (Average) (2010 - 2018)	29.1	57.4	163680.5	404.57	0.64
Total New Transfer & FTIC Enrollments (Average) (2010 - 2018)	36.0	71.1	250493.2	500.49	0.65
Transfer Composition (Average) (2010 - 2018)	1.0	2.0	149.7	12.23	0.61
Institution-Level Continuous Variables					
Avg. Percent Admitted (2010-2018)	1.6	3.1	492.1	22.18	0.37
Avg. SAT Math 75th Percentile (2010-2018)	5.0	9.9	4718.3	68.69	0.10
Avg. Published In-State Tuition & Fees (2010-2018)	1037.6	2046.5	2.08E+08	14414.55	0.83

Avg. Net Price - Students Awarded Grant or Scholarship Aid (2010-2017)	546.2	1077.3	5.73E+07	7568.26	0.42
Avg. Total price for in-state students living off campus (not with family) (2010-2018)	1090.3	2151.2	2.18E+08	14748.87	0.46
Avg. State Appropriations (2010-2018)	1.01E+07	1.98E+07	1.95E+16	1.40E+08	1.04
Avg. Public (GASB) Value of Endowments End of Fiscal Year (2010-2018)	1.06E+08	2.10E+08	1.56E+18	1.25E+09	1.95
Avg. Private (FASB) Value of Endowments End of Fiscal Year (2010-2018)	8.81E+08	1.77E+09	3.96E+19	6.29E+09	1.74
College-Level Continuous Variables					
US News World Report Best Undergrad Engineering Schools 2019 Ranking (Doctorate Offered)	4.0	7.9	2635.9	51.34	0.60
US News World Report Best Undergrad Engineering Schools 2019 Ranking (No Doctorate Offered)	5.2	10.6	774.6	27.83	0.69
Minimum GPA for EGR Transfer	0.0	0.1	0.3	0.51	0.20
Min Required Credits	2.0	4.0	253.9	15.93	0.54
Student-Level Continuous Variables					
Avg. Total entering students at the undergraduate level fall (2010-2018)	203.6	401.7	8.00E+06	2829.05	0.57
Avg. Transfer-in degree/certificate-seeking undergraduate enrollment (2010-2018)	85.3	168.2	1.40E+06	1184.59	0.89
Avg. IPEDS UG Transfer Composition % - All Entering Students	0.9	1.9	170.5	13.06	0.55
Avg. Percentage Transfer-In Full Time (2010-2018)	0.8	1.6	125.0	11.18	0.13
Avg. Percent of total enrollment that are Black or African American (2010-2018)	0.6	1.3	80.3	8.96	1.30
Avg. Percent of total enrollment that are Hispanic/Latino (2010-2018)	1.0	1.9	184.2	13.57	1.19
Avg. Percent of total enrollment that are Minoritized Race or Ethnicity	1.1	2.2	238.9	15.46	0.83
Avg. Percent of total enrollment that are American Indian or Alaska Native (2010-2018)	0.1	0.1	0.6	0.77	2.63
Avg. Percent of total enrollment that are Native Hawaiian or Other Pacific Islander (2010-2018)	0.0	0.1	0.1	0.37	4.74
Avg. Percent of total enrollment that are women (2010-2018)	0.6	1.3	80.0	8.94	0.18
Avg. % of All UG EGR Enrollments - African American (2010-2018)	0.5	0.9	40.6	6.37	1.29
Avg. % of All UG EGR Enrollments - Hispanic (2010-2018)	1.0	1.9	171.4	13.09	1.22
Avg. % of All UG EGR Enrollments - Minoritized (2010-2018)	1.0	2.0	204.9	14.31	0.89
Avg. % of All UG EGR Enrollments - Native American (2010-2018)	0.0	0.1	0.4	0.60	1.46
Avg. % of All UG EGR Enrollments - Native Hawaiian (2010-2018)	0.1	0.1	0.8	0.88	3.62
Avg. % of All UG EGR Enrollments - Women (2010-2018)	0.5	0.9	39.7	6.30	0.30
Avg. Full-time retention rate (2010-2018)	0.6	1.2	67.6	8.22	0.10

Avg. Graduation rate - Bachelor degree within 4 years total (2008-2018)	1.6	3.2	521.4	22.84	0.55
Avg. Graduation rate - Bachelor degree within 5 years total (2008-2018)	1.4	2.7	362.2	19.03	0.31
Avg. Graduation rate - Bachelor degree within 6 years total (2008-2018)	1.2	2.4	278.6	16.69	0.25

Table A2. Summary Counts of Institutions by State

State	Total # of Institutions
AL	4
AR	1
AZ	3
CA	21
CO	3
CT	1
DE	1
FL	7
GA	2
HI	1
IA	2
ID	3
IL	6
IN	4
KS	3
KY	2
LA	3
MA	9
MD	4
ME	1
MI	9
MN	2
MO	3
MS	2
MT	2
NC	4
ND	1
NE	1
NH	1
NJ	5
NM	2
NV	2
NY	15
OH	10
OK	3
OR	2
PA	9

RI	1
SC	2
SD	2
TN	4
TX	14
UT	3
VA	5
WA	2
WI	5
WV	1
Total	193

Table A3. Summary Counts of State-Level Transfer Policies

State-Level Transfer Policy?	Transferable core of lower-division courses	Statewide Common Course Numbering System	Statewide guaranteed transfer of an associate degree	Statewide Reverse Transfer
No	25	90	51	93
Yes	121	56	95	53
Private	47	47	47	47
Total	193	193	193	193

Table A4. Summary Counts of Institutions by Control of Institution

Control of institution (HD2013)	Count
Private not-for-profit	47
Public	146
Total	193

Table A5. Summary Counts of Multi-Institution or Multi-Campus Organizations

Multi-institution or multi-campus organization (HD2013)	Count
No	87
Yes	106
Total	193

Table A6. Summary Counts of Institutions by Land Grant Institution

Land Grant Institution (HD2013)	Count

No	143
Yes	50
Total	193

Table A7. Summary Counts of Hispanic Serving Institutions

Hispanic Serving Institution	Count
No	165
Yes	28
Total	193

Table A8. Summary Counts of Historically Black College or University

Historically Black College or University (HD2013)	Count
No	191
Yes	2
Total	193

Table A9. Summary Counts of Tribal College

Tribal College (HD2013)	Count
No	193
Yes	0
Total	193

Table A10. Summary Counts of Institutions by Carnegie Classification: Basic

Carnegie Classification 2010: Basic (HD2013)	Count
Research Universities (very high research activity)	88
Research Universities (high research activity)	61
Master's Colleges and Universities (larger programs)	22
Doctoral/Research Universities	8
Baccalaureate Colleges--Diverse Fields	4
Master's Colleges and Universities (medium programs)	4
Master's Colleges and Universities (smaller programs)	2
Schools of engineering	2
Baccalaureate Colleges--Arts & Sciences	1
Not Applicable, not in Carnegie universe (not accredited or nondegree-granting)	1
Total	193

Table A11. Summary Counts by Carnegie Classification: Undergraduate Profile

Carnegie Classification 2010: Undergraduate Profile (HD2013)	Count
Full-time four-year, more selective, lower transfer-in	59
Full-time four-year, selective, higher transfer-in	40
Full-time four-year, more selective, higher transfer-in	38
Medium full-time four-year, selective, higher transfer-in	24
Full-time four-year, selective, lower transfer-in	16
Medium full-time four-year, inclusive	7
Full-time four-year, inclusive	5
Not applicable, special focus institution	2
Medium full-time four-year, selective, lower transfer-in	1
Not applicable, not in Carnegie universe (not accredited or nondegree-granting)	1
Total	193

Table A12. Summary Counts of Institutions by Degree of Urbanization

Degree of urbanization (Urban-centric locale) (HD2013)	Count
City: Large	62
City: Midsize	36
Suburb: Large	31
City: Small	30
Town: Remote	9
Suburb: Midsize	7
Town: Distant	7
Suburb: Small	5
Rural: Fringe	4
Town: Fringe	2
Total	193

Table A13. Summary Counts of US News and World Report Ranking Program Types

US News Ranking - Program Type	Count
Doctoral Offered	164
No Doctoral Offered	29
Total	193

Appendix MS2-B: Plots for Significant Results Related to Availability of Engineering Transfer Enrollment Information

Figure B1. Comparing Admit Rate by Engineering Transfer Enrollment Data

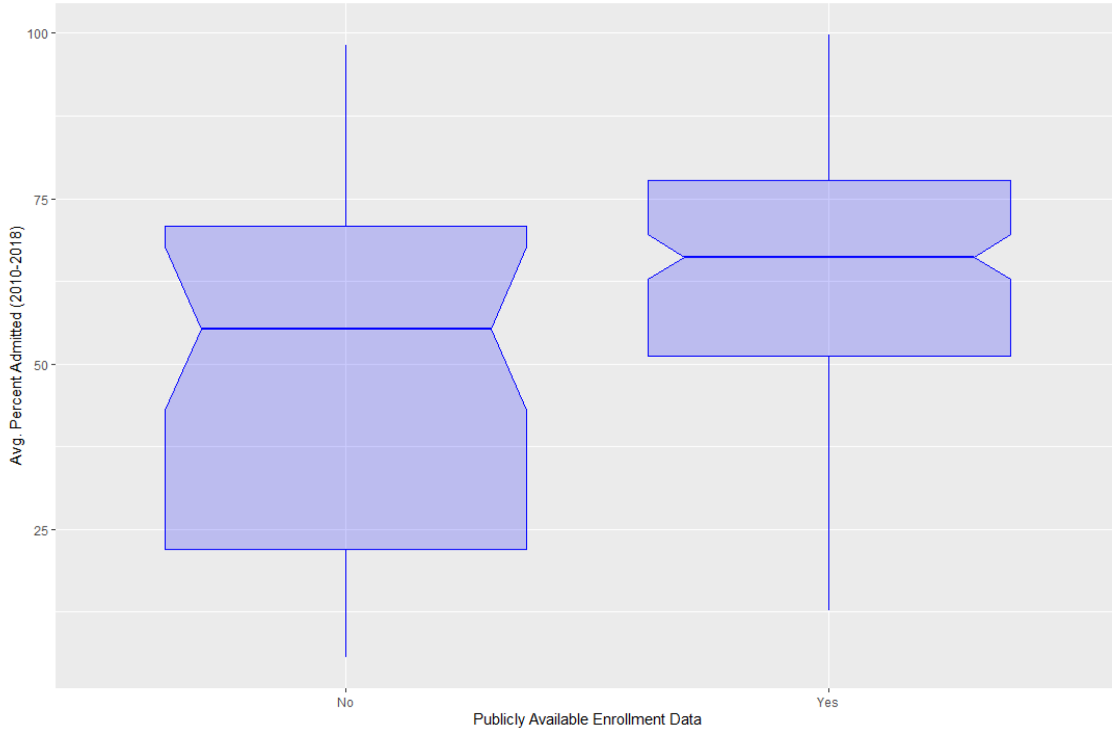


Figure B2. Comparing Admit Rate of Publics by Engineering Transfer Enrollment Data

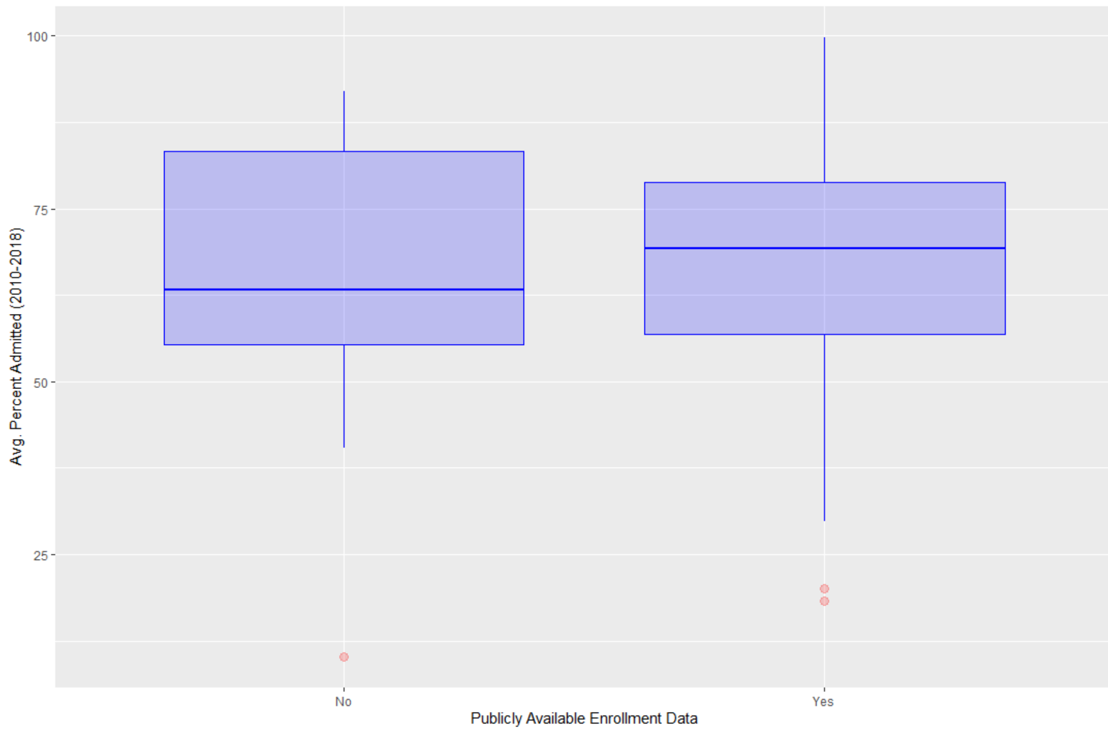


Figure B3. Comparing Admit Rate of Privates by Engineering Transfer Enrollment Data

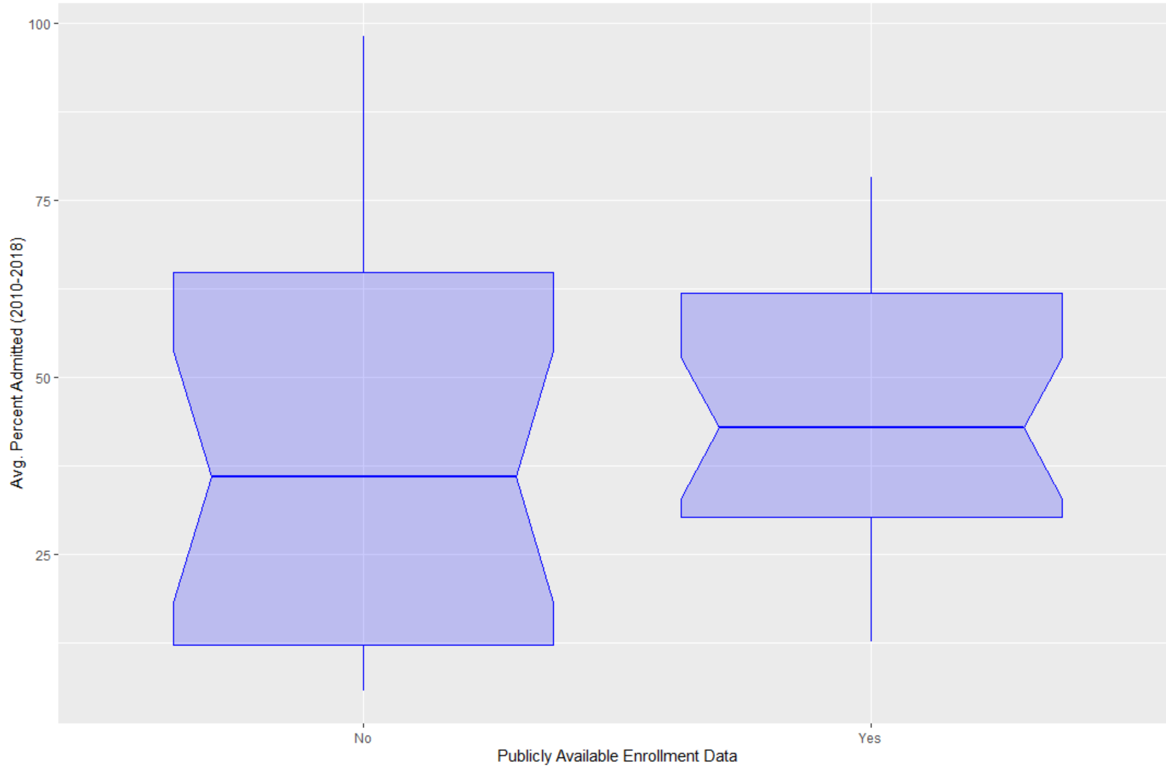


Figure B4. Comparing Avg. SAT Math 75th Percentile by Engineering Transfer Enrollment Data

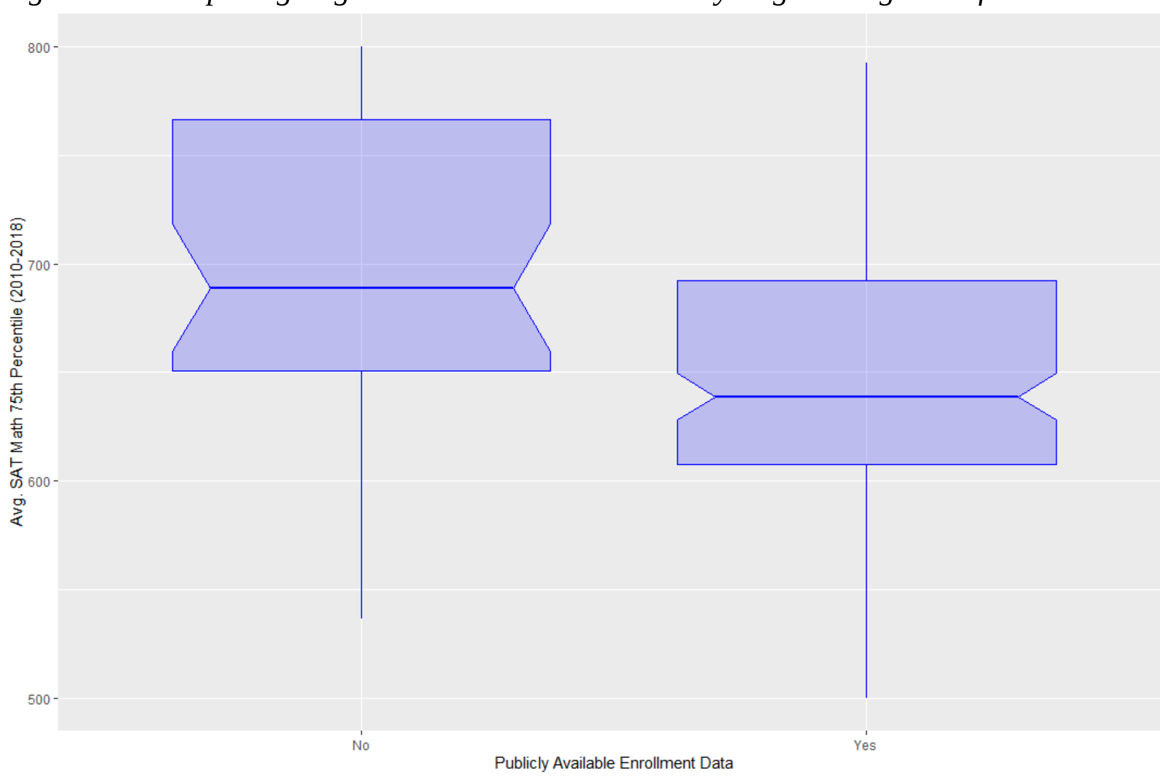


Figure B5. Comparing Avg. SAT Math 75th Percentile of Publics by Engineering Transfer Enrollment Data

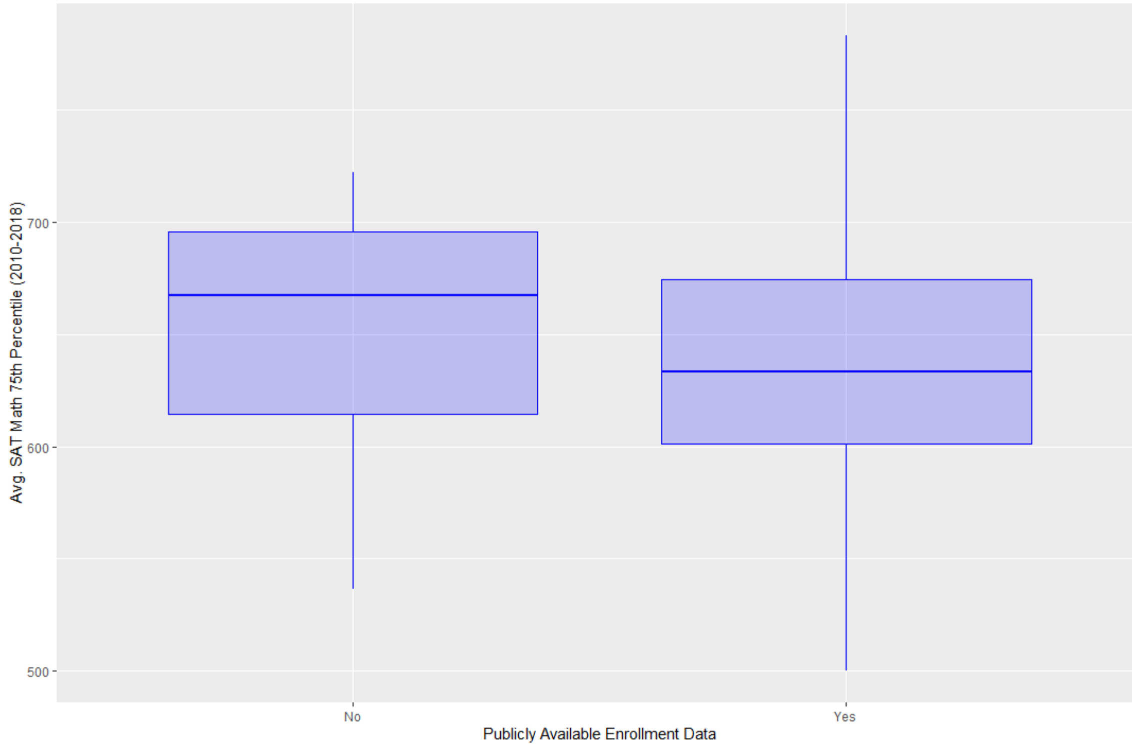


Figure B6. Comparing Avg. 75th Percentile SAT Math of Private Institutions by Engineering Transfer Enrollment Data

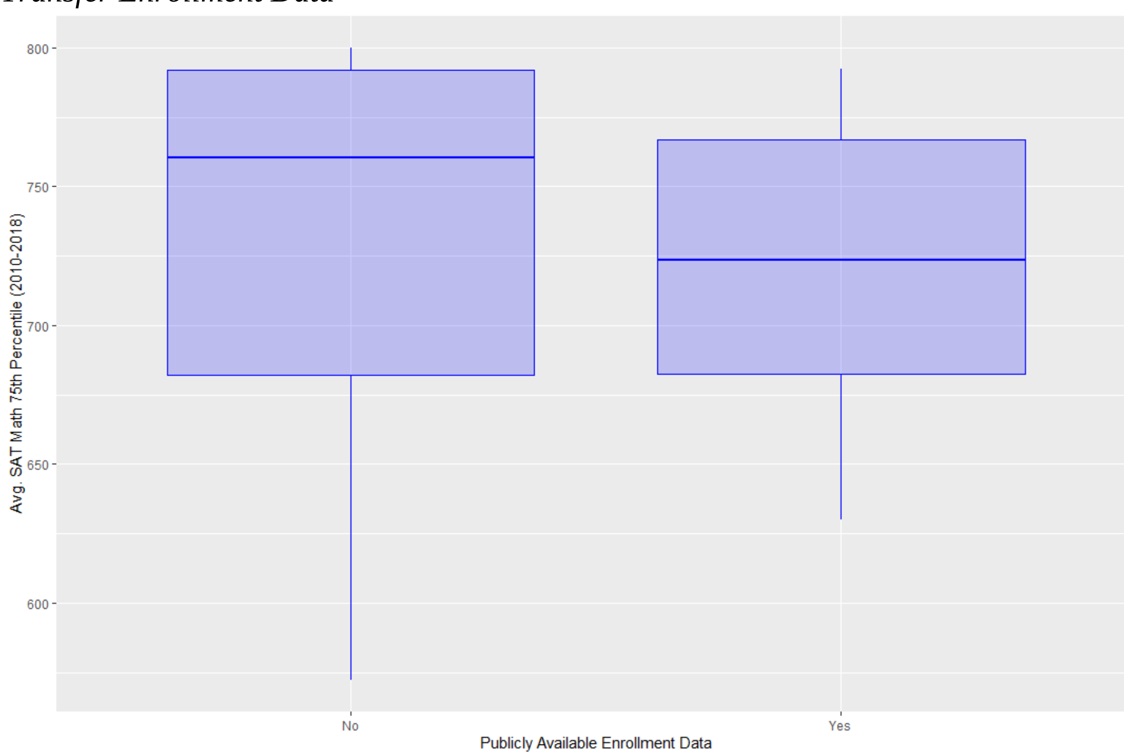


Figure B7. Comparing State Appropriations of Publics by Engineering Transfer Enrollment Data

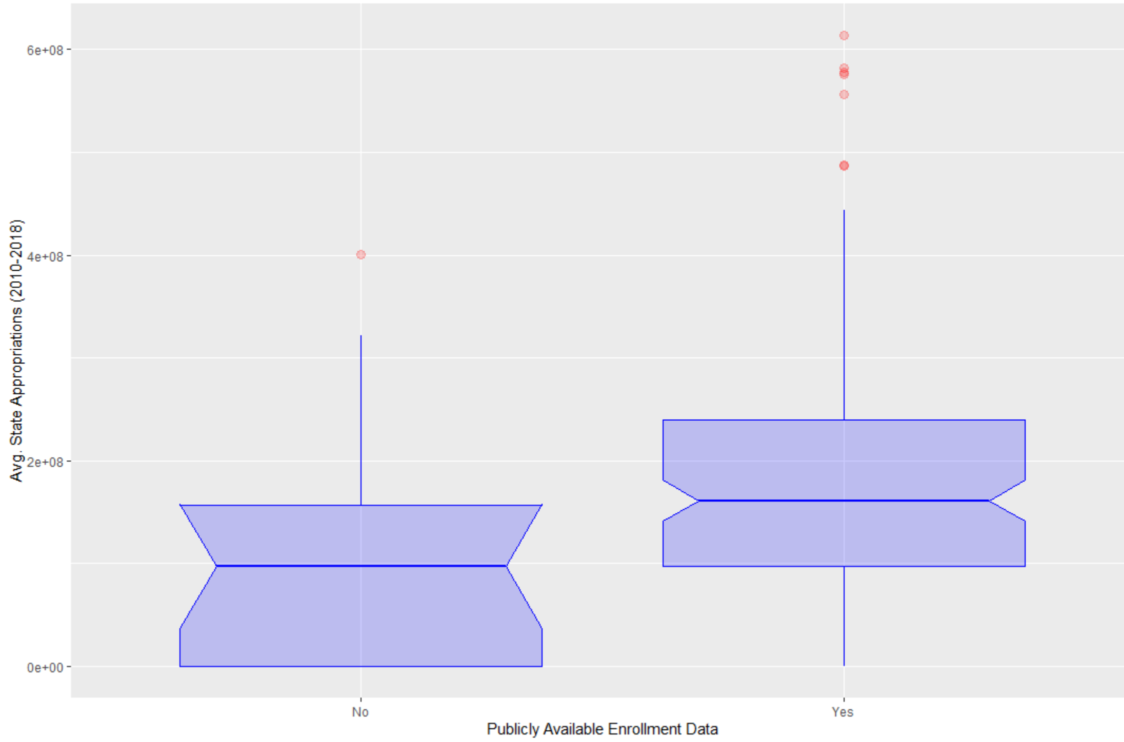


Figure B8. Comparing Net Price of Private Institutions by Engineering Transfer Enrollment Data

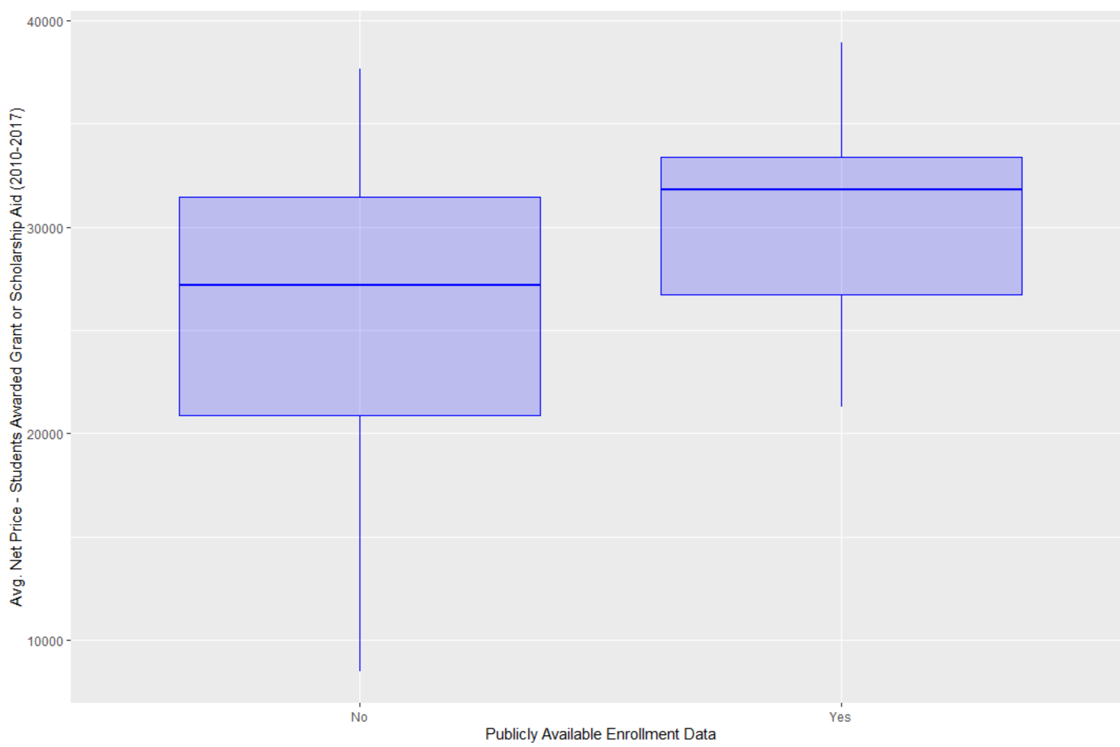


Figure B9. US News Engineering Program Rank for Institutions with Doctoral Programs by Engineering Transfer Enrollment Data

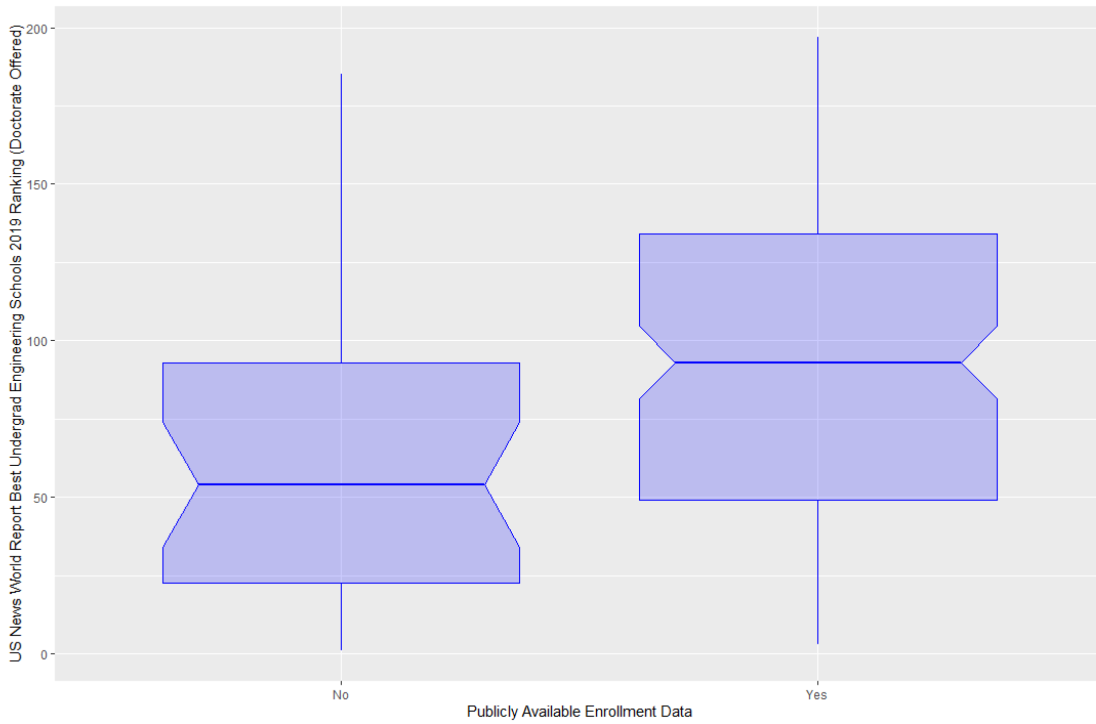


Figure B10. Comparing US News Engineering Program Rank for Institutions with No Doctoral Programs by Engineering Transfer Enrollment Data

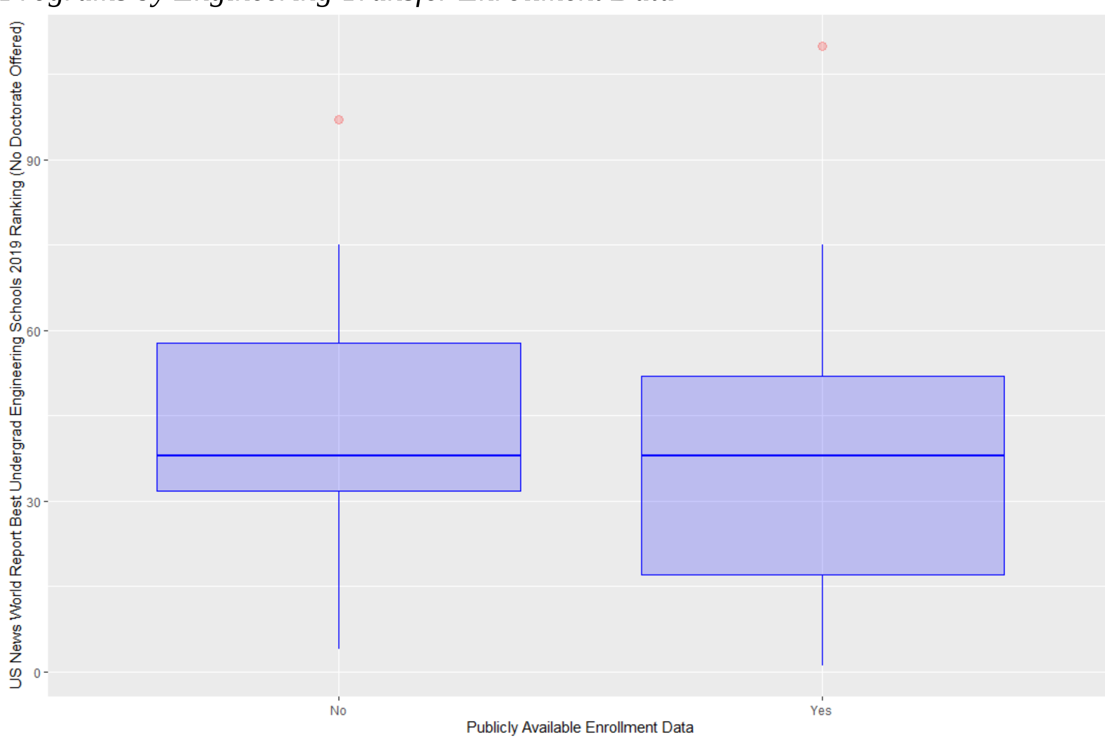


Figure B11. Comparing US News Engineering Program Rank for Public Institutions with Doctoral Programs by Engineering Transfer Enrollment Data

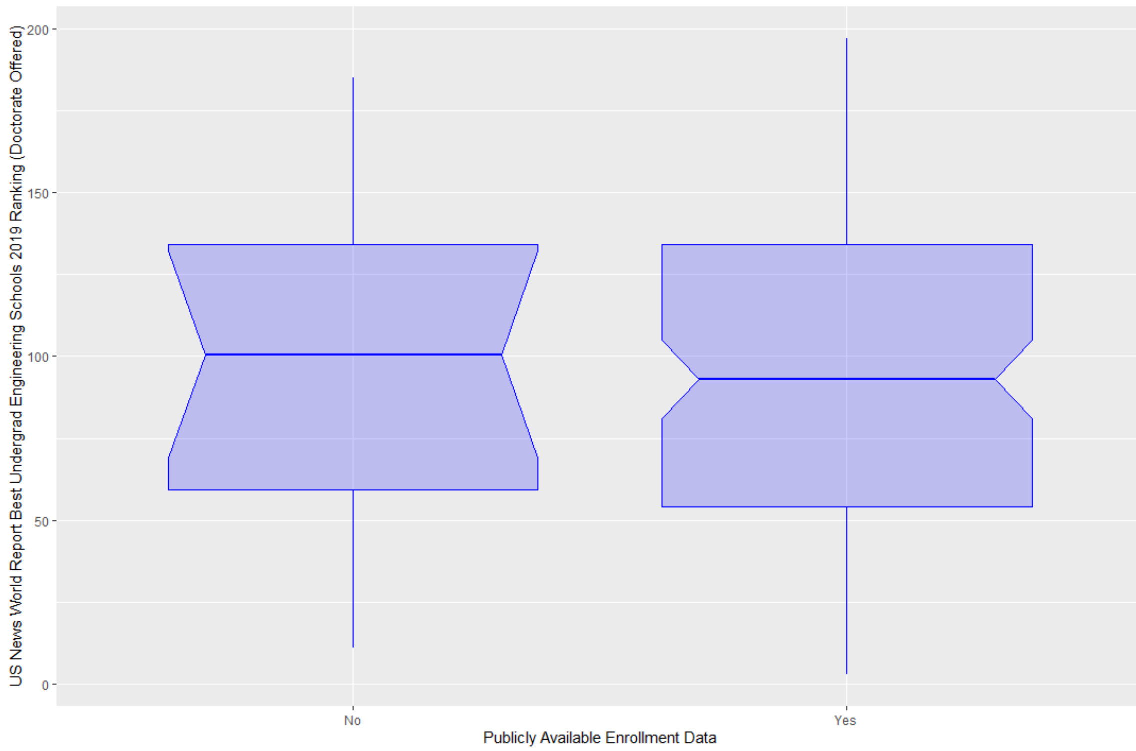


Figure B12. Comparing US News Engineering Program Rank for Private Institutions with Doctoral Programs by Engineering Transfer Enrollment Data

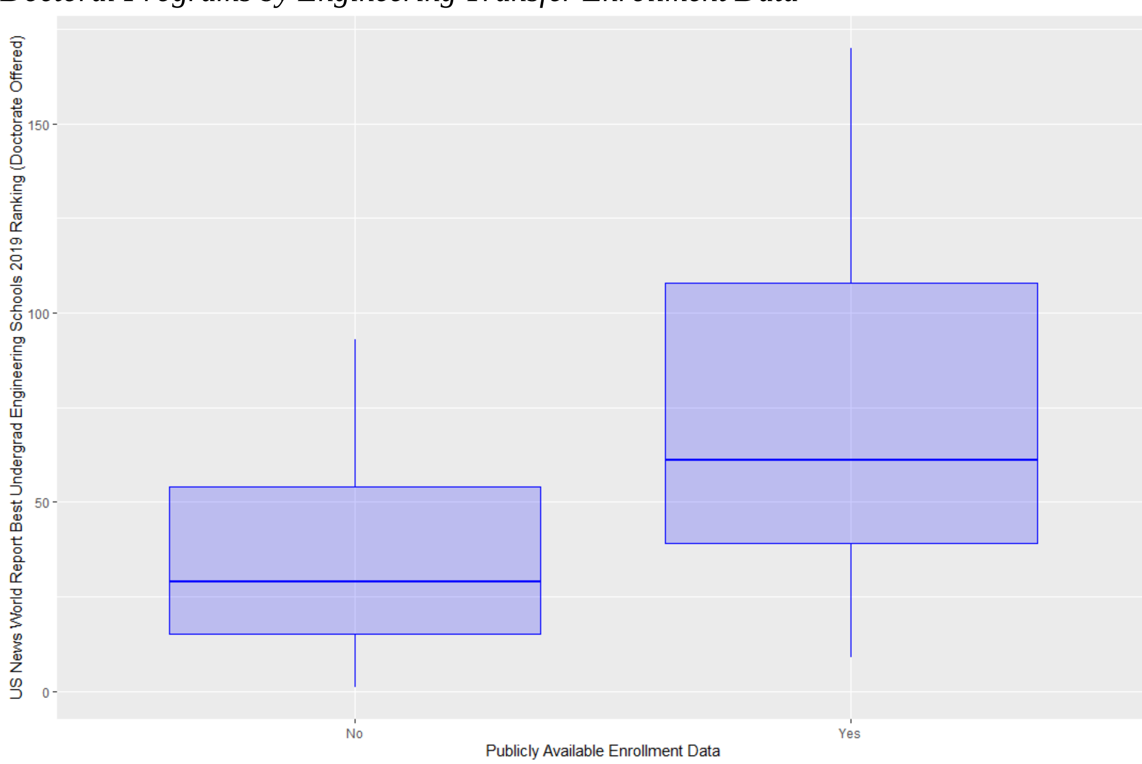


Figure B13. Comparing Total Entering UG Students by Engineering Transfer Enrollment Data

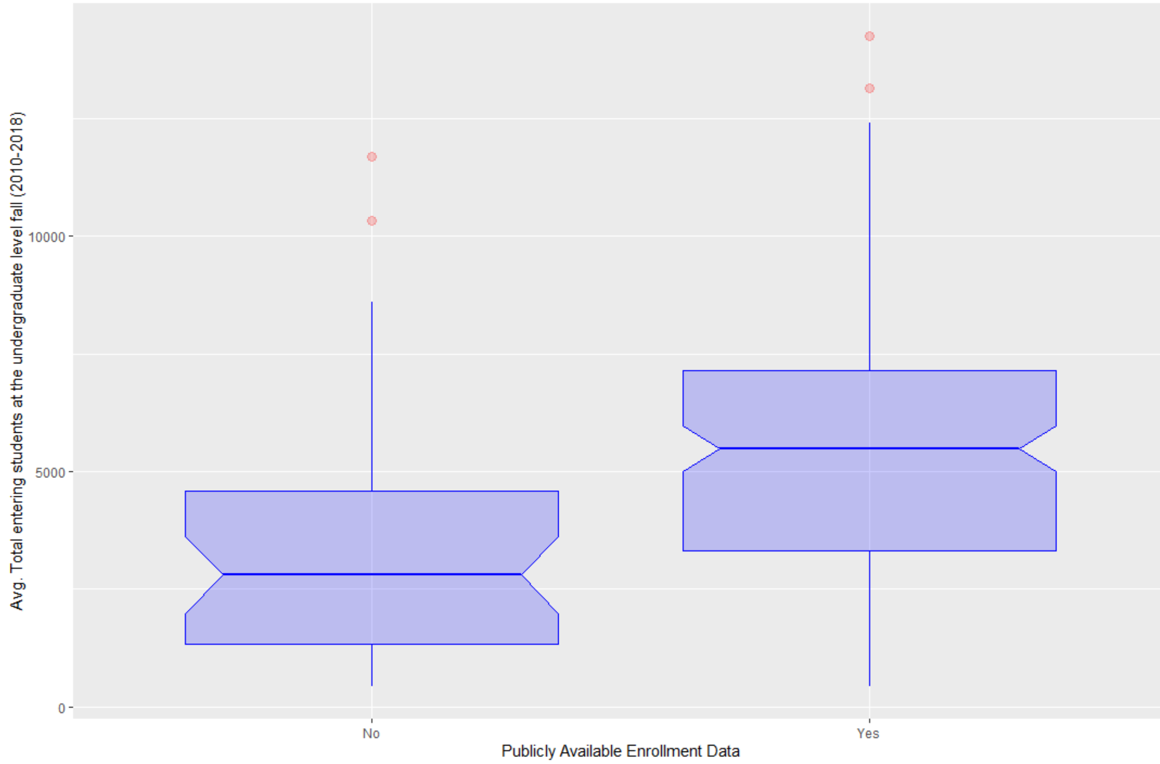


Figure B14. Comparing Total Entering Transfer Students by Engineering Transfer Enrollment Data

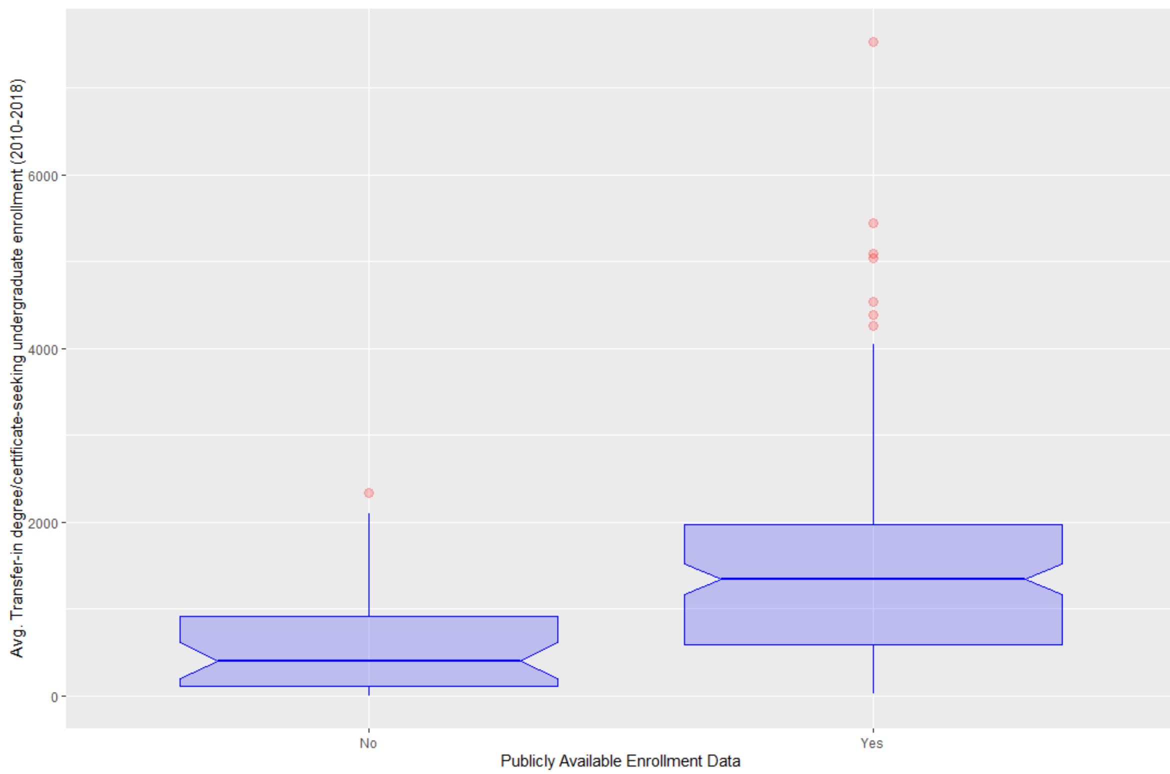


Figure B15. Comparing Transfer Composition of Institutions by Engineering Transfer Enrollment Data

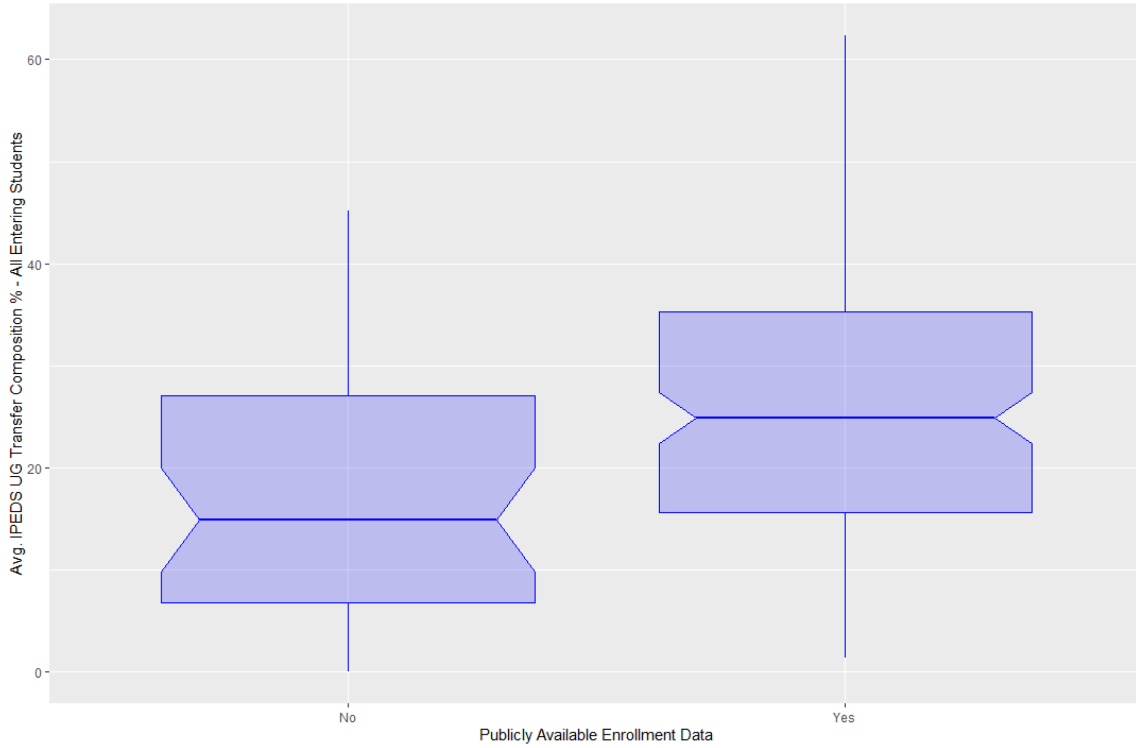


Figure B16. Comparing Percent of Institution-Wide Minoritized Enrollments by EGR Transfer Enrollment Data

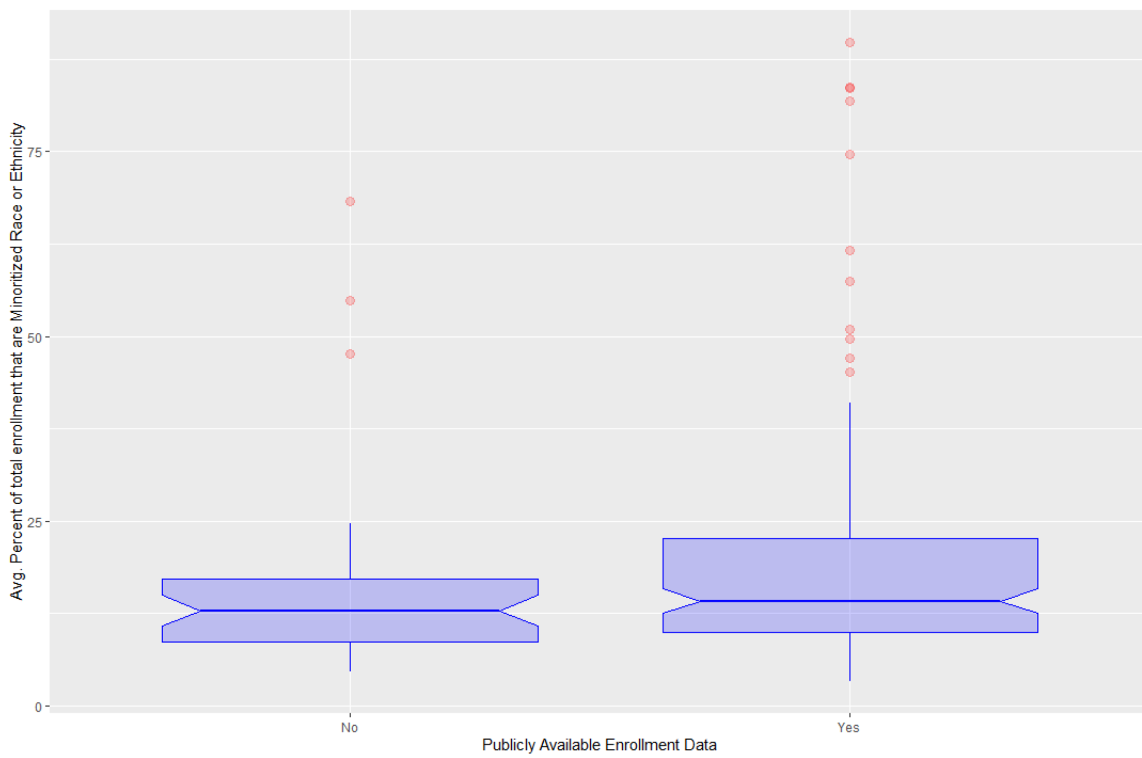


Figure B17. Comparing Percent of Minoritized Enrollments in Engineering by EGR Transfer Enrollment Data

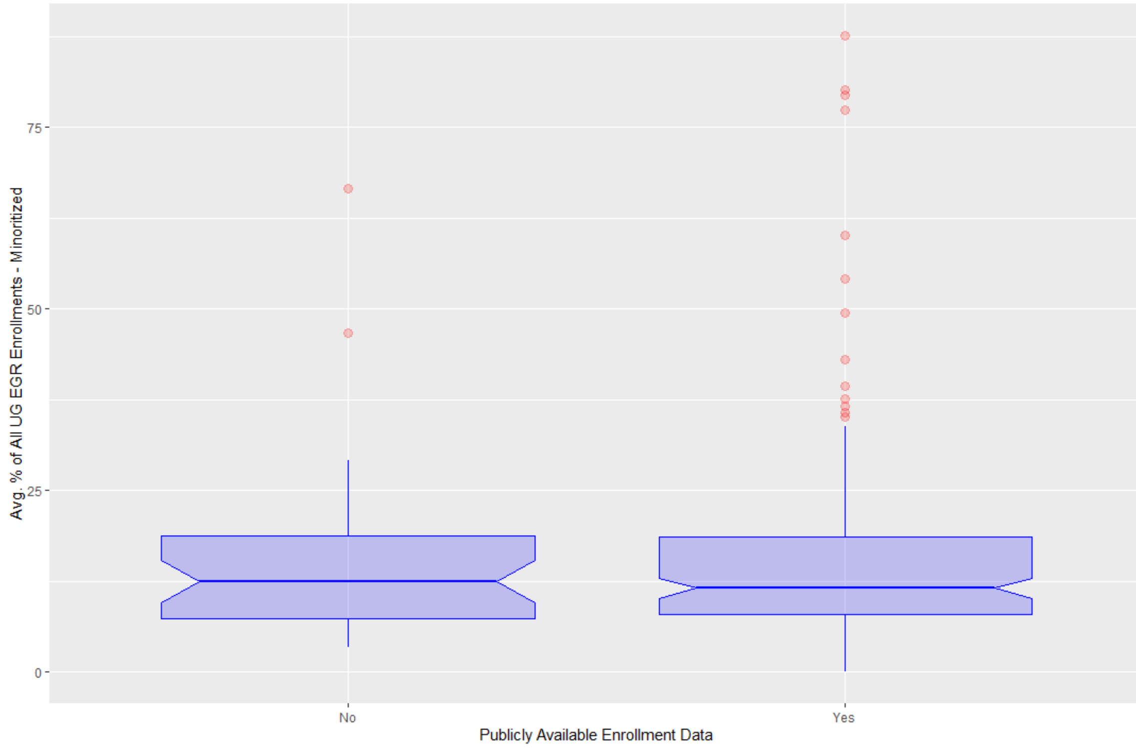


Figure B18. Comparing Percent of Institution-Wide Women Enrollments by Engineering Transfer Enrollment Data

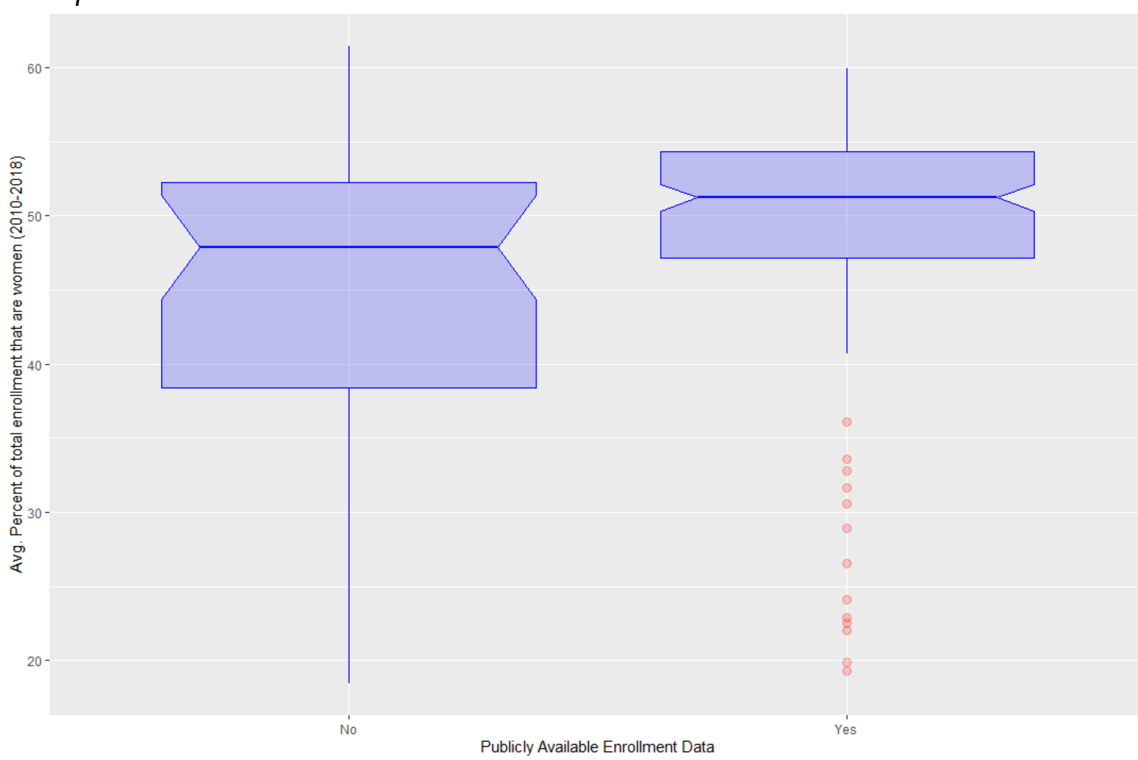


Figure B19. Comparing % of Women Enrollments in Engineering by Engineering Transfer Enrollment Data

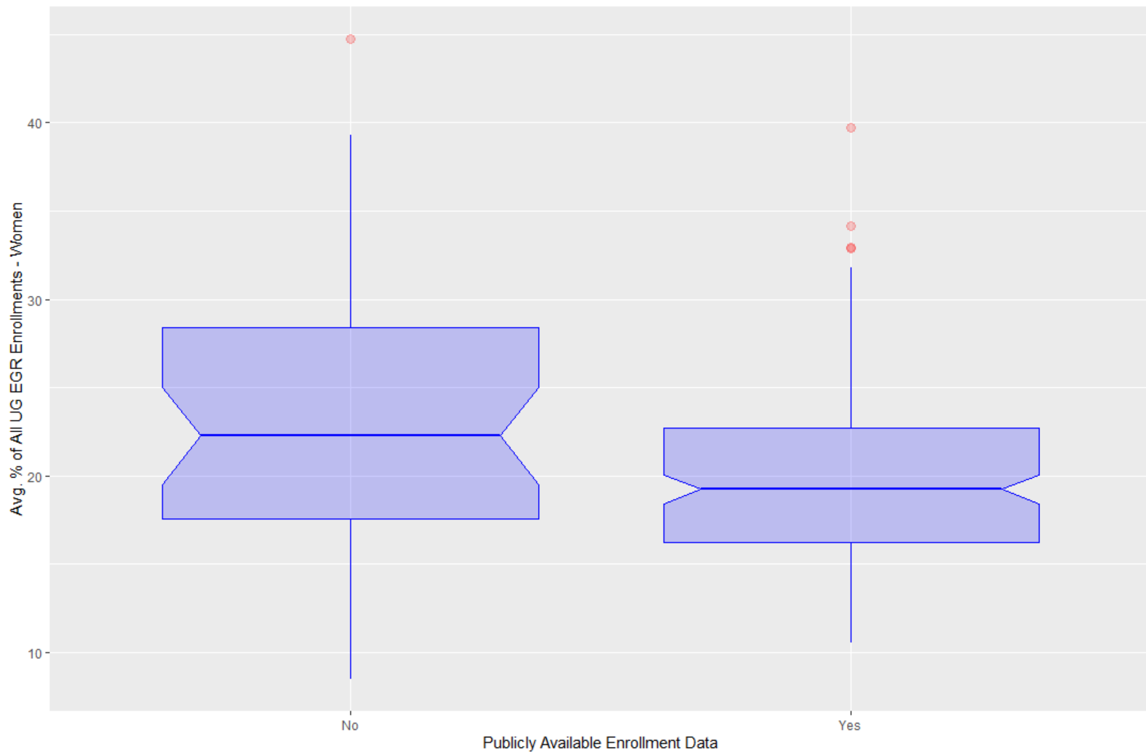
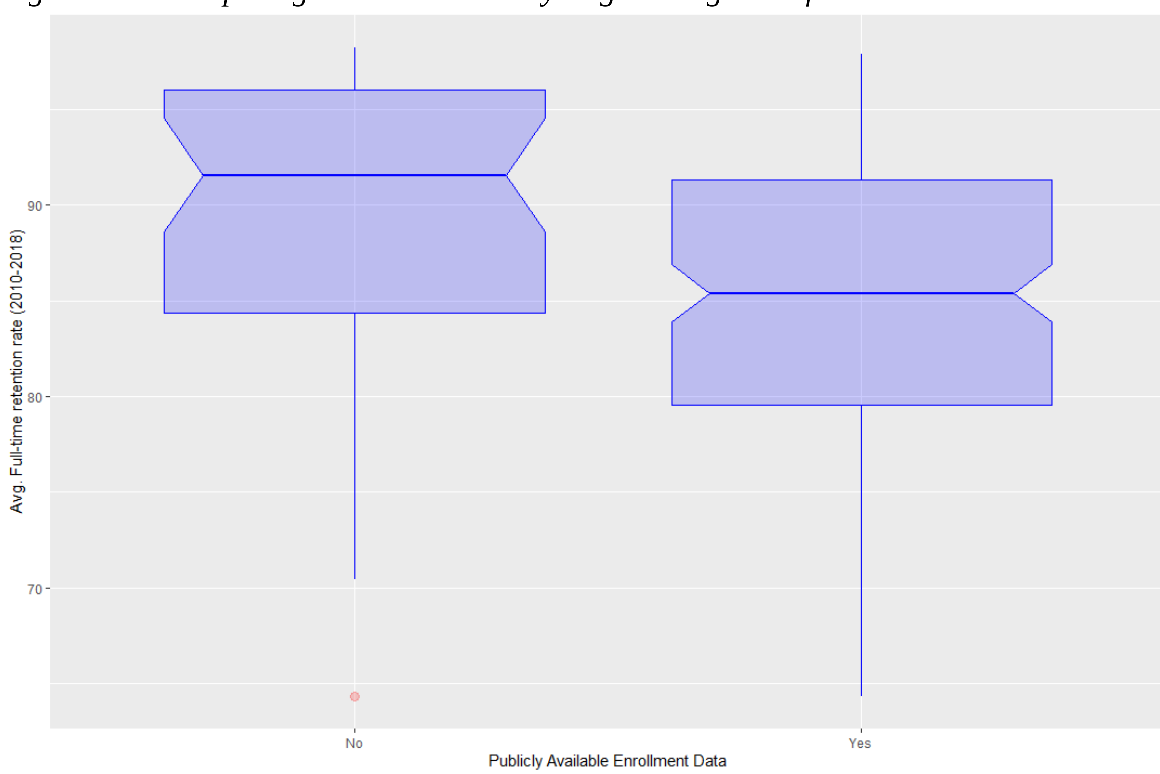


Figure B20. Comparing Retention Rates by Engineering Transfer Enrollment Data



Appendix MS2-C: Plots for Significant Results Related to Publicly Available Graduation Data

Figure C1. Comparing Avg. SAT Math 75th Percentile by Engineering Transfer Graduation Data

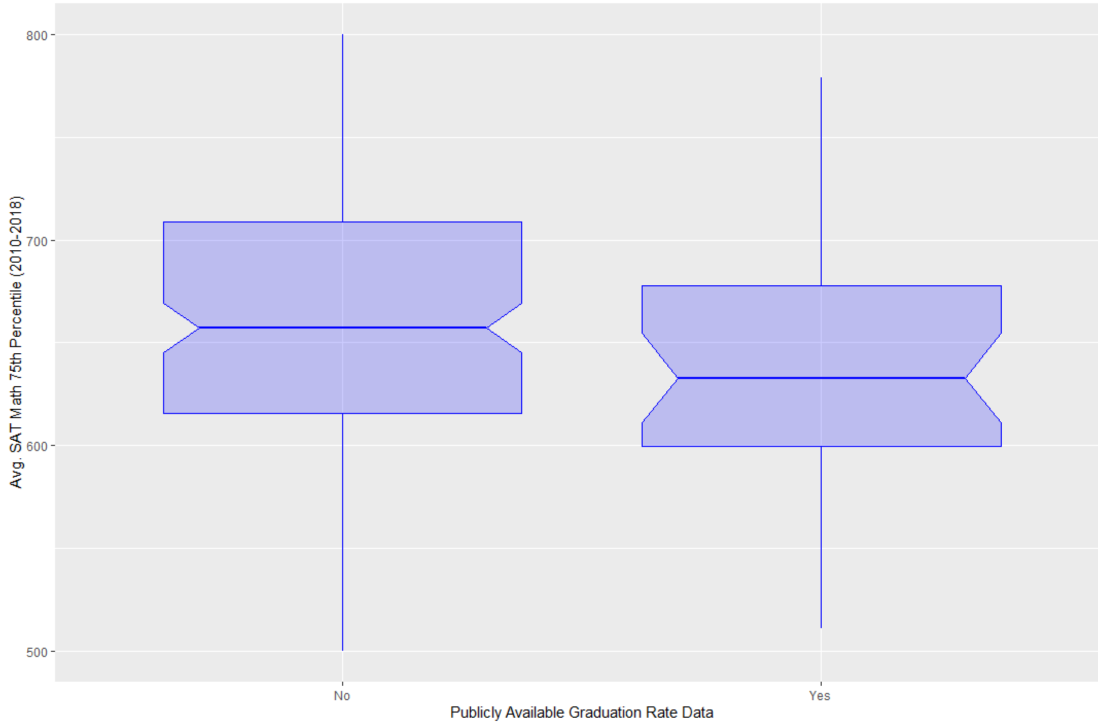


Figure C2. Comparing State Appropriations by Engineering Transfer Graduation Data

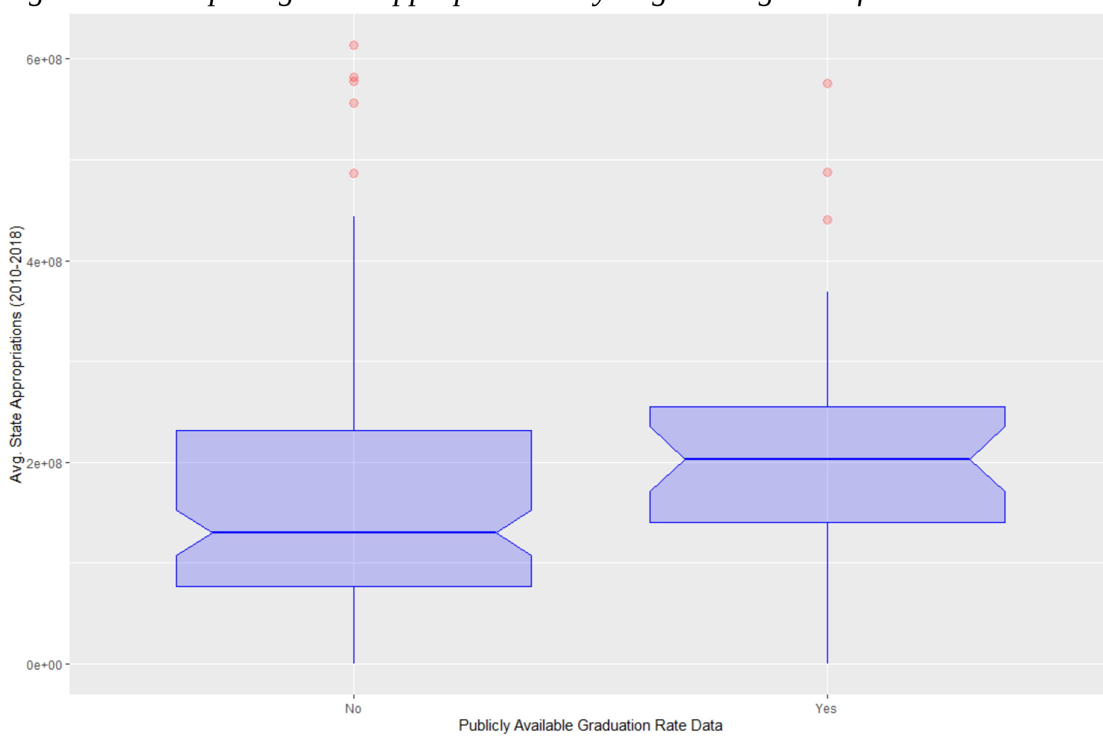


Figure C3. Comparing Avg. Total Entering Undergraduates by Engineering Transfer Graduation Data

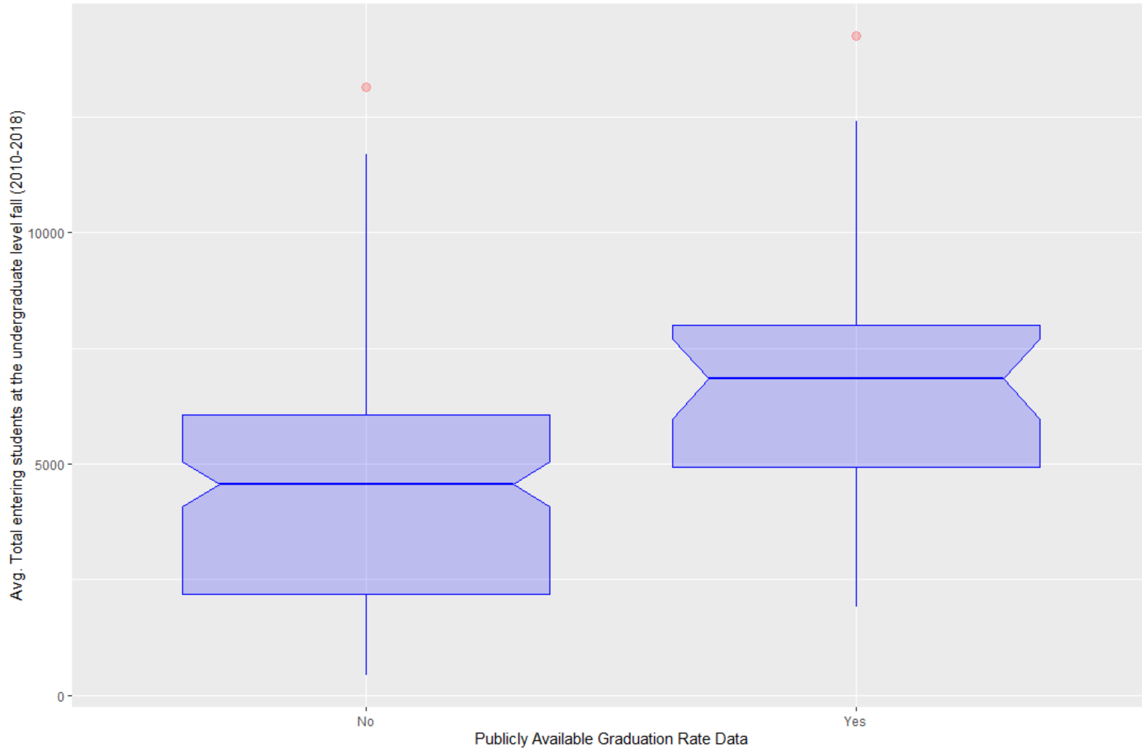


Figure C4. Comparing Avg. Entering Transfer-In Students by Engineering Transfer Graduation Data

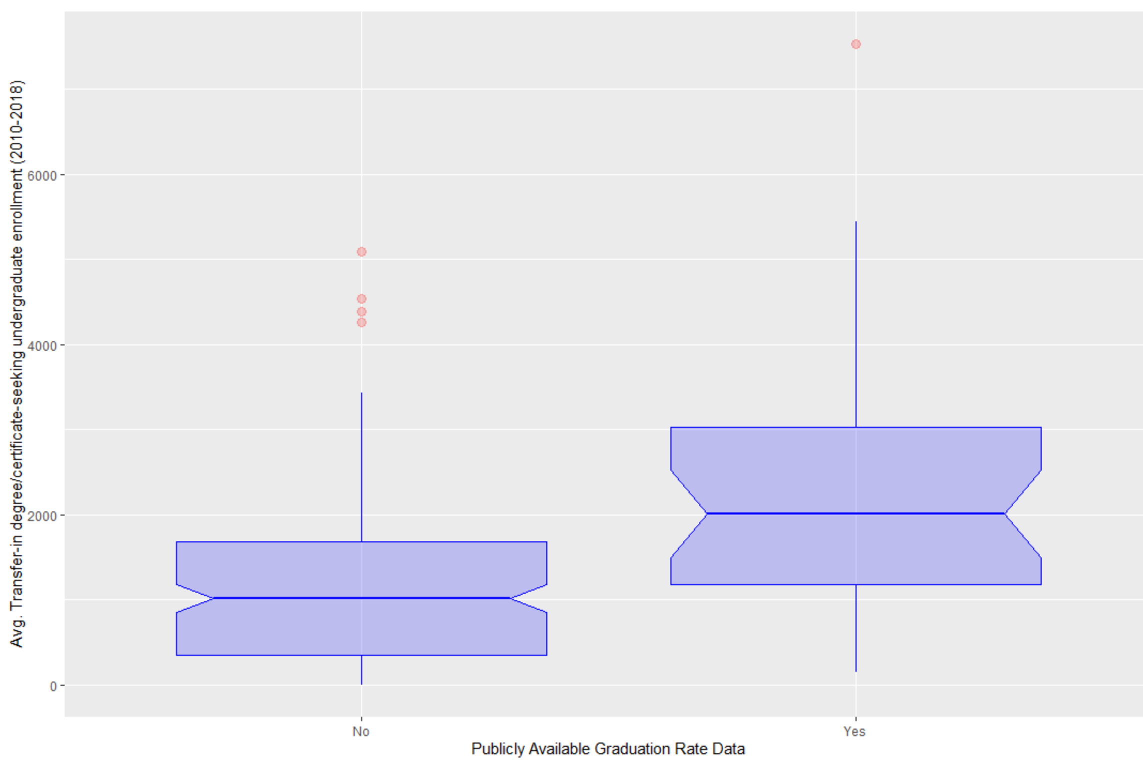


Figure C5. Comparing Avg. Institution Transfer Composition by Engineering Transfer Graduation Data

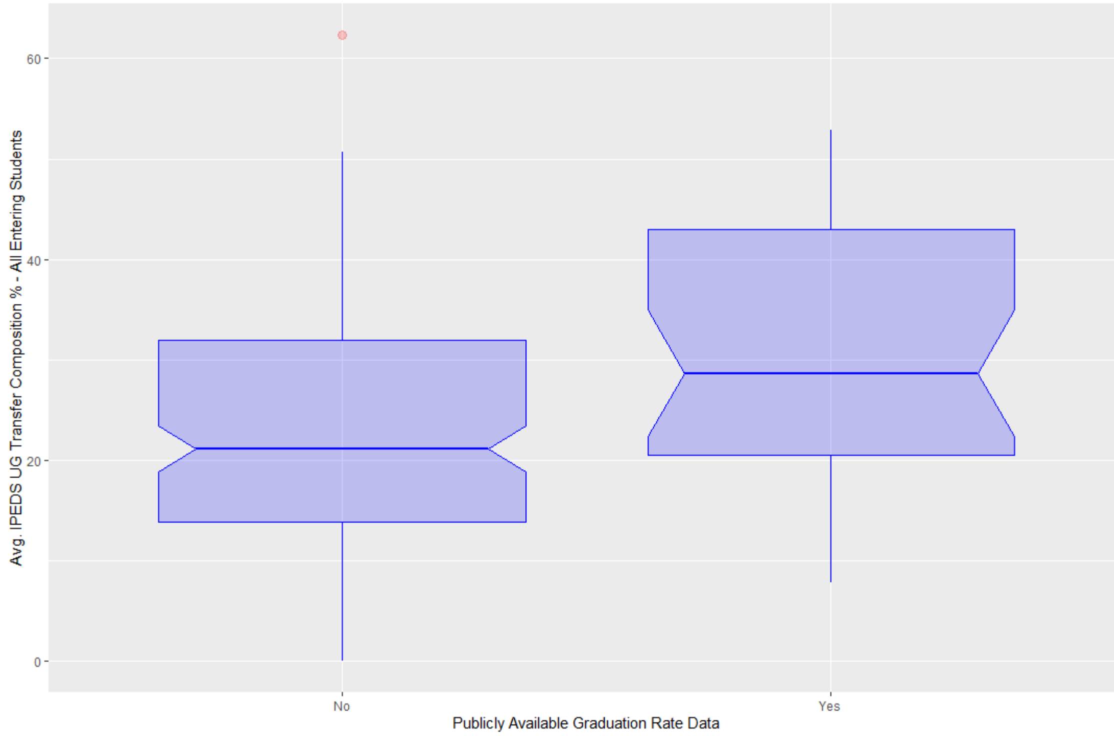
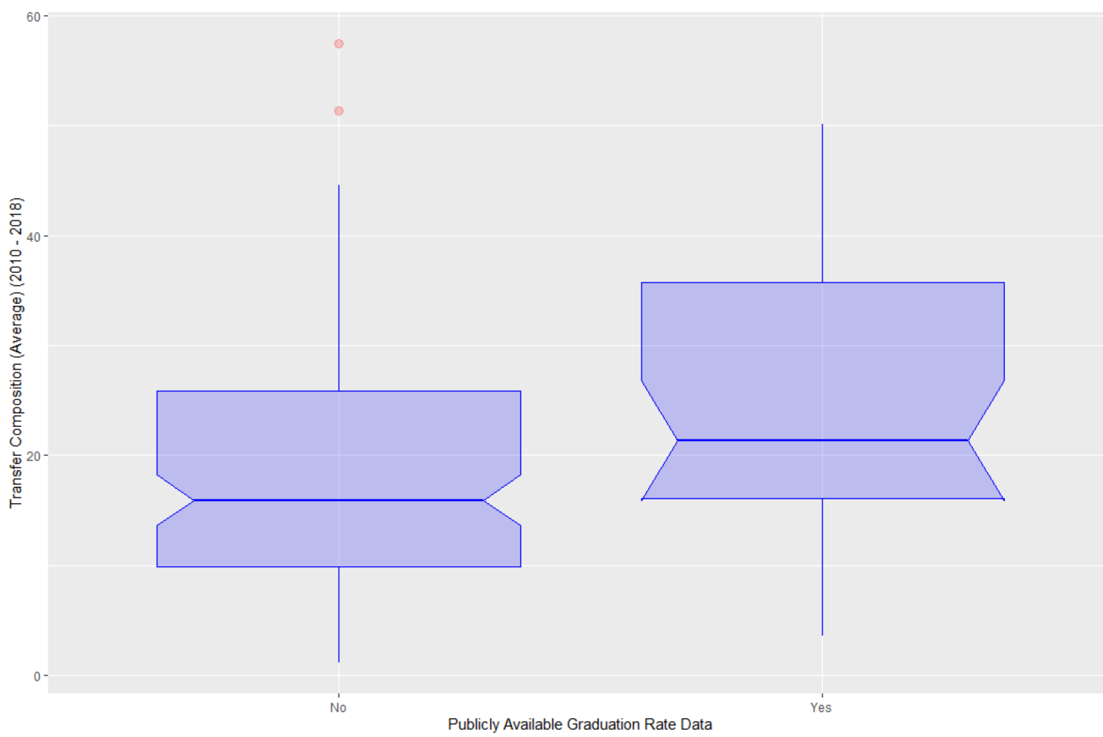


Figure C6. Comparing Avg. Engineering Transfer Composition by Engineering Transfer Graduation Data



Appendix MS2-D: Plots for Significant Results Related to Transfer Composition

Figure D1. Distribution of Transfer Composition by Average 75th Percentile SAT Math Score

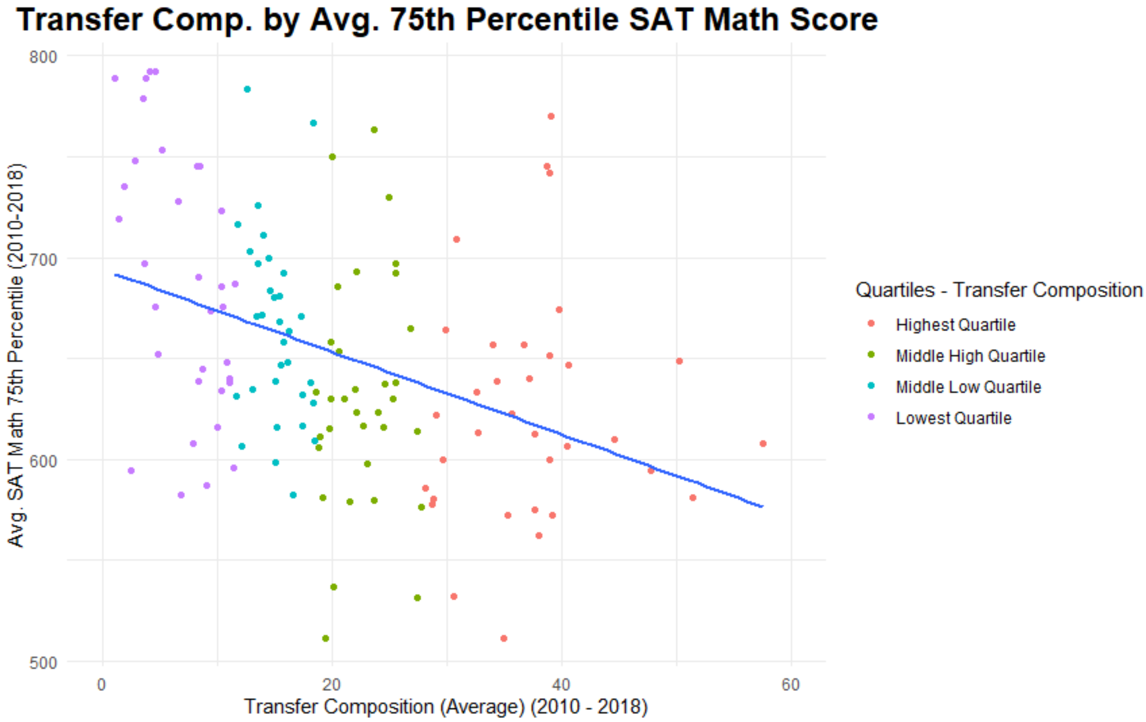


Figure D2. Distribution of Transfer Composition by Avg. Published Tuition and Fees for Publics

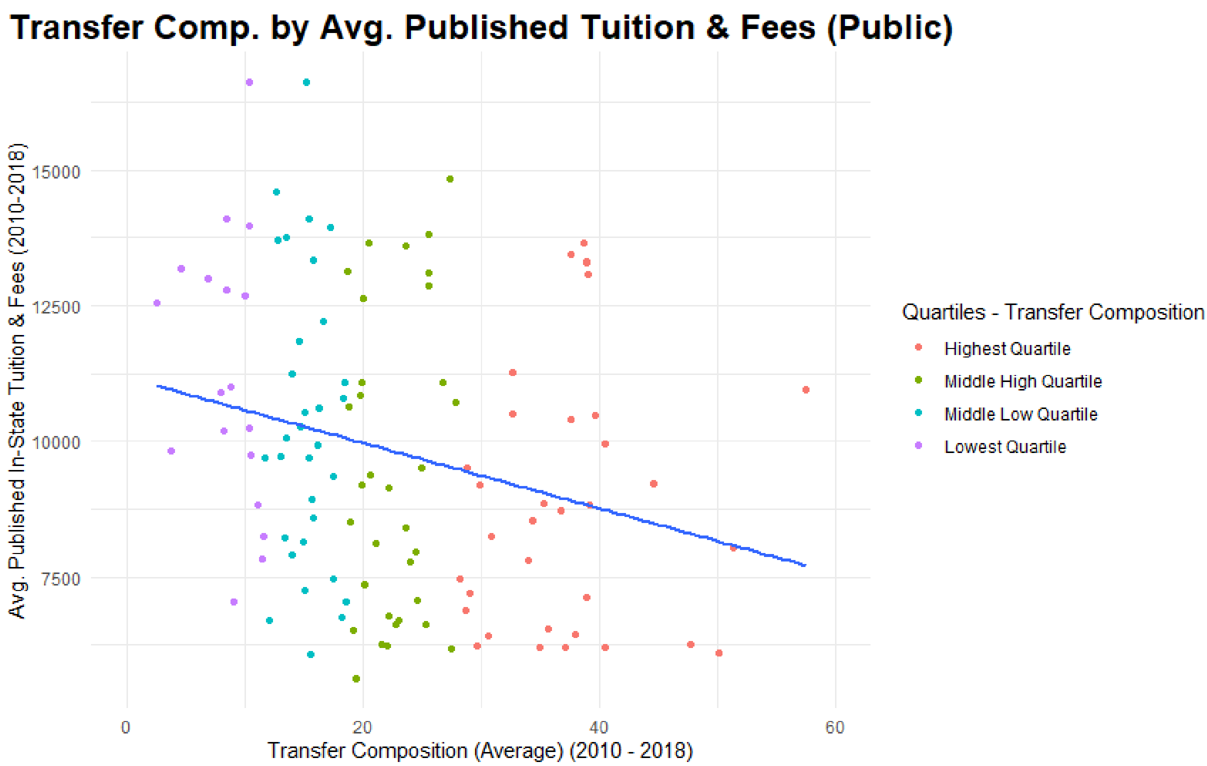


Figure D3. Distribution of Transfer Composition by Avg. Published Tuition and Fees for Privates

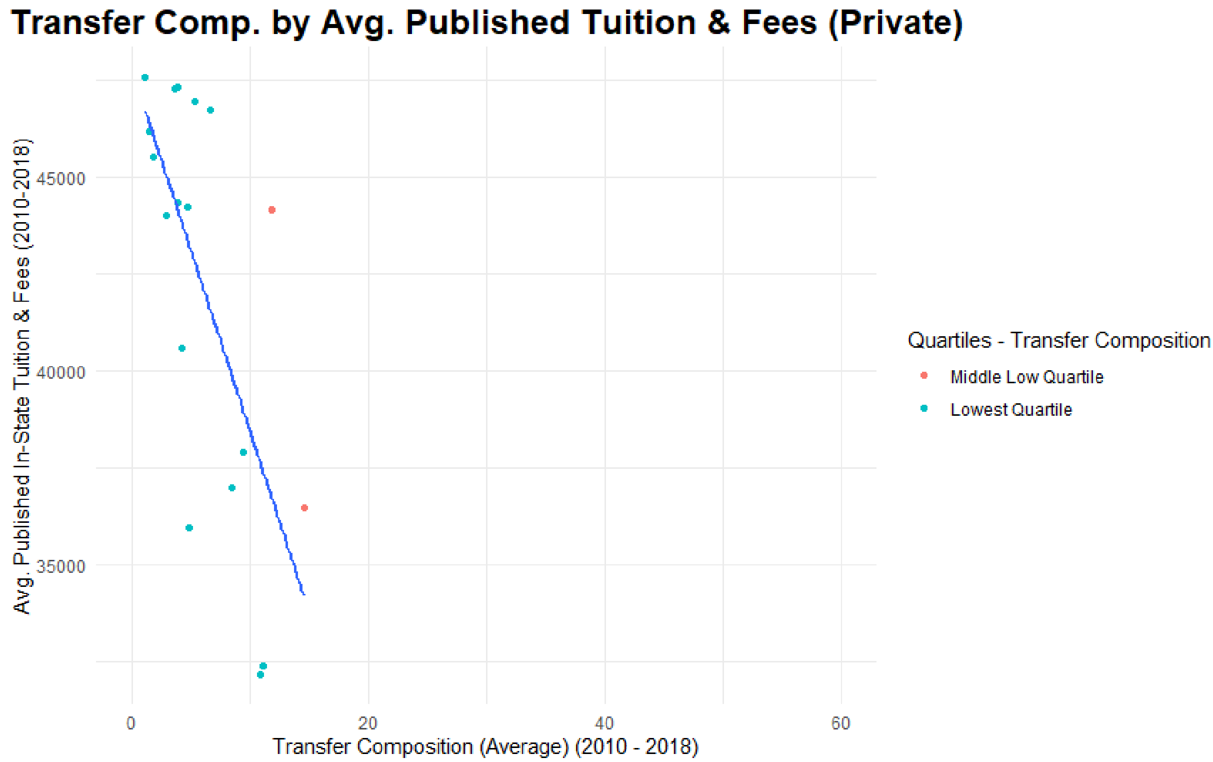


Figure D4. Distribution of Transfer Composition by Avg. Net Price for Publics

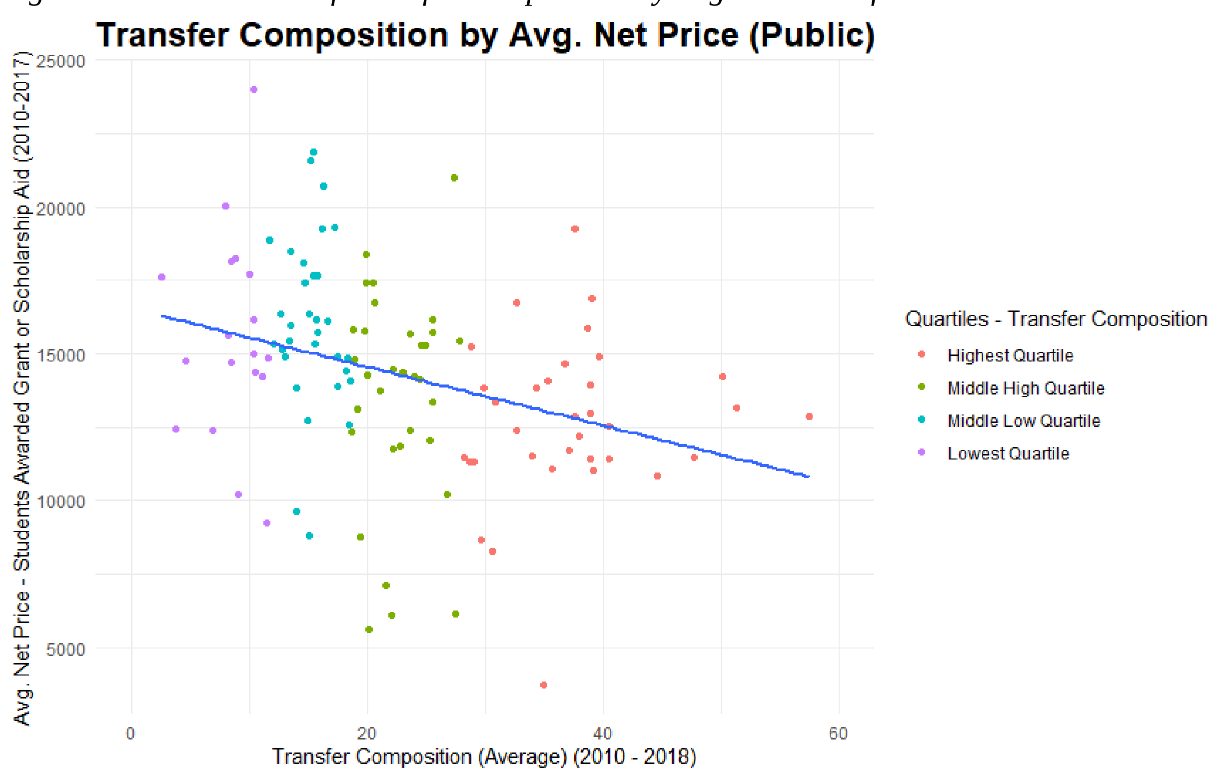


Figure D5. Distribution of Transfer Composition by Avg. Total Price for Private Institutions

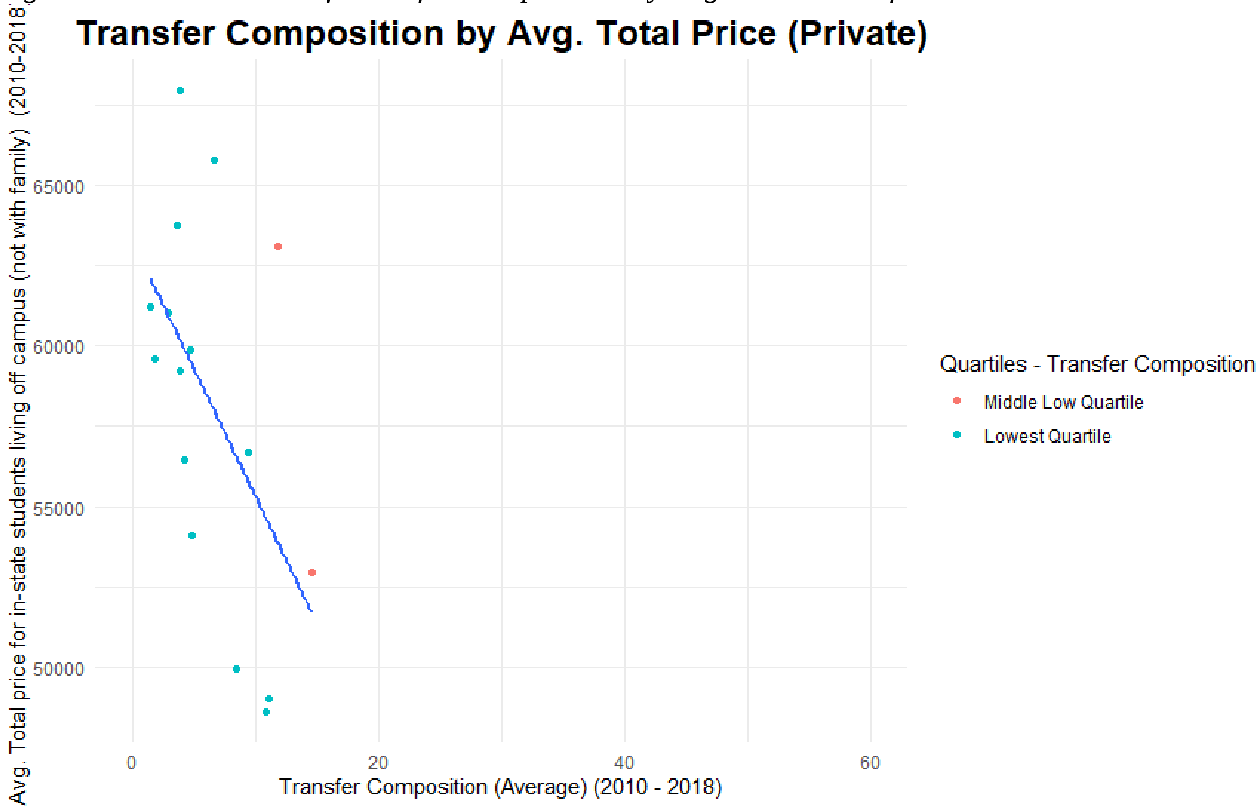


Figure D6. Distribution of Transfer Composition by Avg. Endowment Assets for Publics

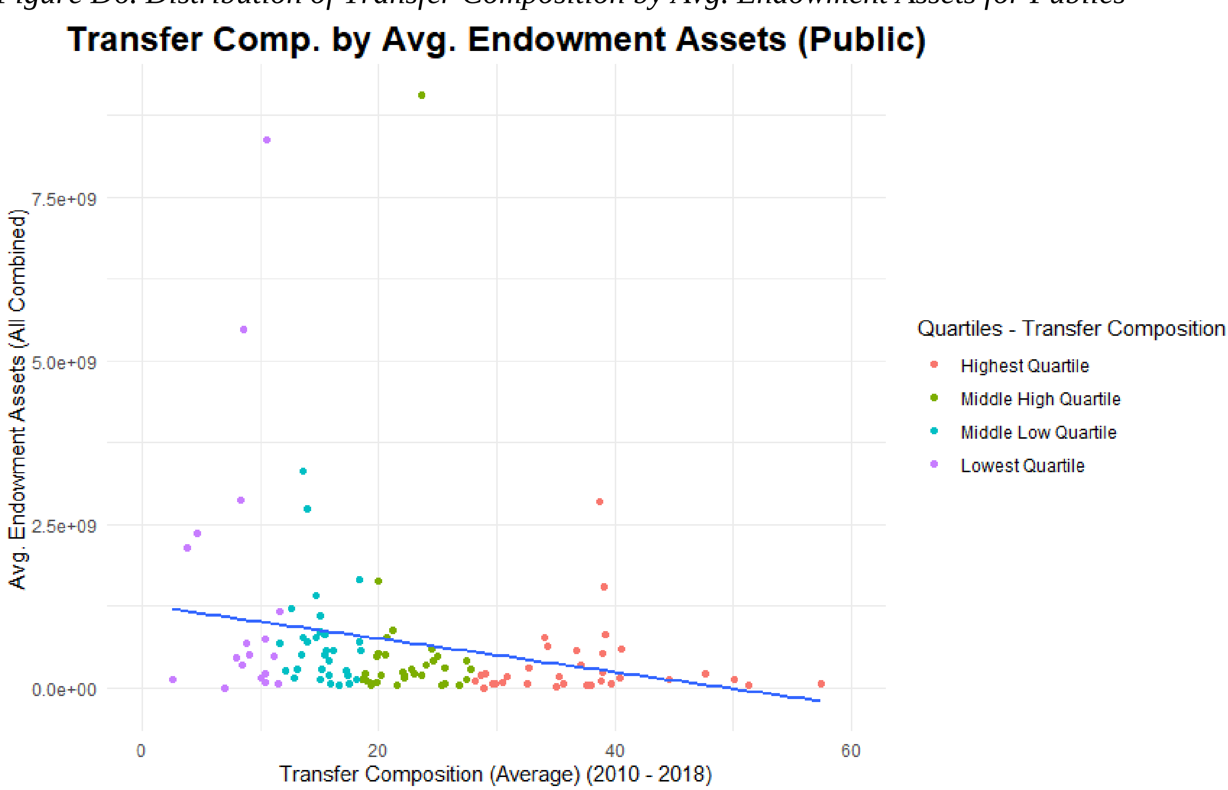


Figure D7. Distribution of Transfer Composition by U.S. News Engineering Program Ranking

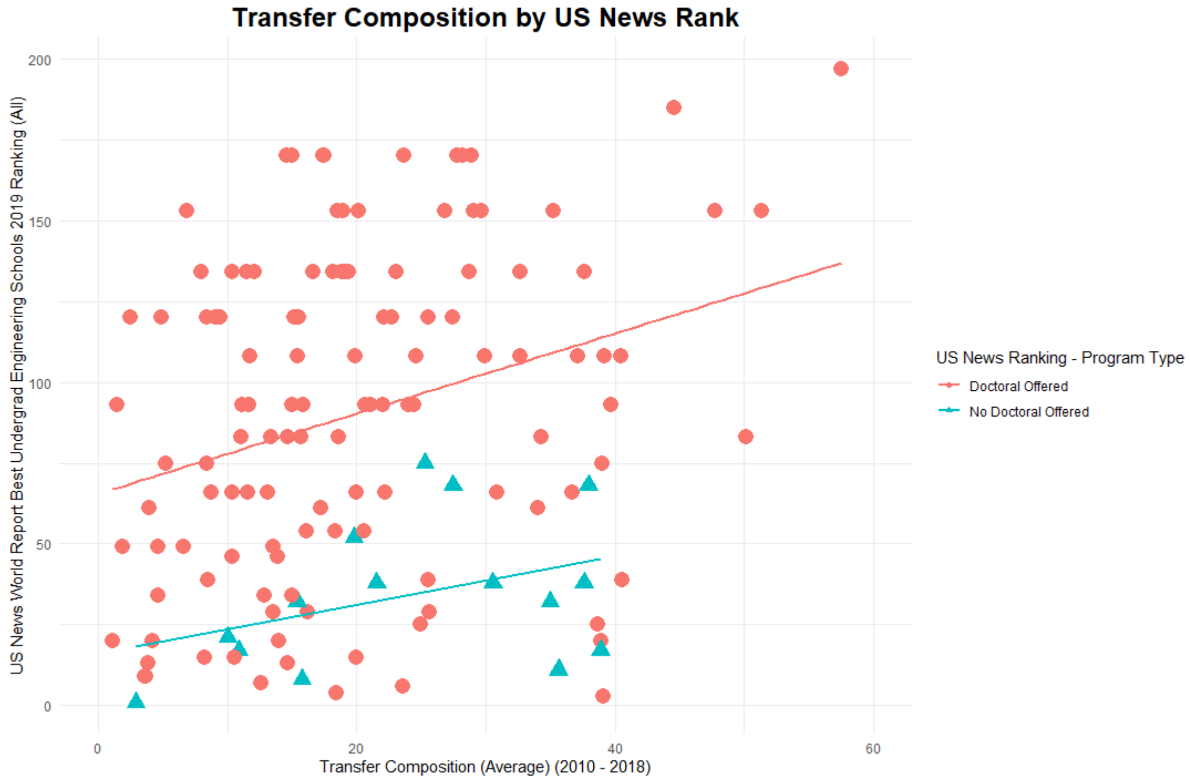


Figure D8. Distribution of Transfer Composition by Minimum Transfer GPA for Admissions in Engineering

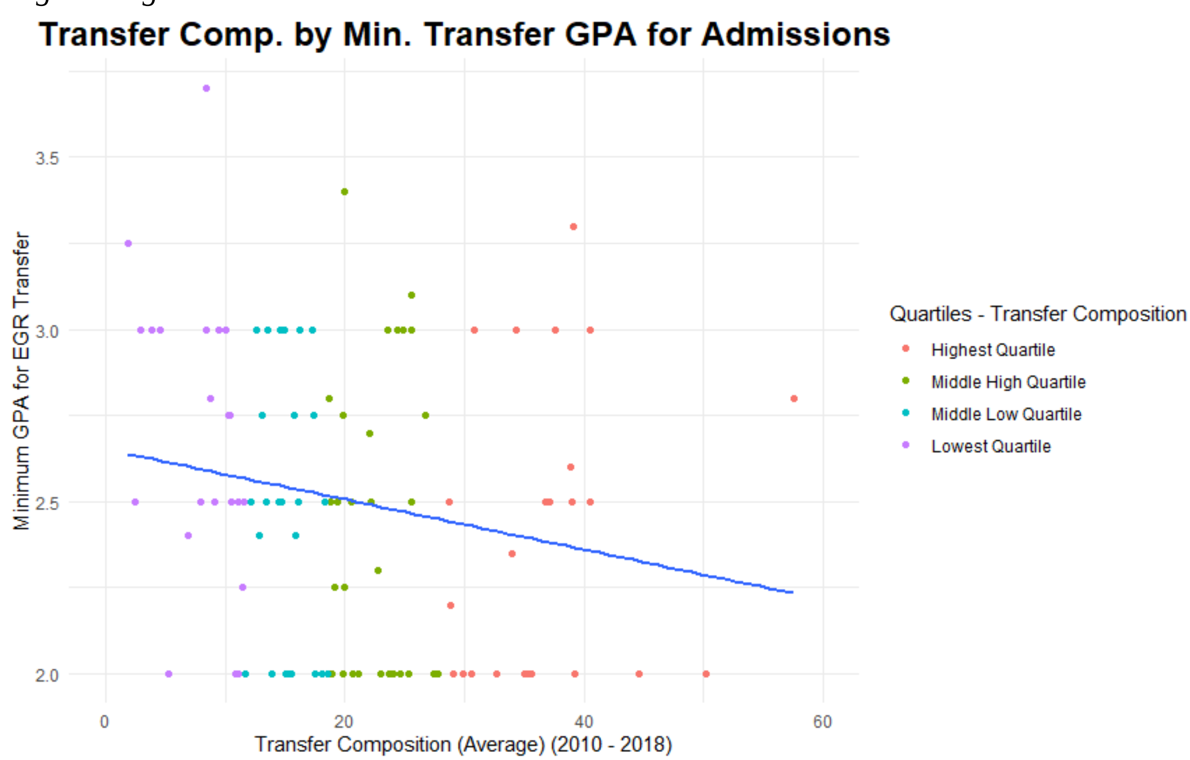


Figure D9. Distribution of Transfer Composition by Total Engineering Undergraduates

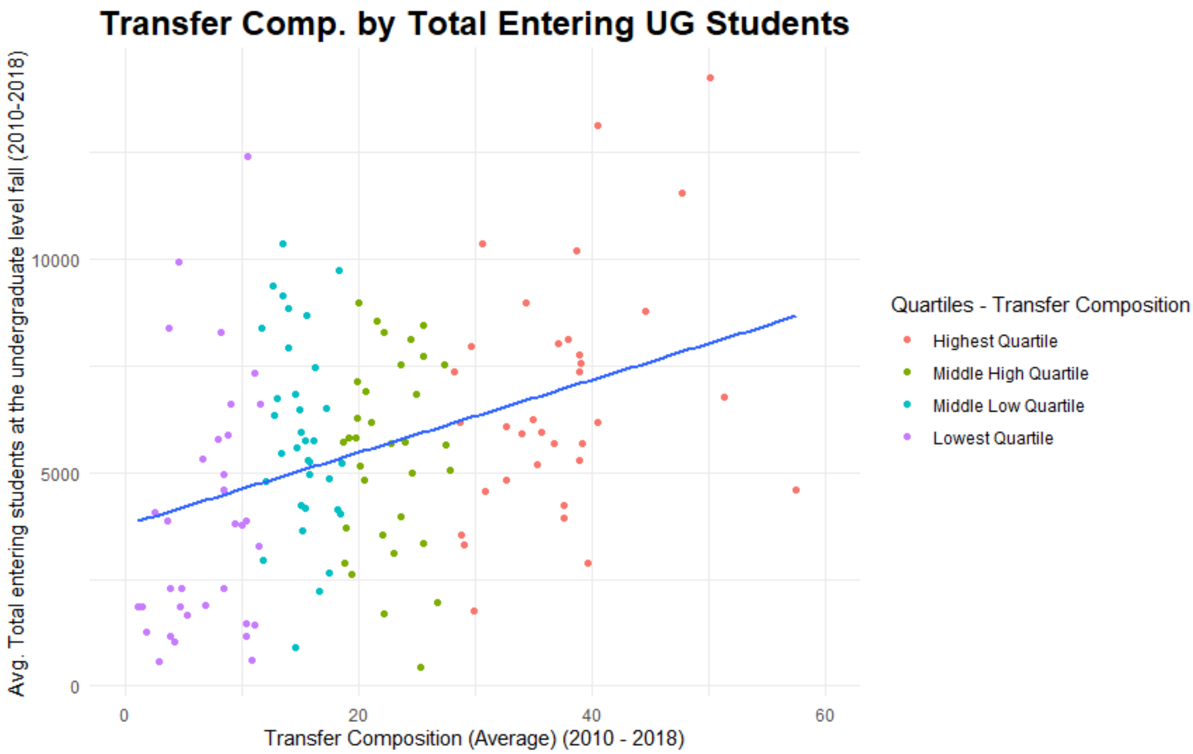


Figure D10. Distribution of Transfer Composition by Total Entering Degree-Seeking Transfer Students

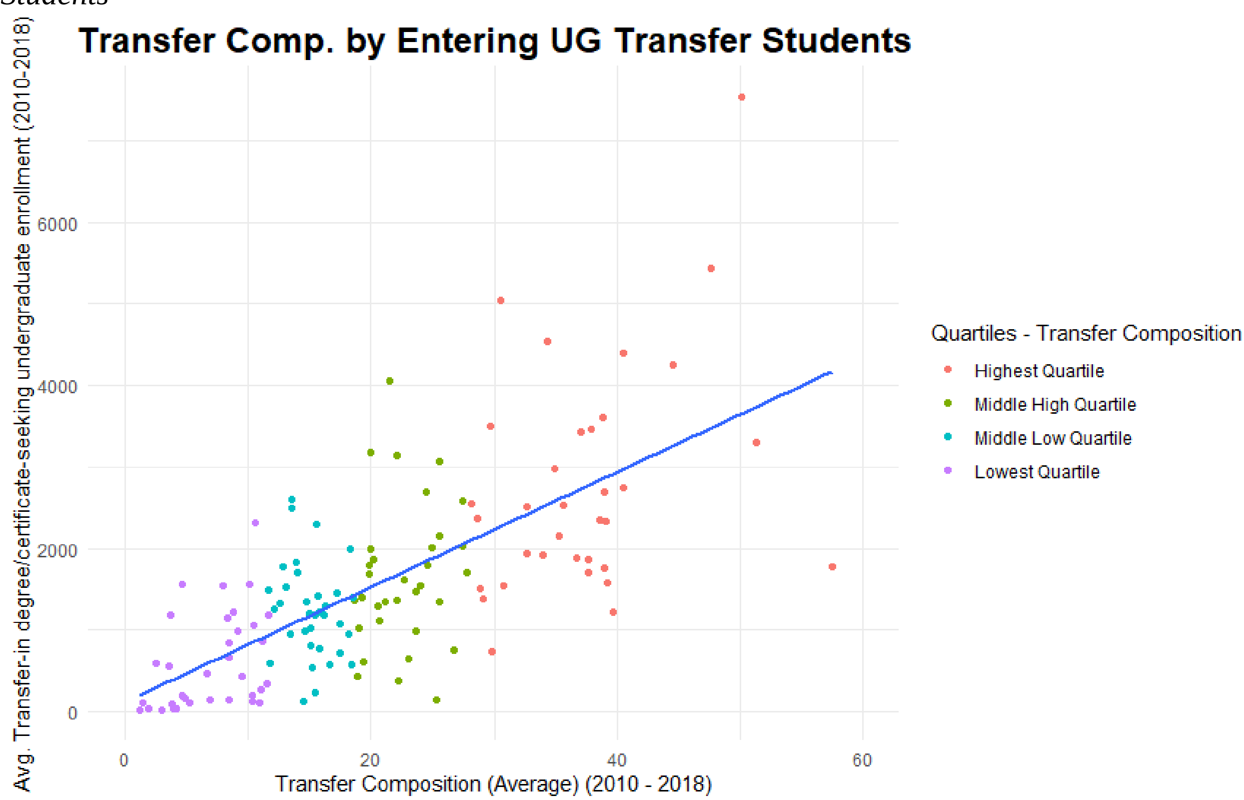


Figure D11. Distribution of Transfer Composition by IPEDS UG Transfer Composition

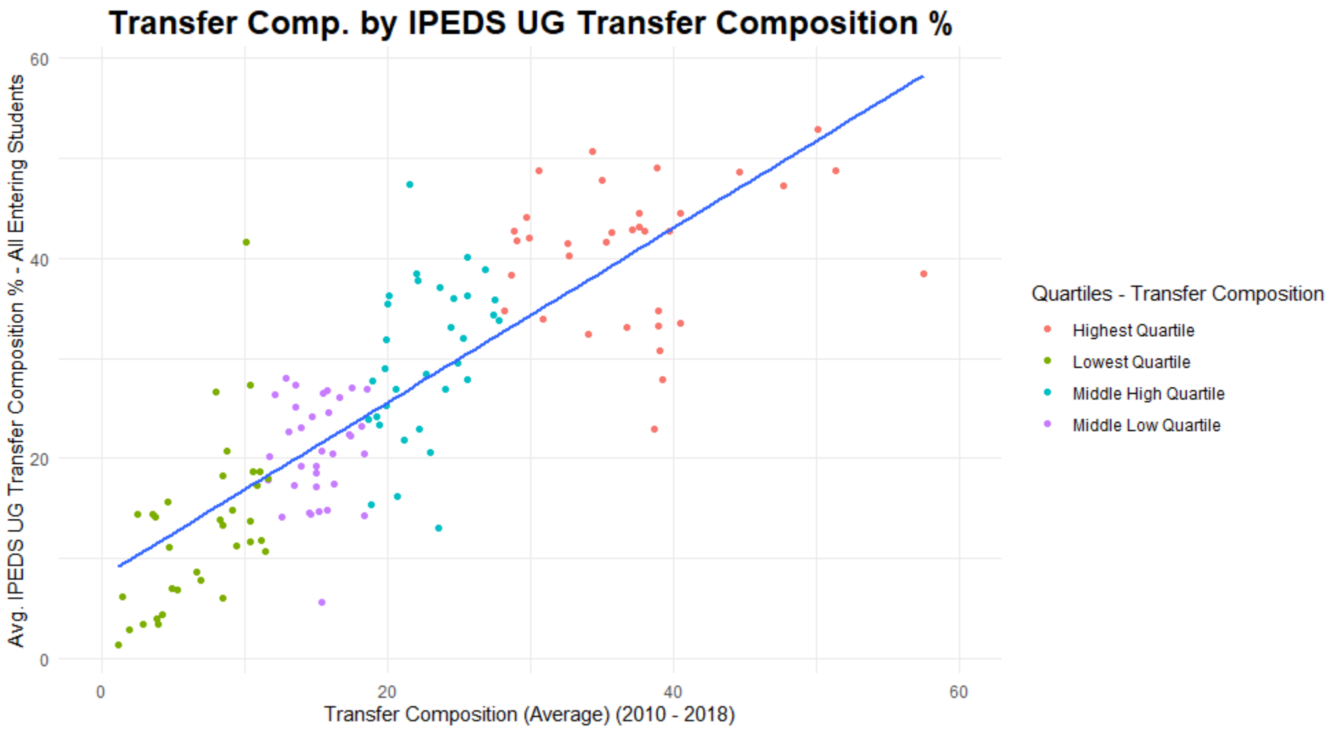


Figure D12. Distribution of Transfer Composition by Entering Full-Time Transfer Students

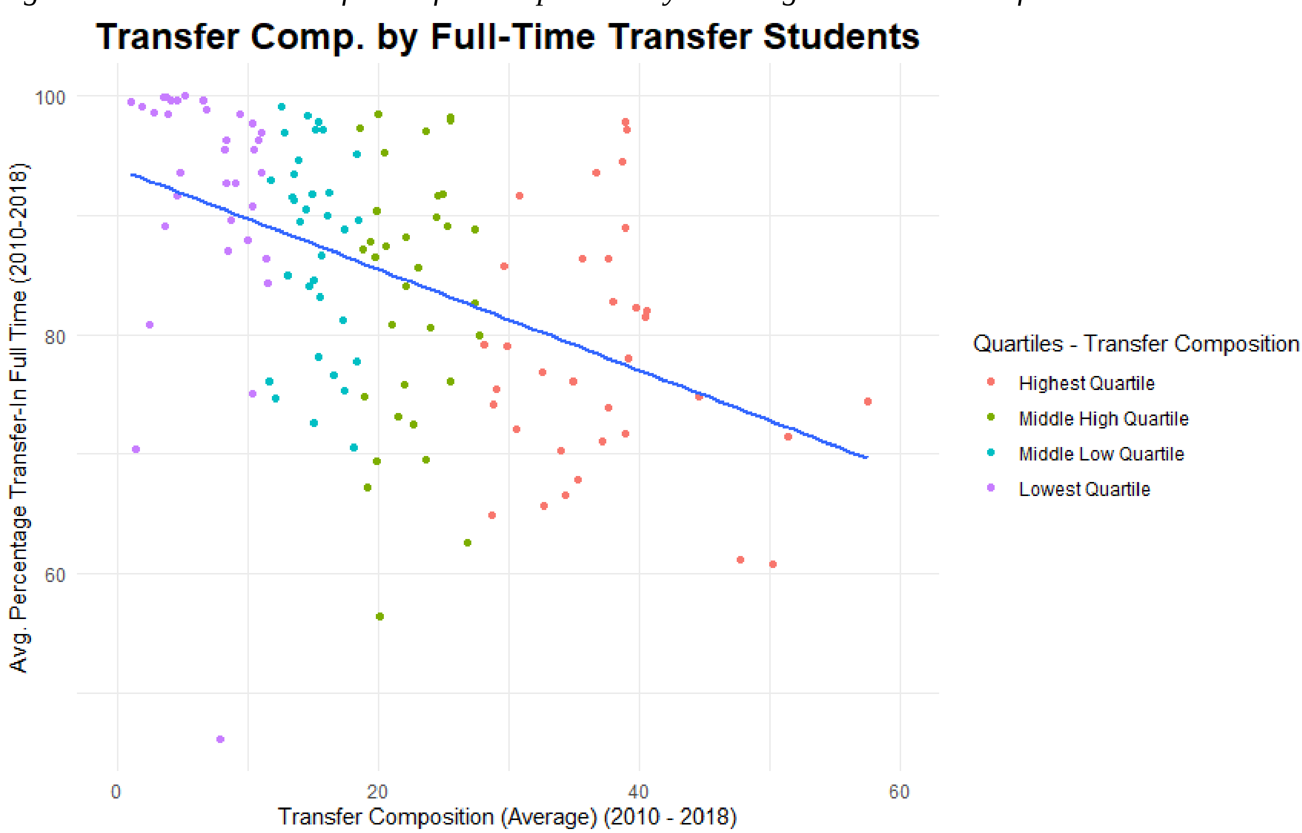


Figure D13. Distribution of Transfer Composition by Avg. Undergraduate Black/African American Enrollment

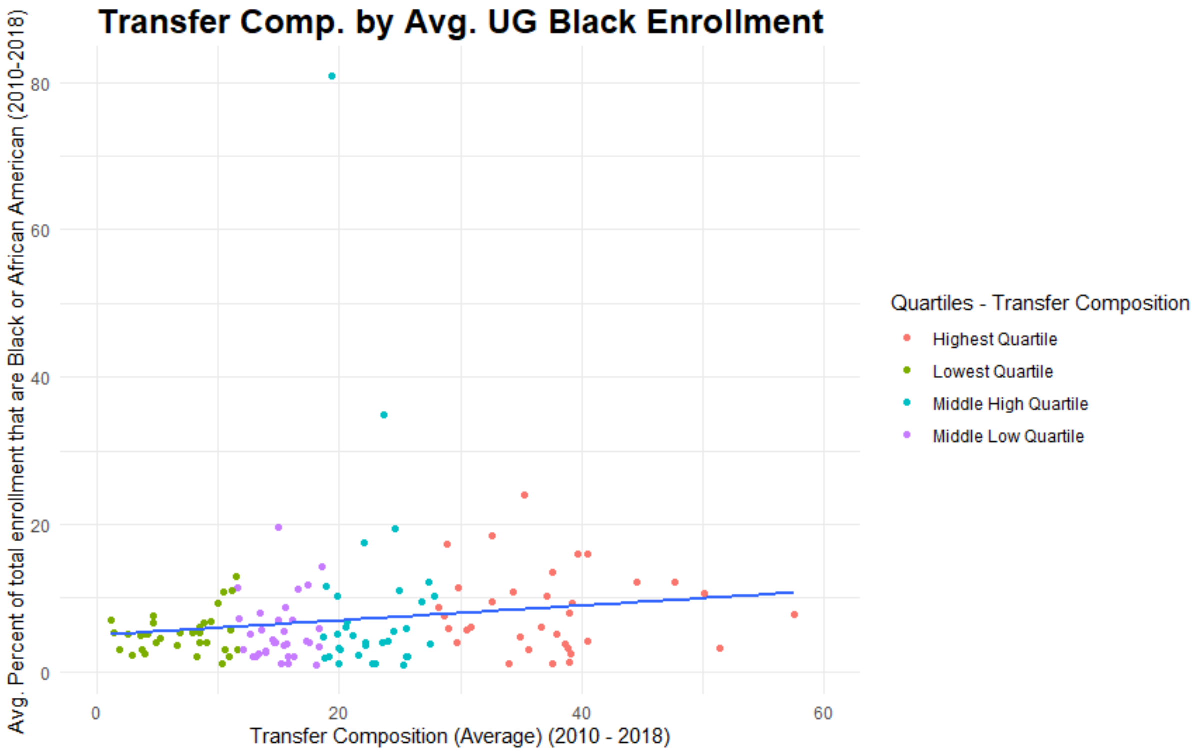


Figure D14. Distribution of Transfer Composition by Avg. Undergraduate Black/African American Enrollment in Engineering

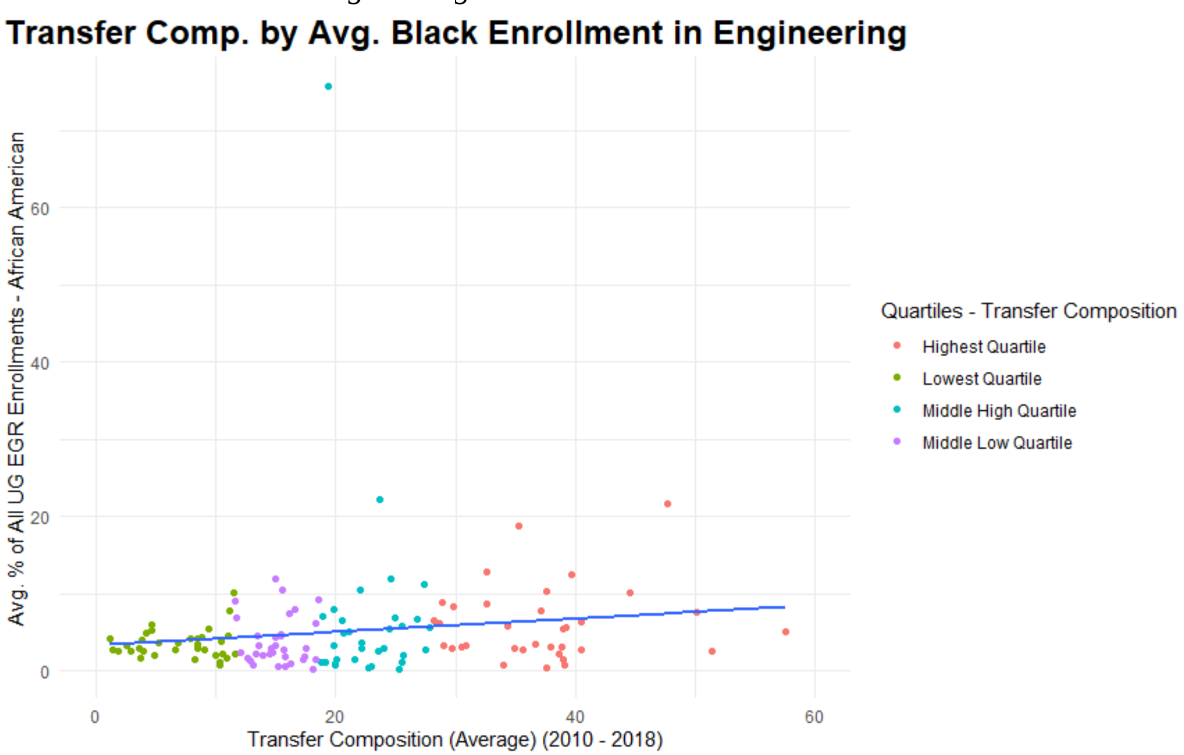


Figure D15. Distribution of Transfer Composition by Avg. Undergraduate Hispanic/Latinx Enrollment

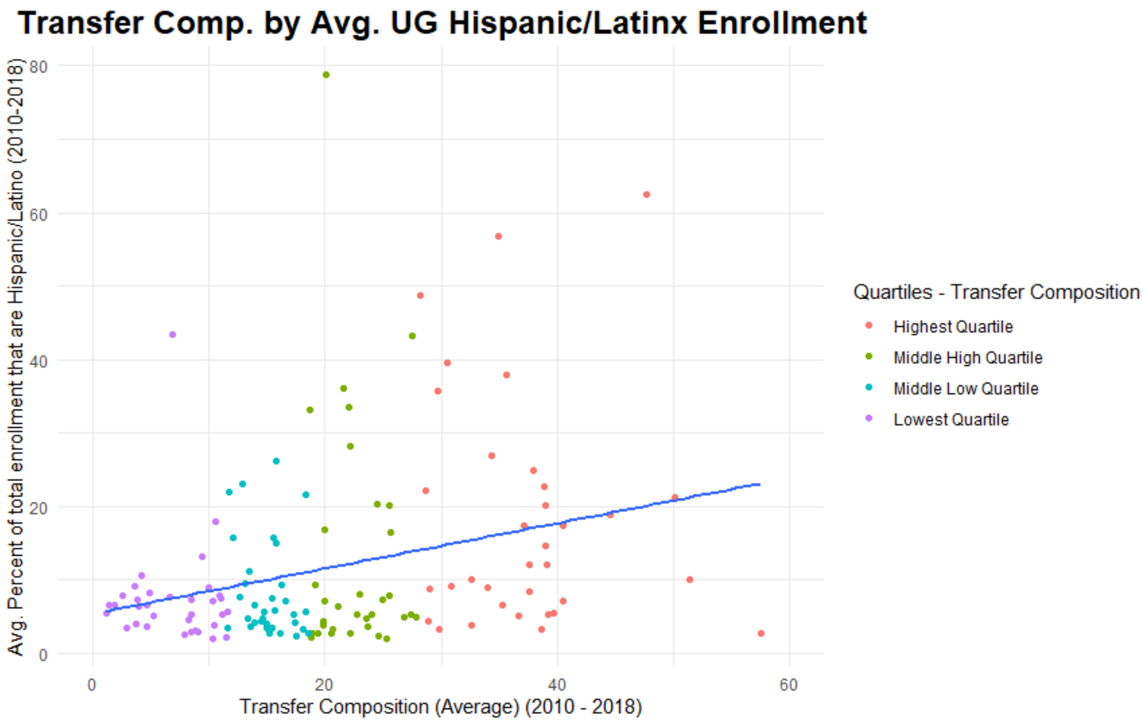


Figure D16. Distribution of Transfer Composition by Avg. Hispanic/Latinx Enrollment in Engineering

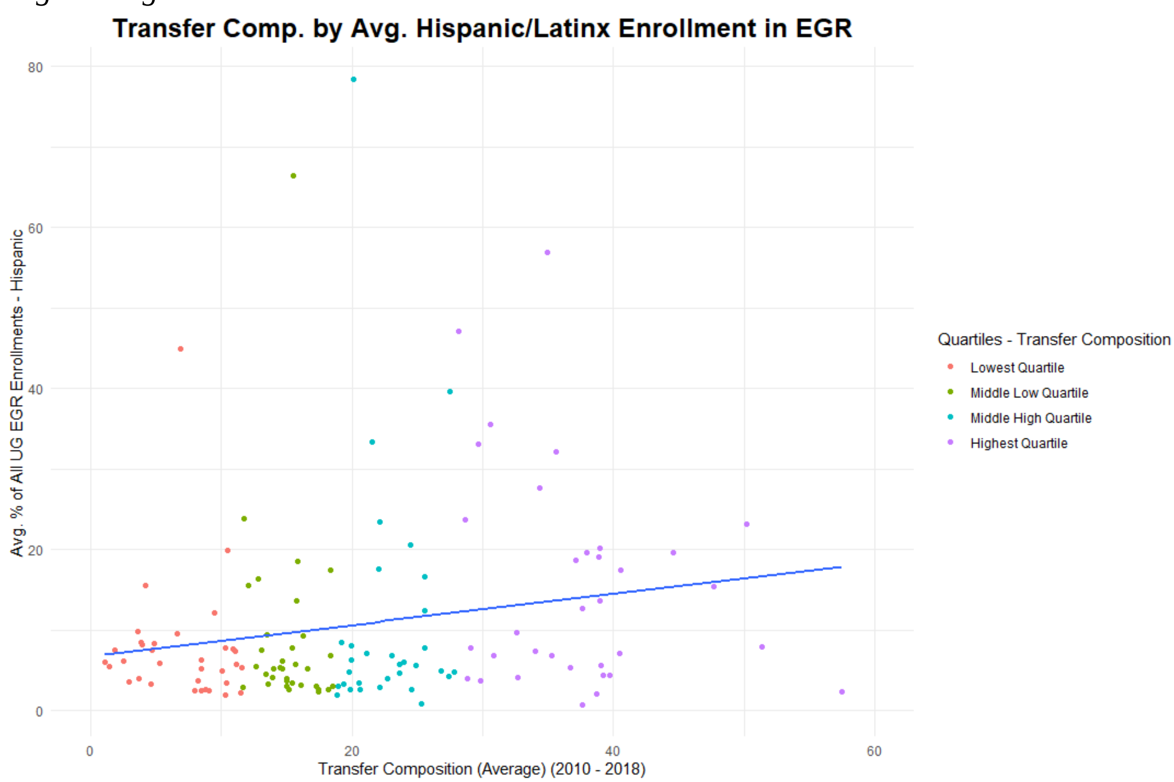


Figure D17. Distribution of Transfer Composition by Avg. Undergraduate Minoritized Enrollment

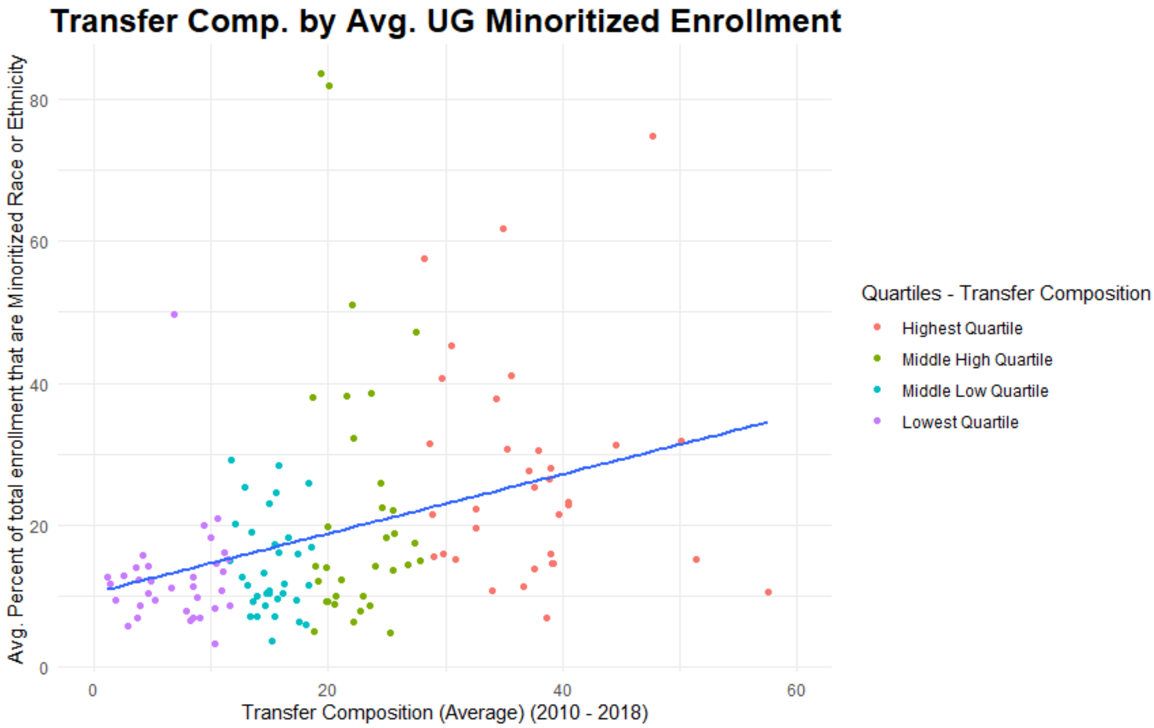


Figure D18. Distribution of Transfer Composition by Avg. Minoritized Enrollment in Engineering

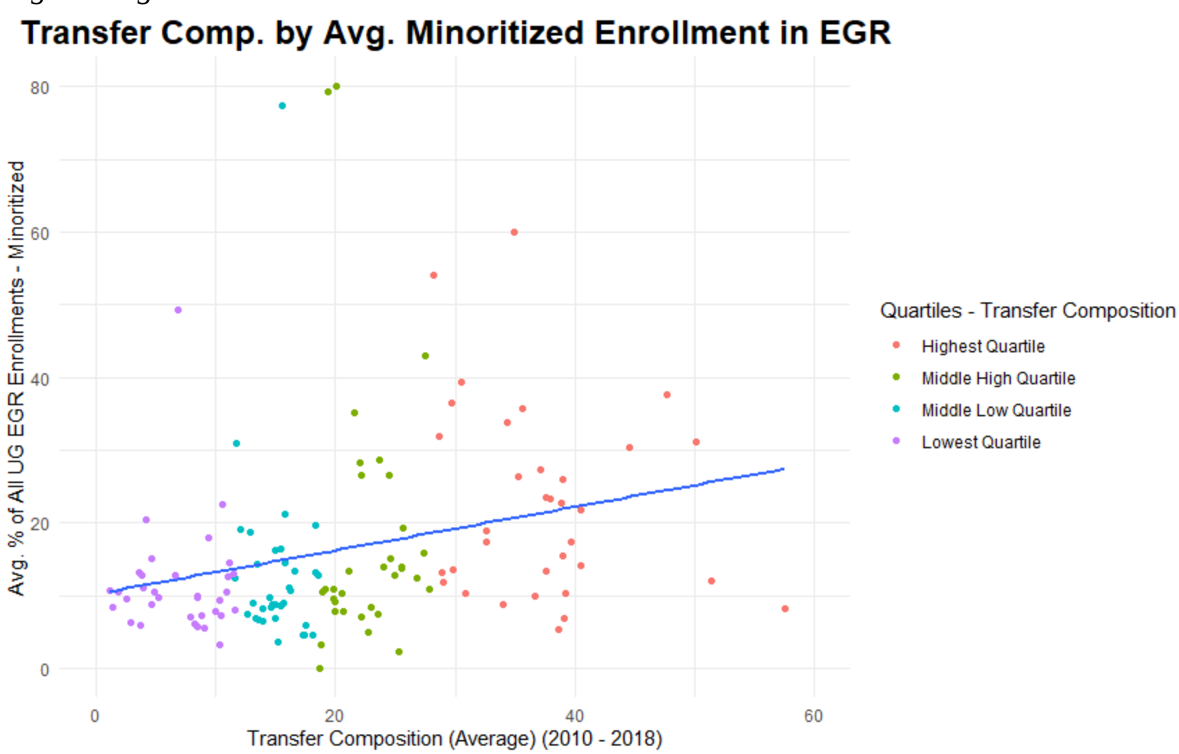


Figure D19. Distribution of Transfer Composition by Avg. Undergraduate Women Enrollment

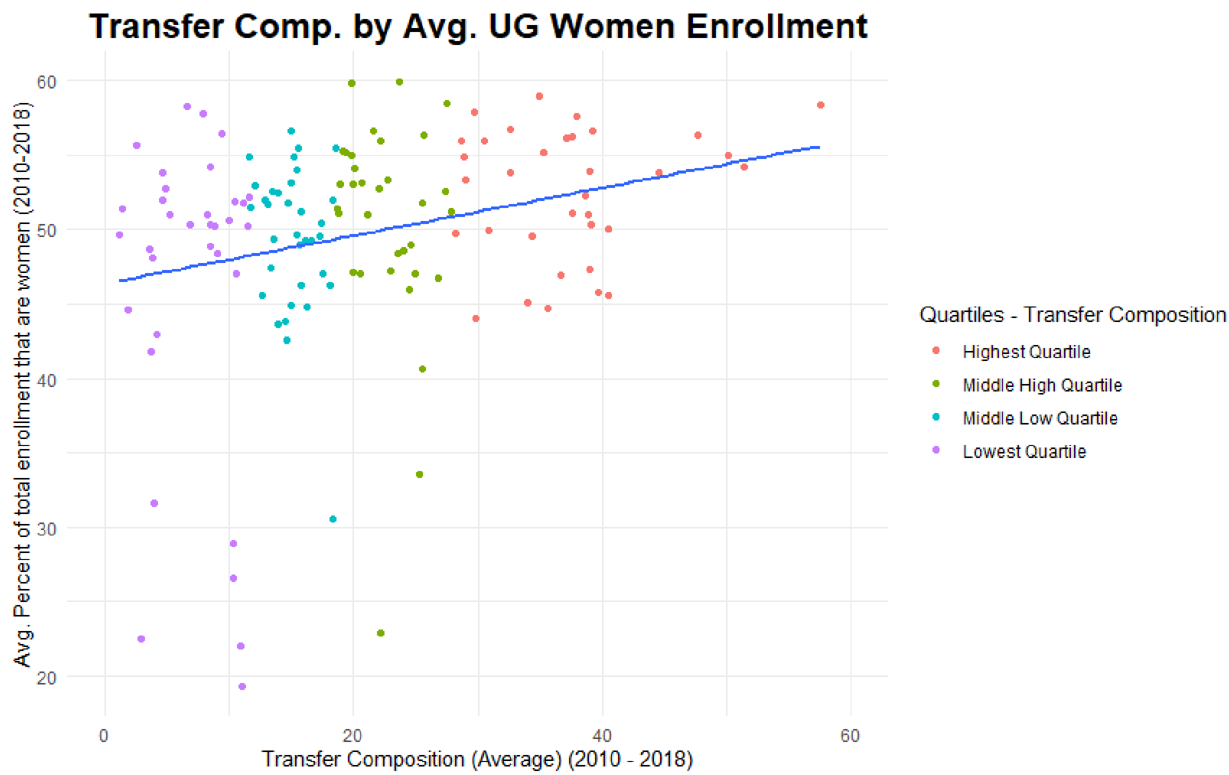


Figure D20. Distribution of Transfer Composition by Avg. Women Enrollment in Engineering

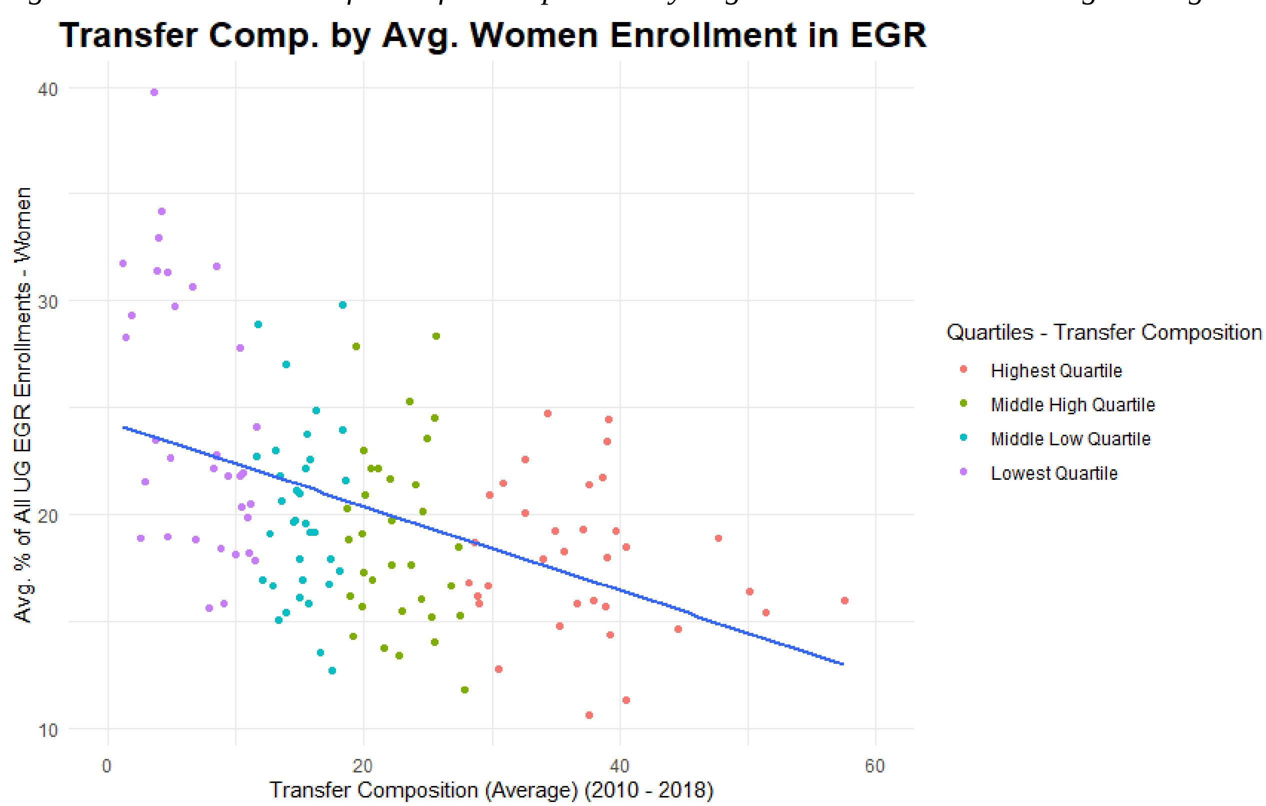


Figure D21. Distribution of Transfer Composition by First-Time Full-Time Retention Rates

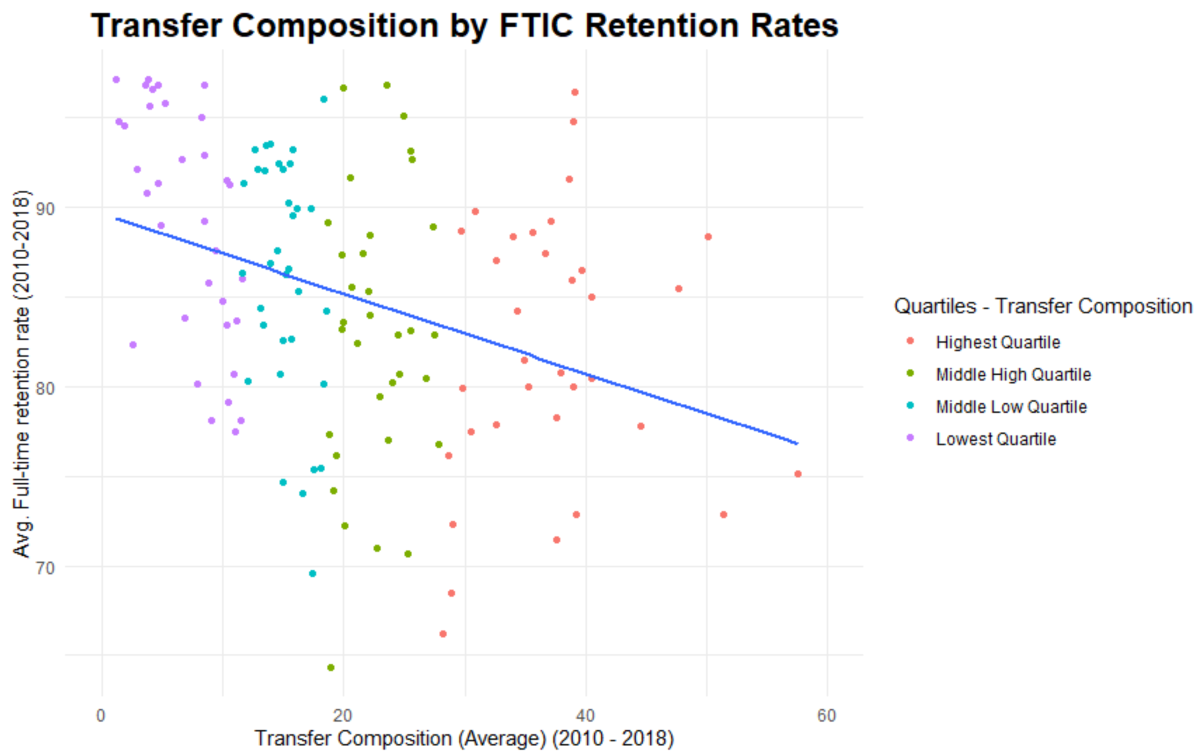


Figure D22. Distribution of Transfer Composition by IPEDS First-Time Full-Time 4-Year Graduation Rates

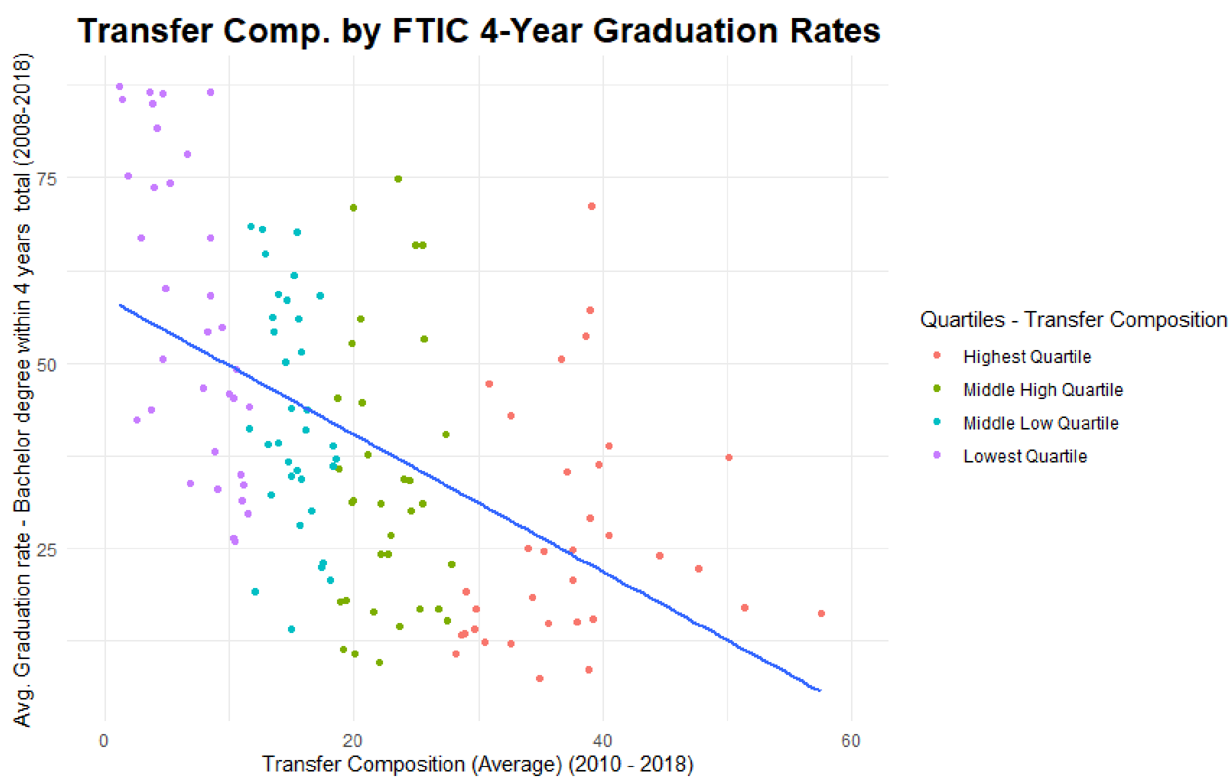


Figure D23. Distribution of Transfer Composition by IPEDS First-Time Full-Time 5-Year Graduation Rates

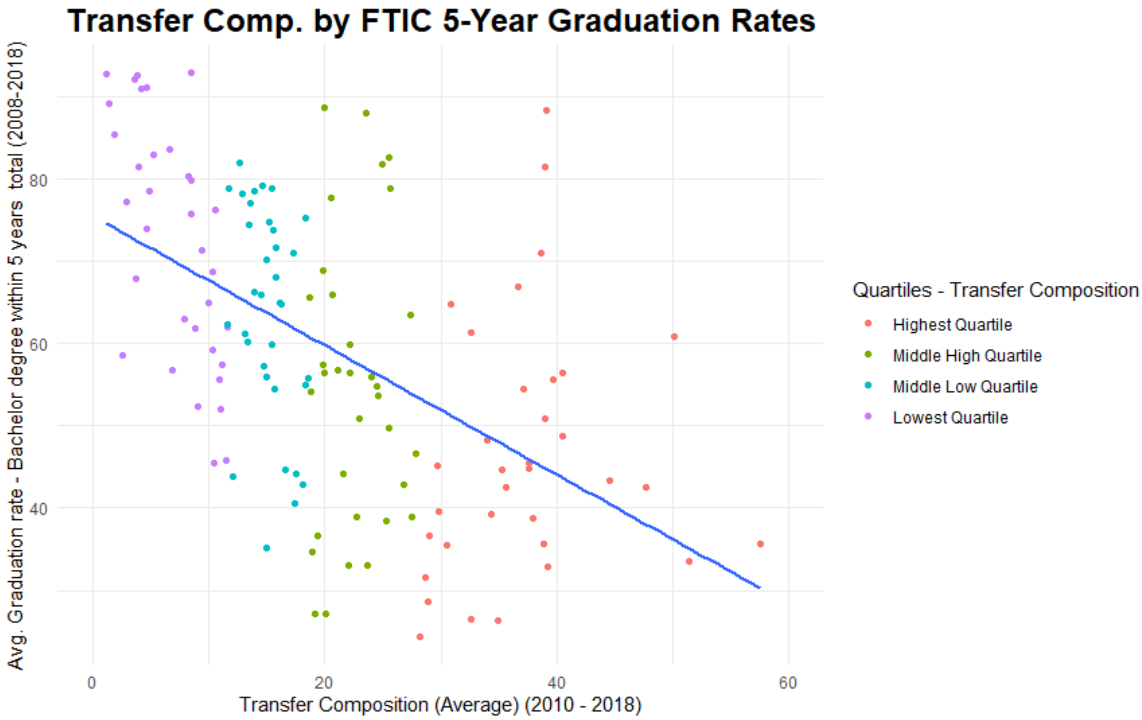
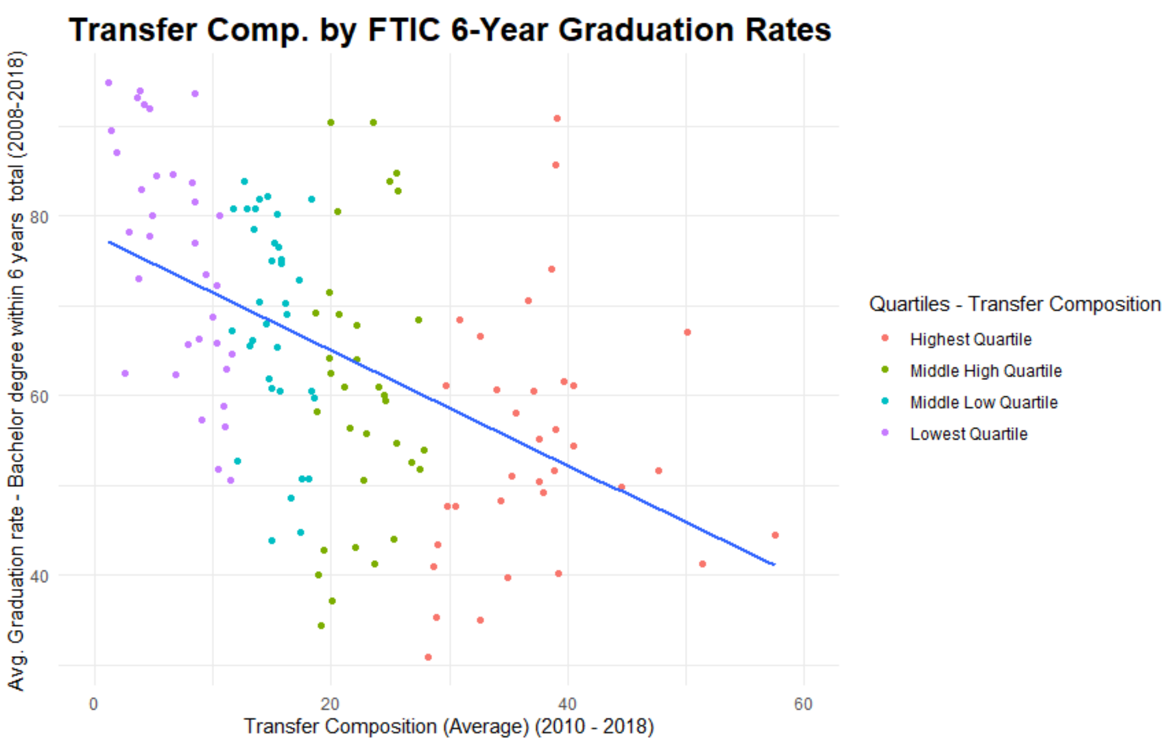


Figure D24. Distribution of Transfer Composition by IPEDS First-Time Full-Time 6-Year Graduation Rates



Appendix MS2-E: Plots for Non-Significant Results Related to Availability of Engineering Transfer Enrollment Information

Figure E1. Comparing Transferable Core of Lower-Division Courses Policy by Engineering Transfer Enrollment Data

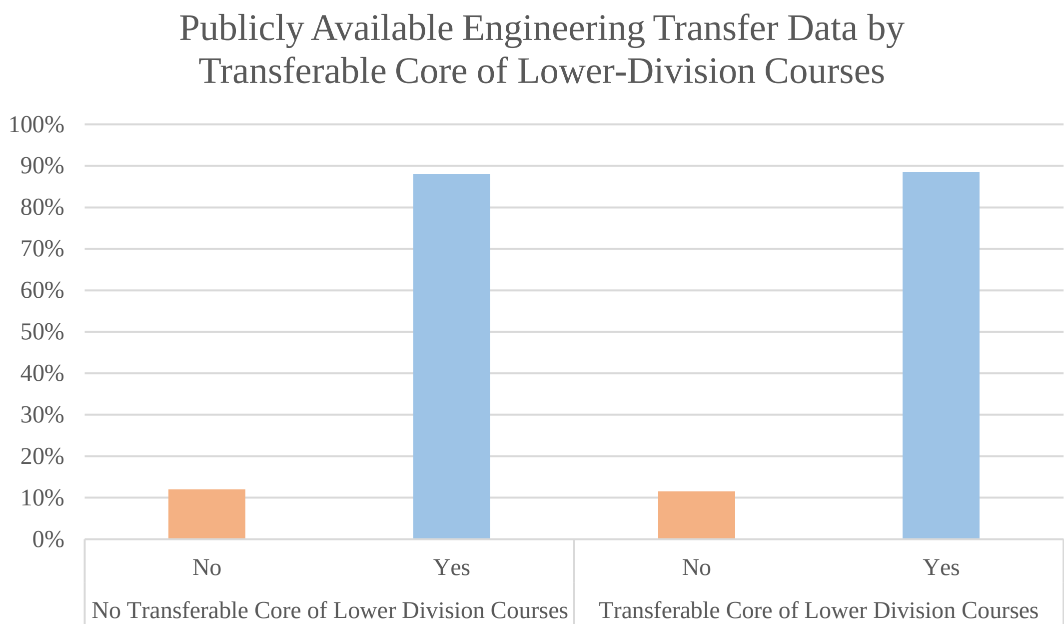


Figure E2. Comparing Statewide Common Course Numbering System by Engineering Transfer Enrollment Data

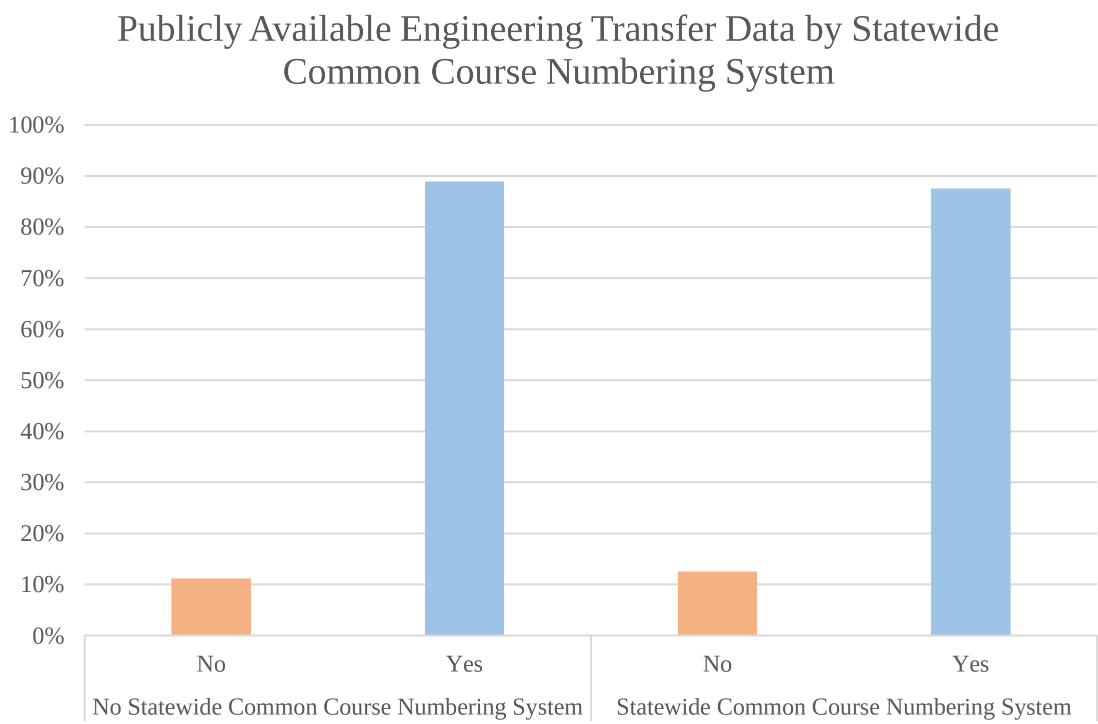


Figure E3. Comparing Statewide Reverse Transfer by Engineering Transfer Enrollment Data

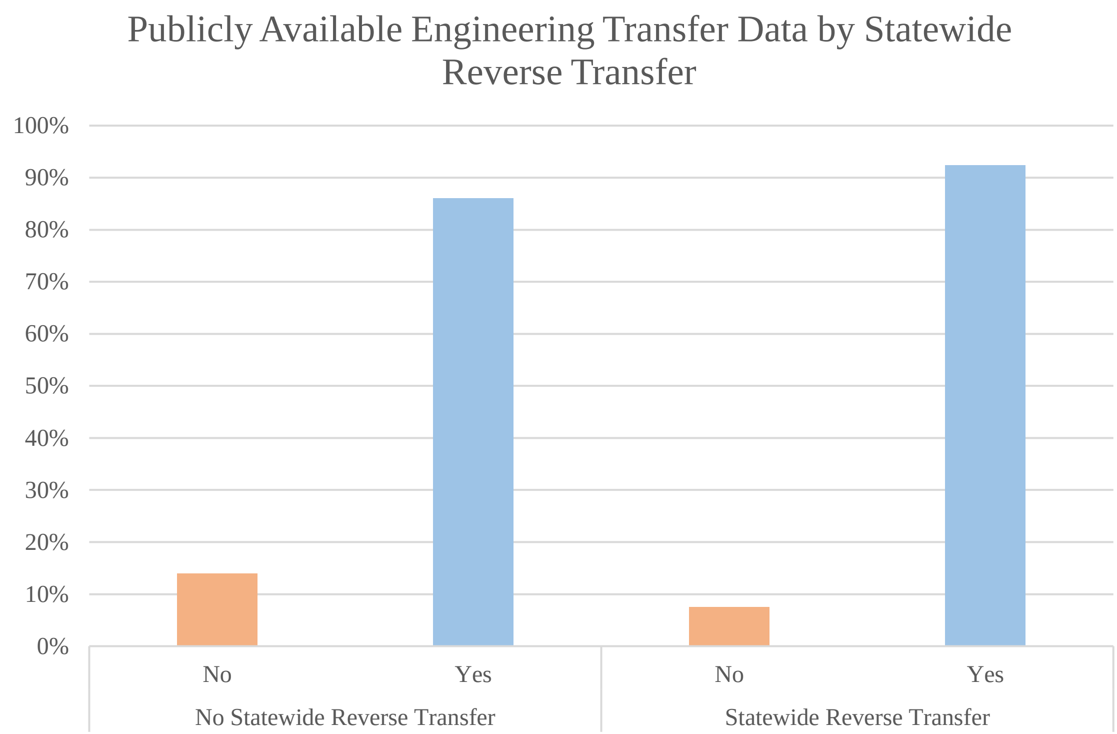


Figure E4. Comparing Statewide Guaranteed Transfer of an Associate Degree by Engineering Transfer Enrollment Data

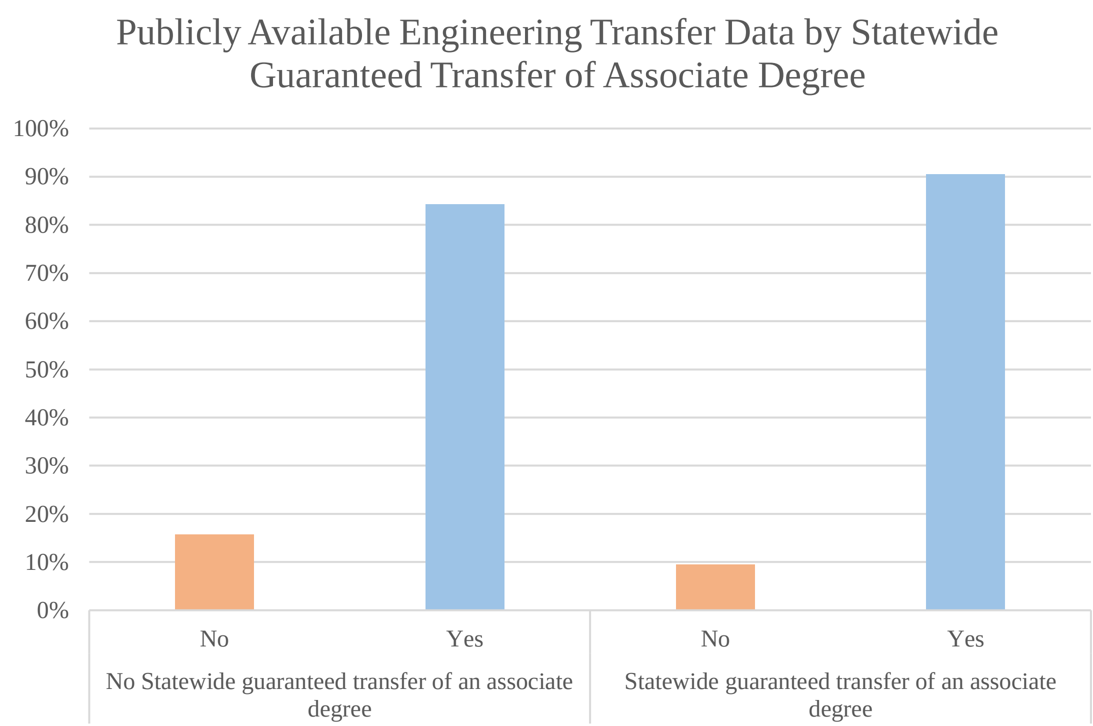


Figure E5. Comparing Engineering Transfer Enrollment Data by Multi-Institution/Campus Organization for Publics

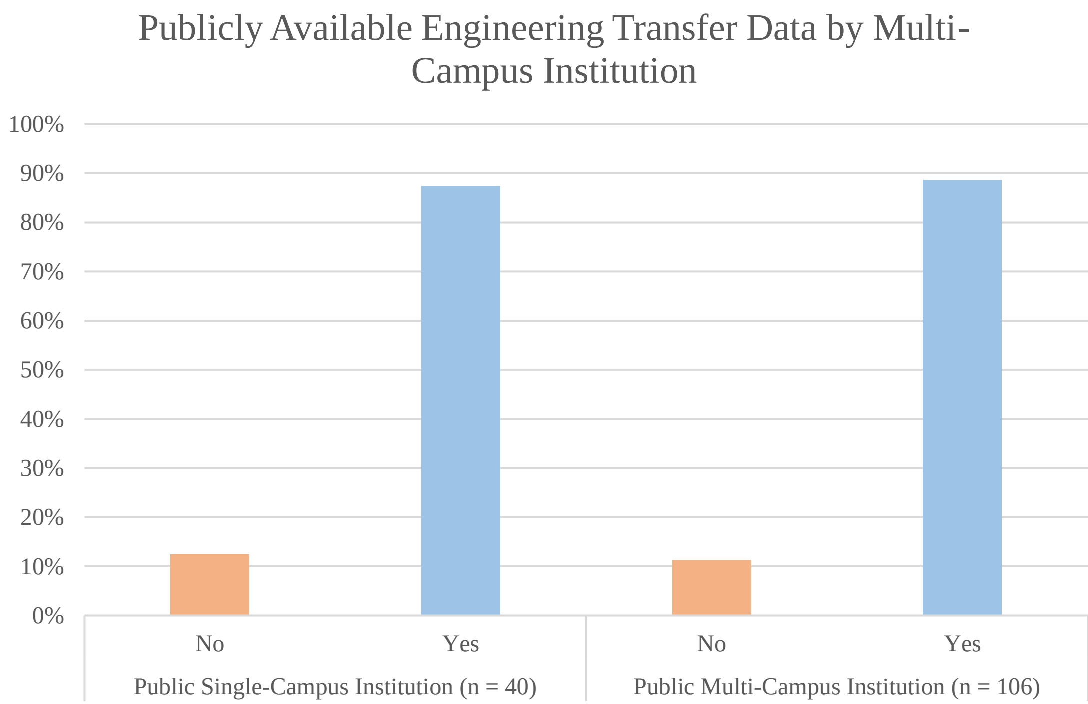


Figure E6. Comparing Hispanic Serving Institution by Engineering Transfer Enrollment Data

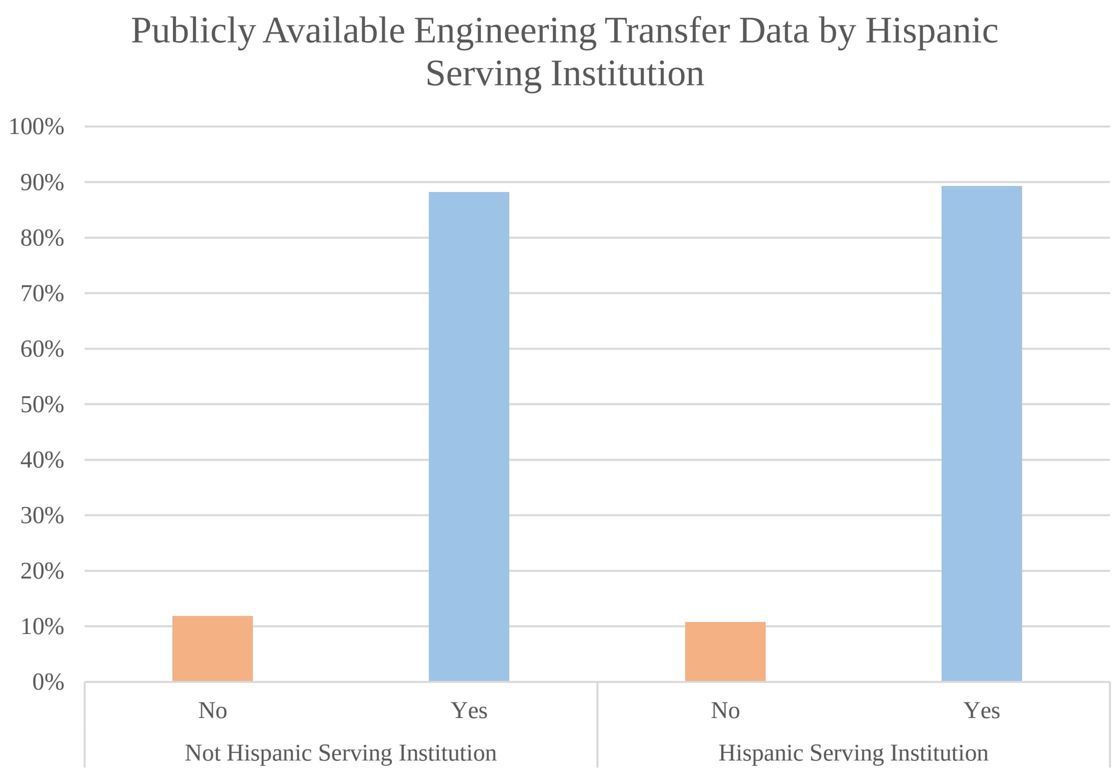


Figure E7. Comparing Carnegie Classification: Size and Setting by Engineering Transfer Enrollment Data

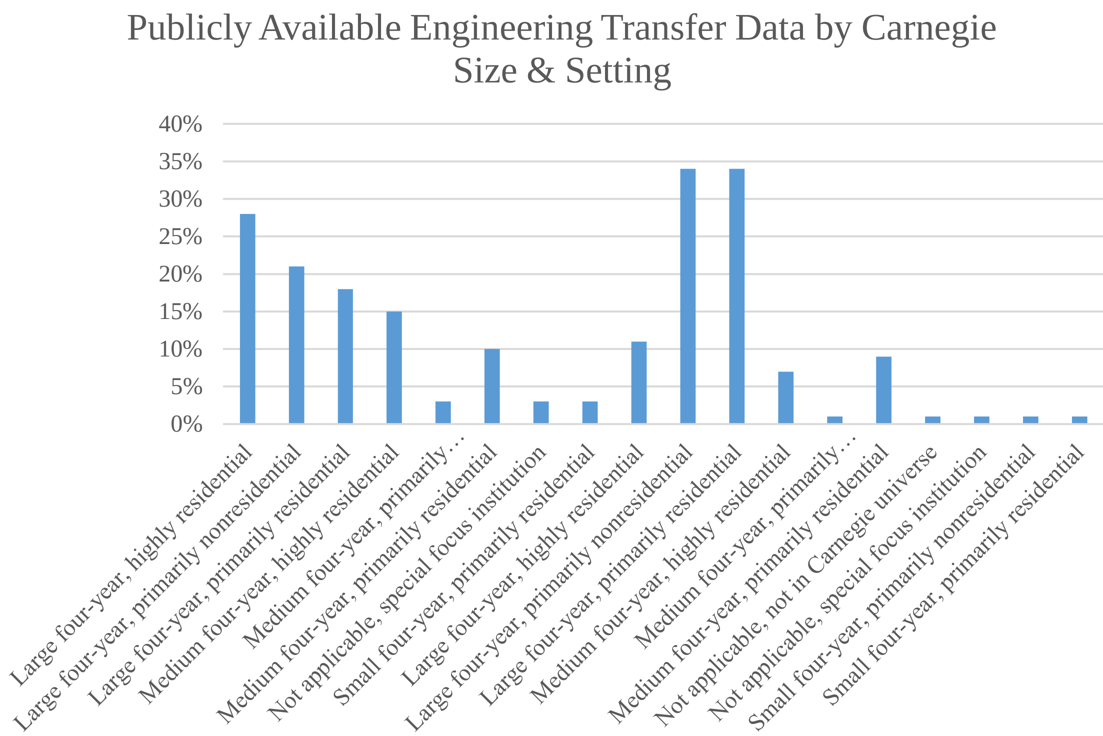


Figure E8. Comparing Carnegie Classification: Undergraduate Profile by Engineering Transfer Enrollment Data

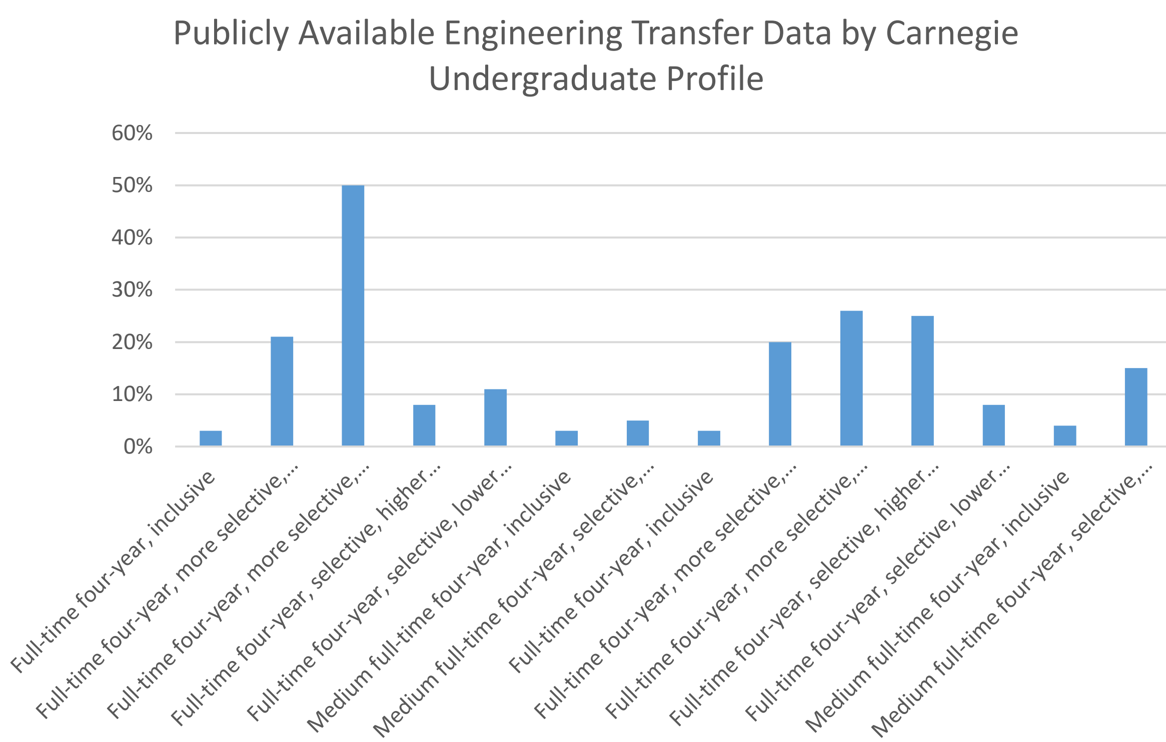


Figure E9. Comparing Carnegie Classification: Basic by Engineering Transfer Enrollment Data

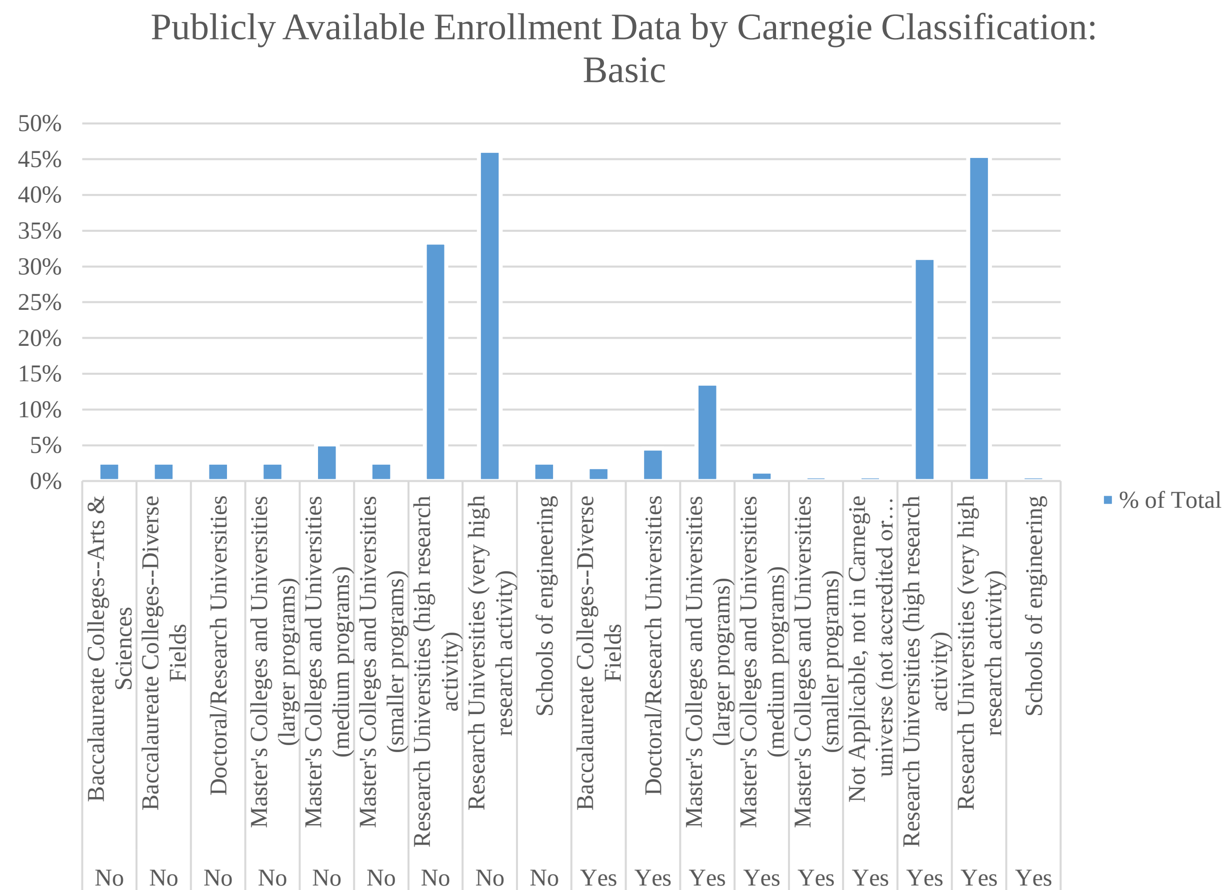


Figure E10. Comparing Degree of Urbanization by Engineering Transfer Enrollment Data

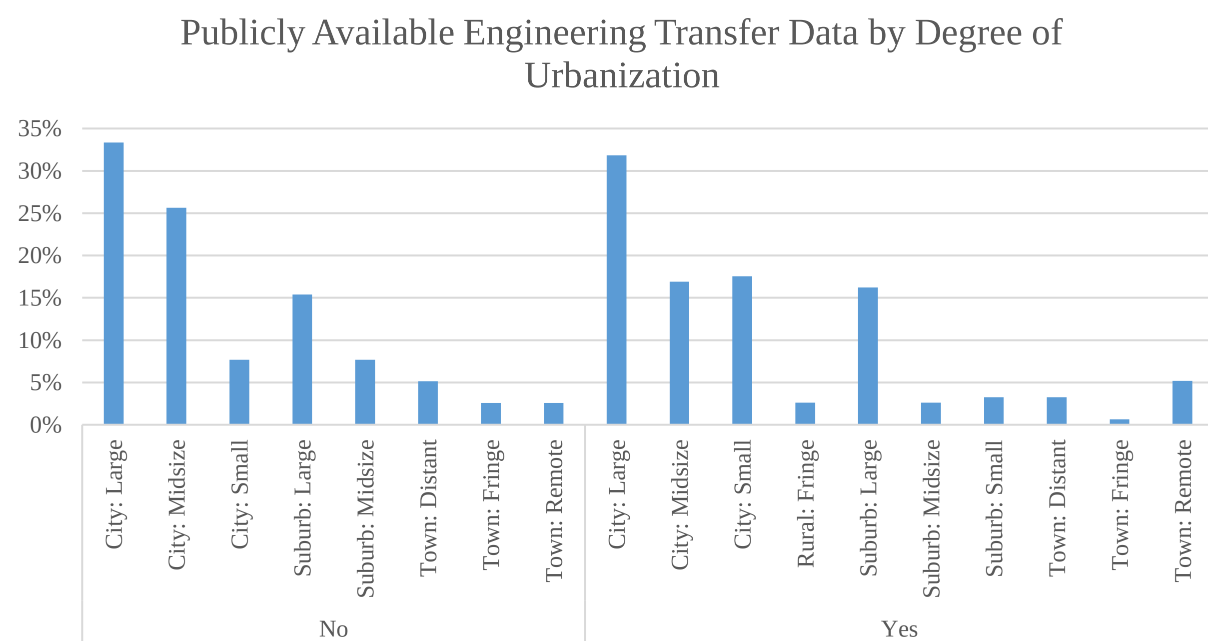


Figure E11. Comparing Net Price for Public Institutions with Publically Available Enrollment Data

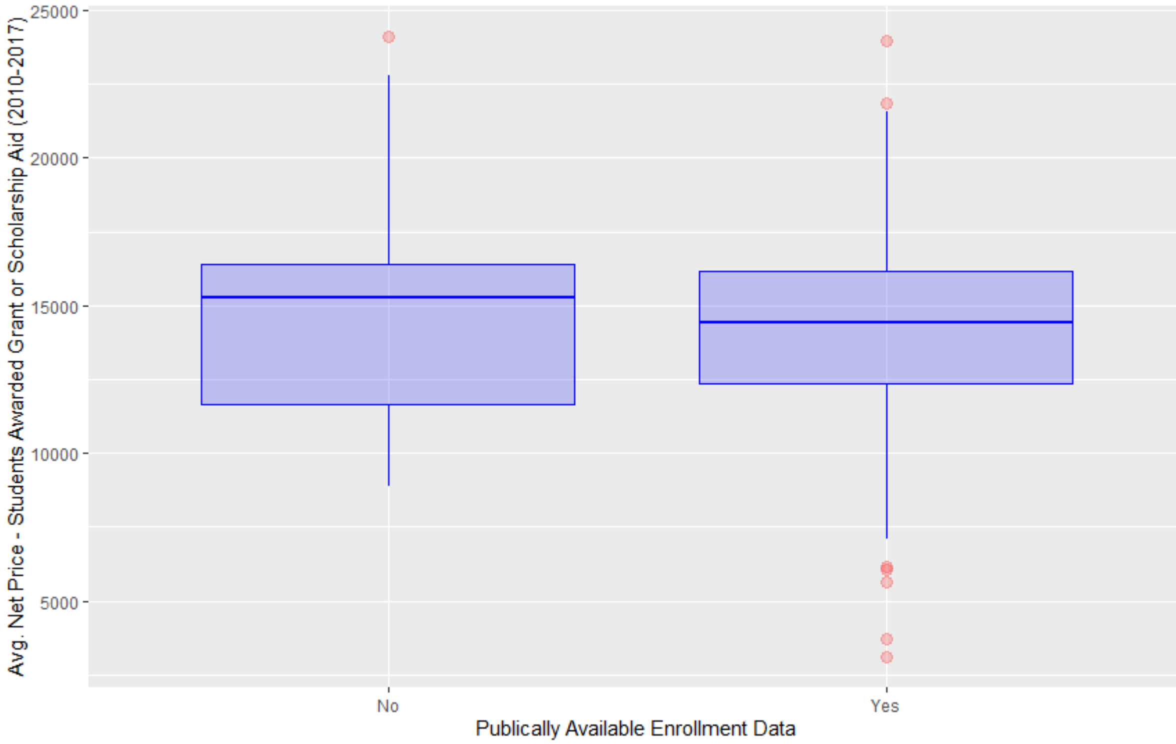


Figure E12. Comparing Tuition and Fees for Public Institutions with Publically Available Enrollment Data

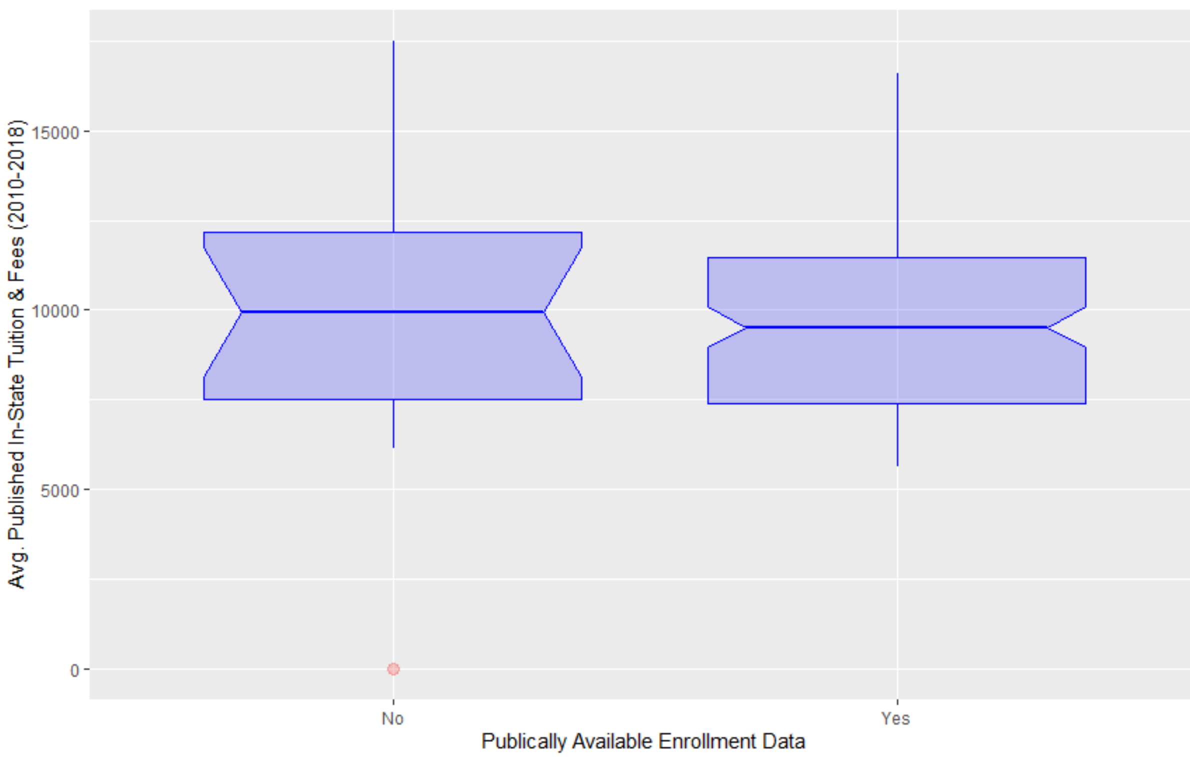


Figure E13. Comparing Total Price for In-State Students at Public Institutions Living Off Campus with Publically Available Enrollment Data

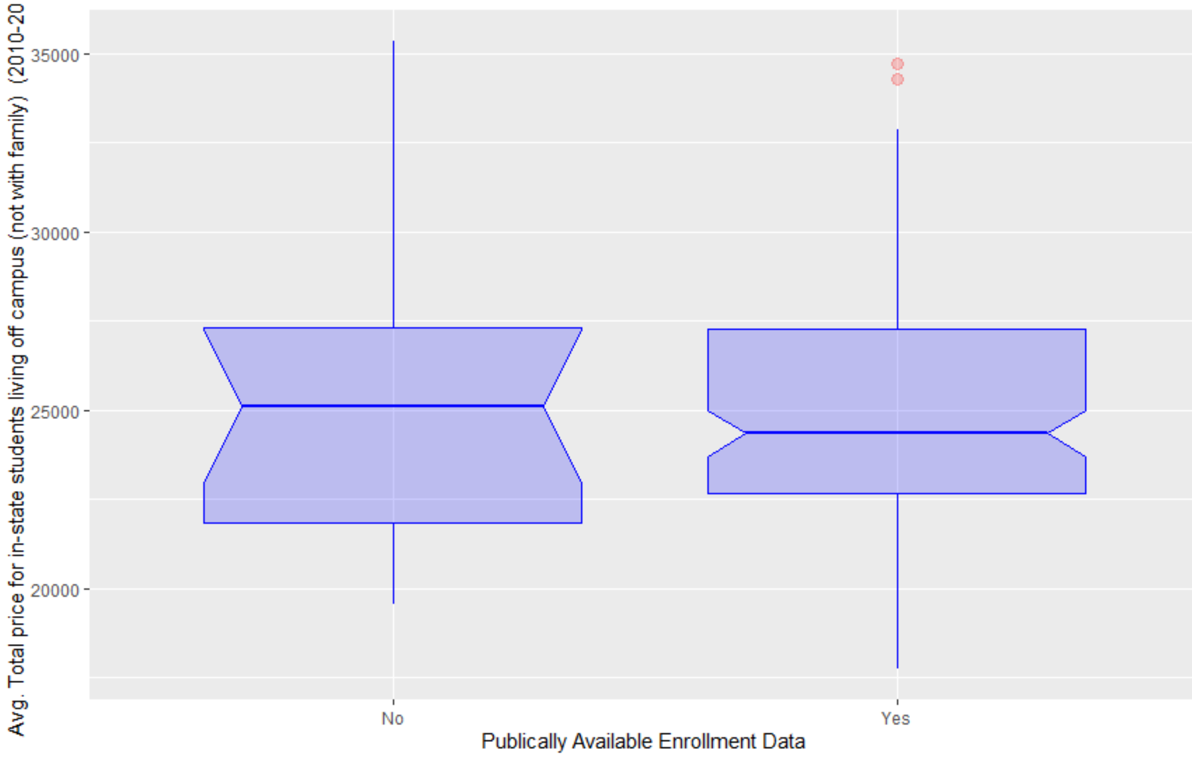


Figure E14. Comparing Endowment Assets of Public Institutions by Engineering Transfer Enrollment Data

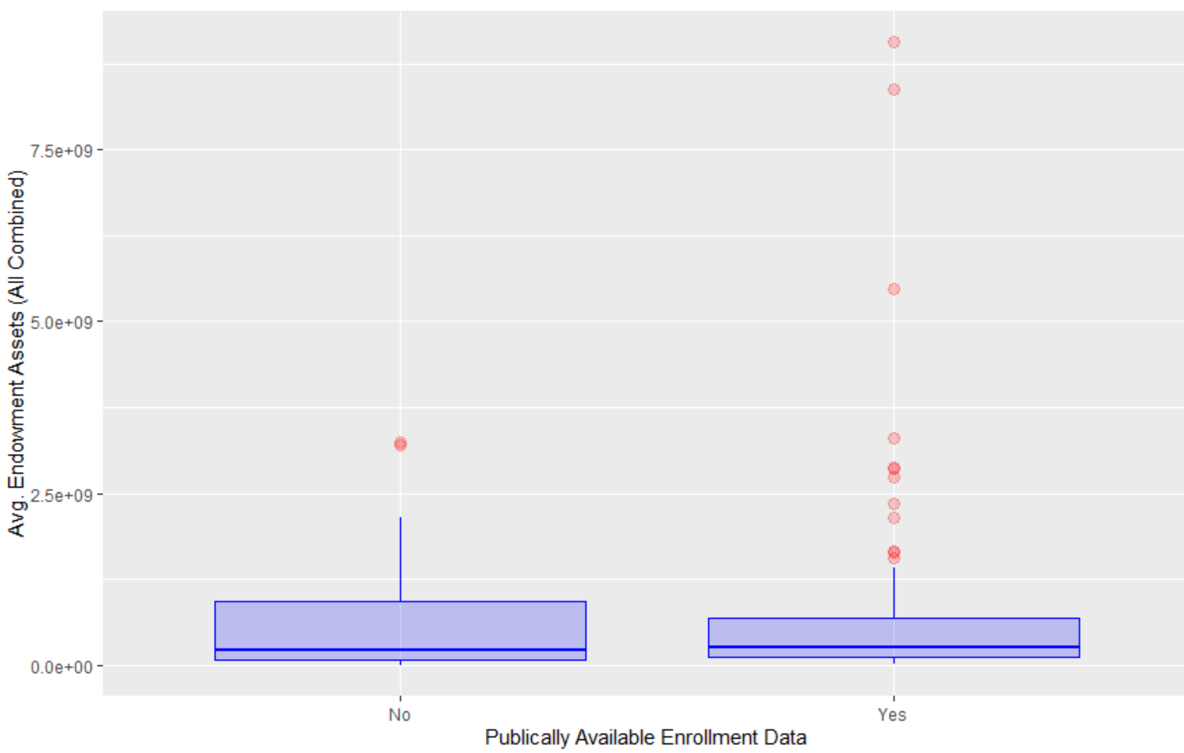


Figure E15. Comparing Tuition & Fees of Private Institutions by Engineering Transfer Enrollment Data

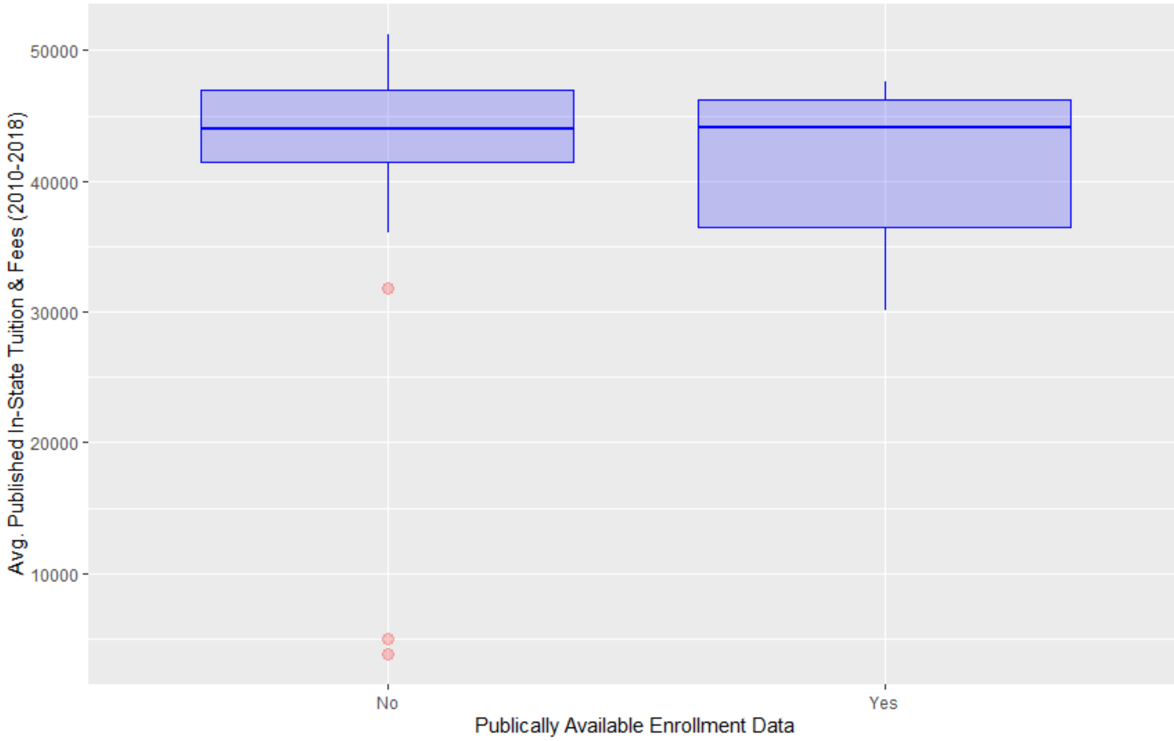


Figure E16. Comparing Total Price for Students Living Off Campus at Private Institutions by Engineering Transfer Enrollment Data

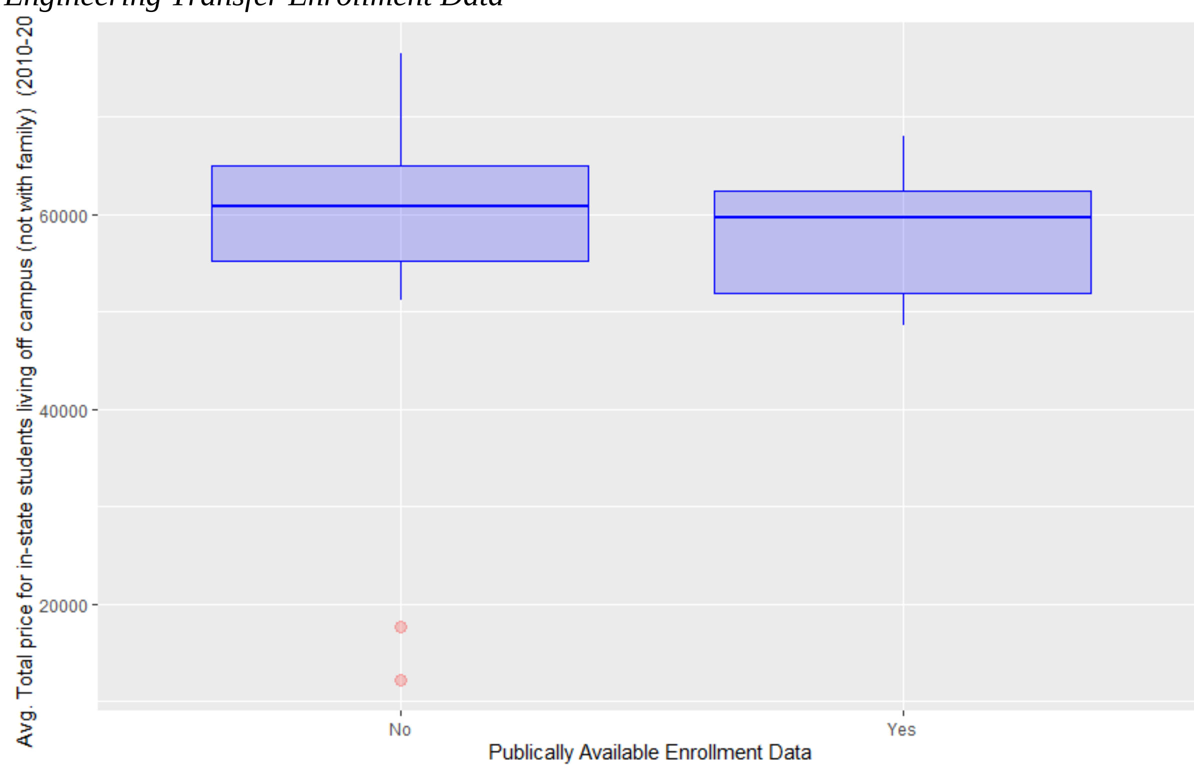


Figure E17. Comparing Endowment Assets of Private Institutions by Engineering Transfer Enrollment Data

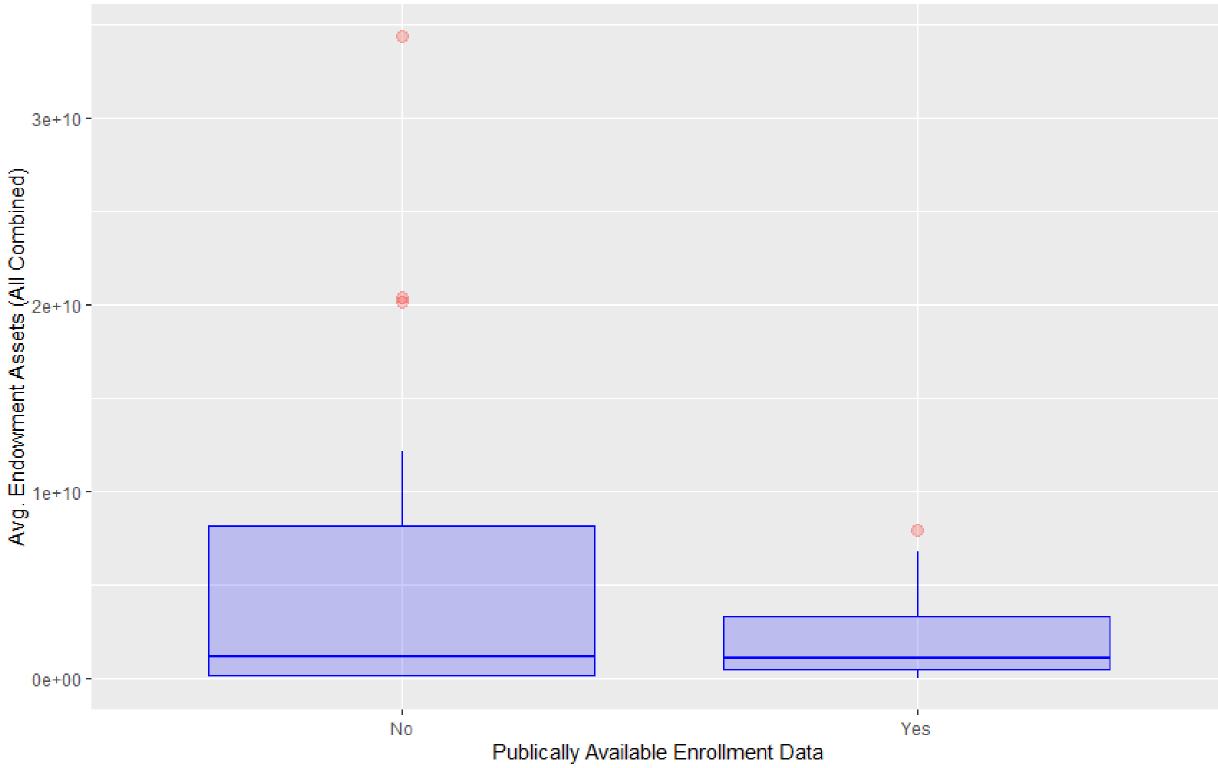


Figure E18. Comparing Transfer-In Full Time Enrollment by Engineering Transfer Enrollment Data

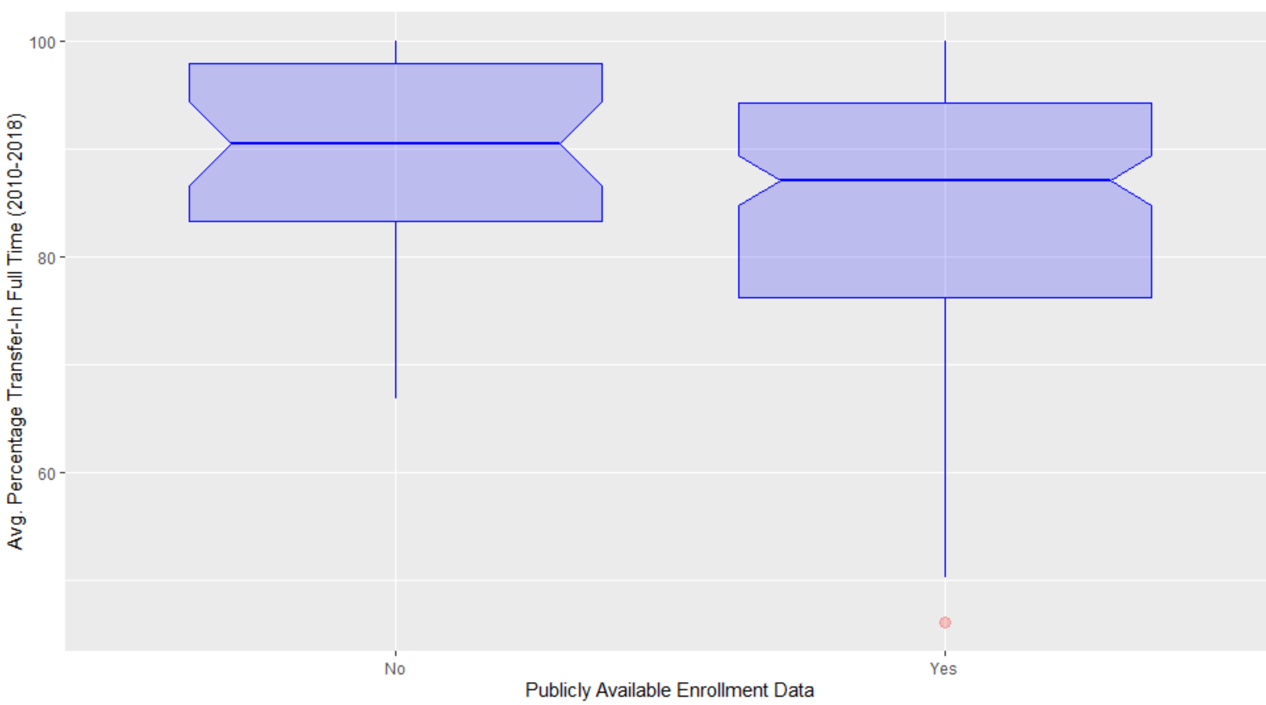


Figure E19. Comparing Institution Black/African American Enrollment by Engineering Transfer Enrollment Data

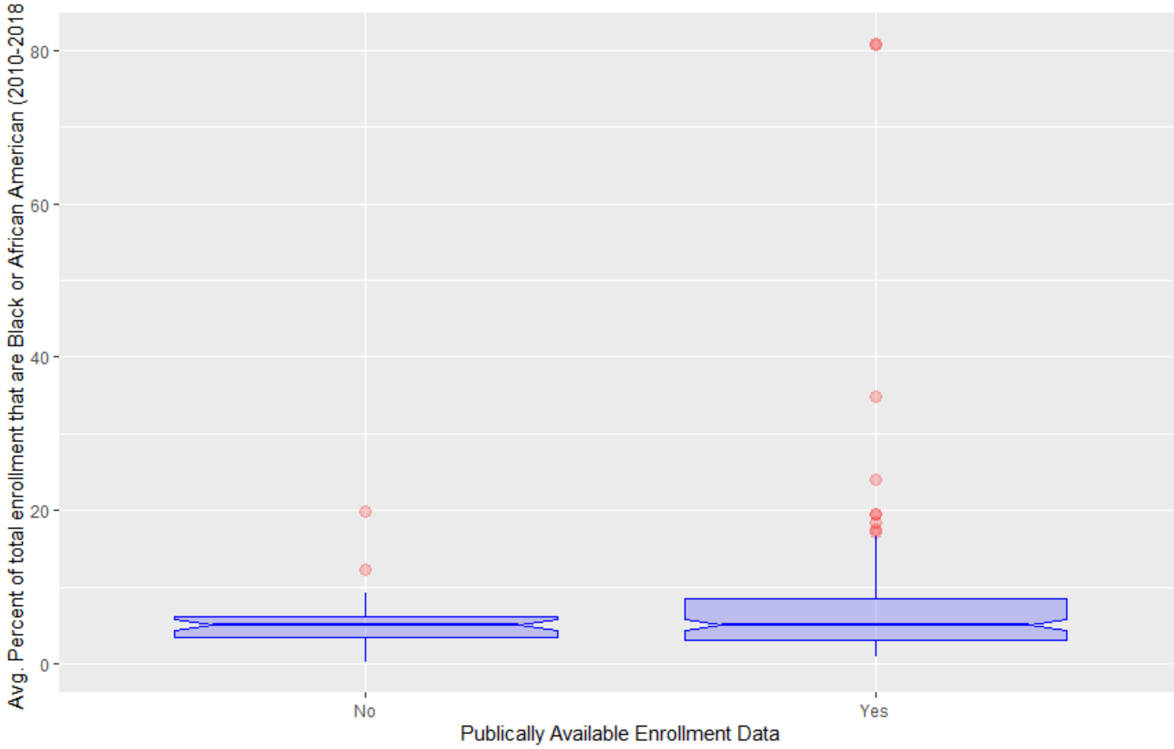


Figure E20. Comparing Institution Hispanic/Latinx Enrollment by Engineering Transfer Enrollment Data

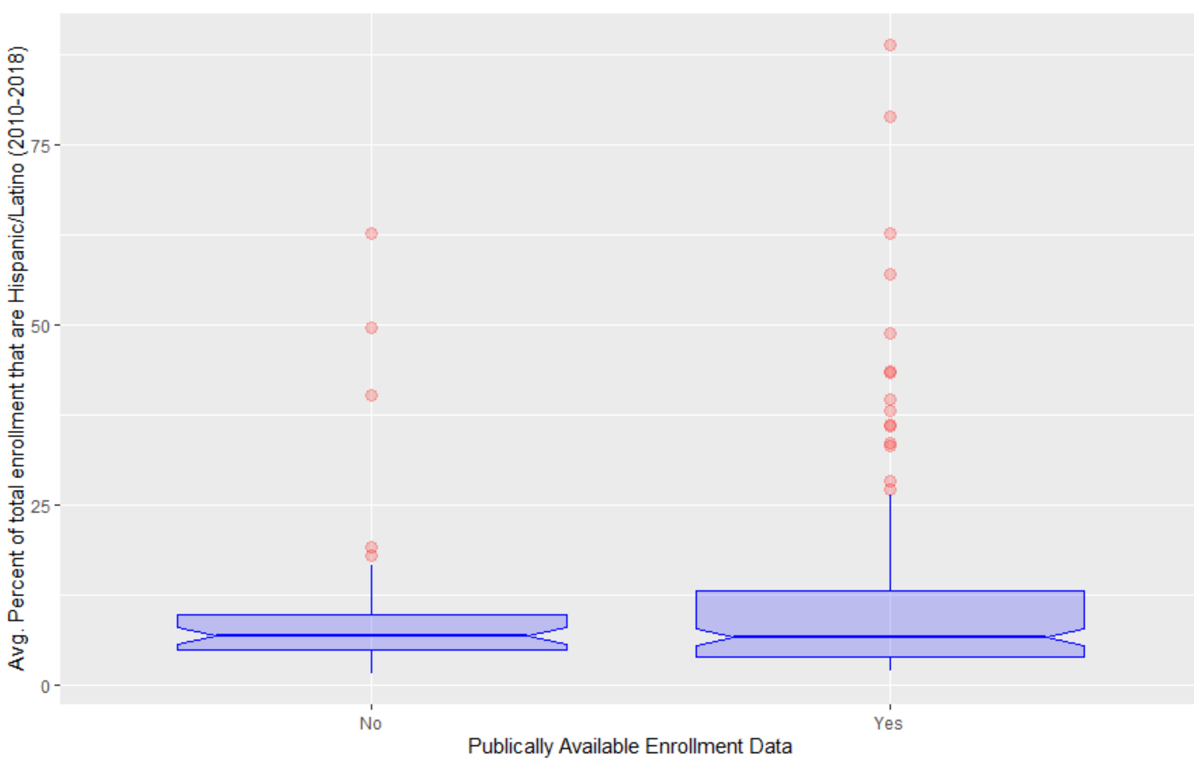


Figure E21. Comparing Institution Minoritized Enrollment by Engineering Transfer Enrollment Data

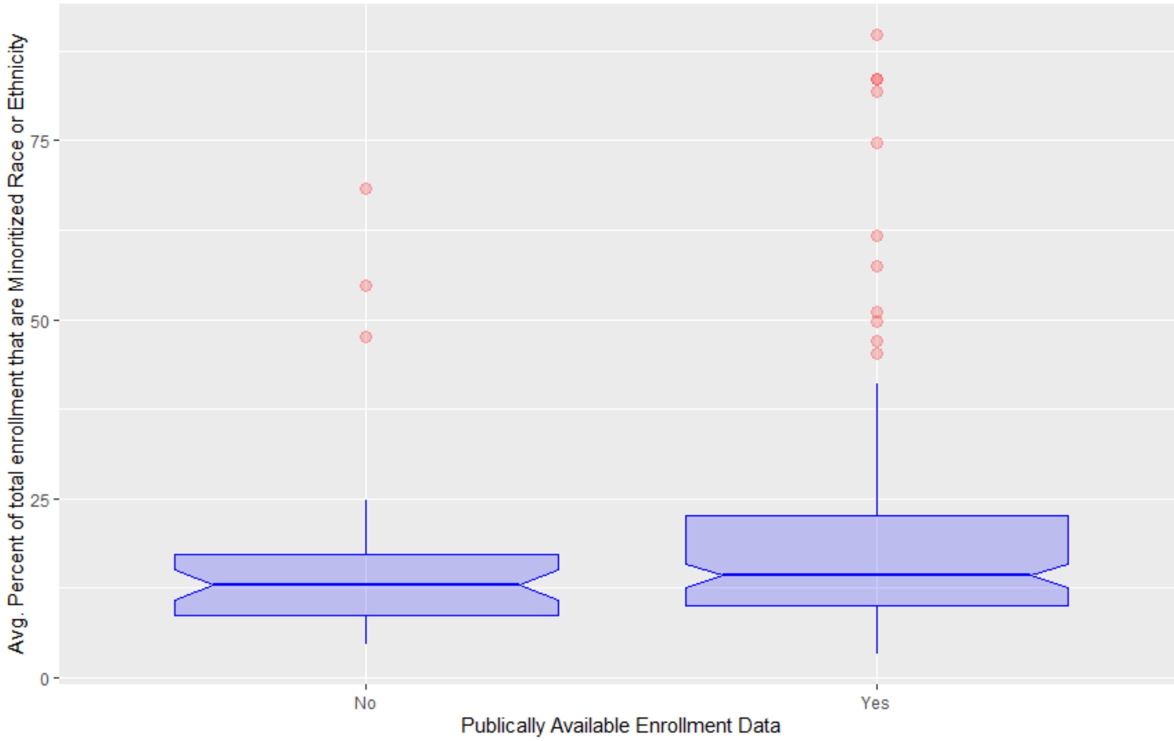


Figure E22. Comparing Black/African American Enrollment in Engineering by Engineering Transfer Enrollment Data

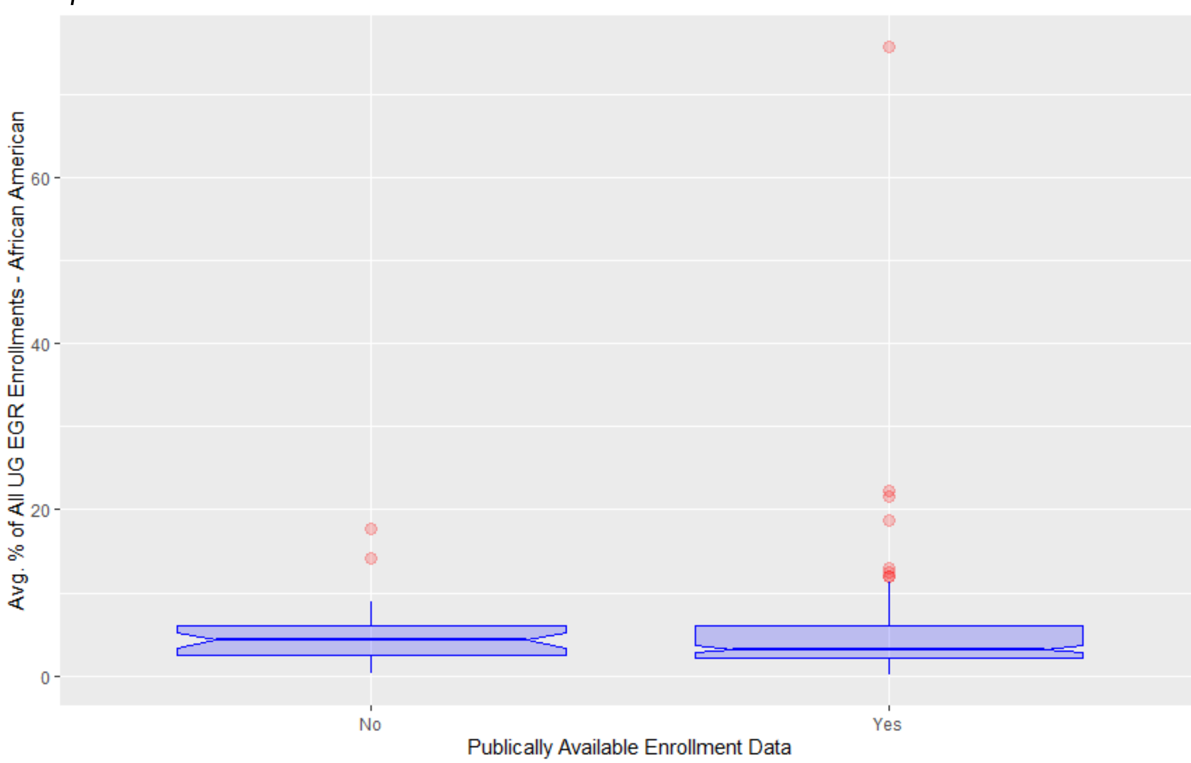
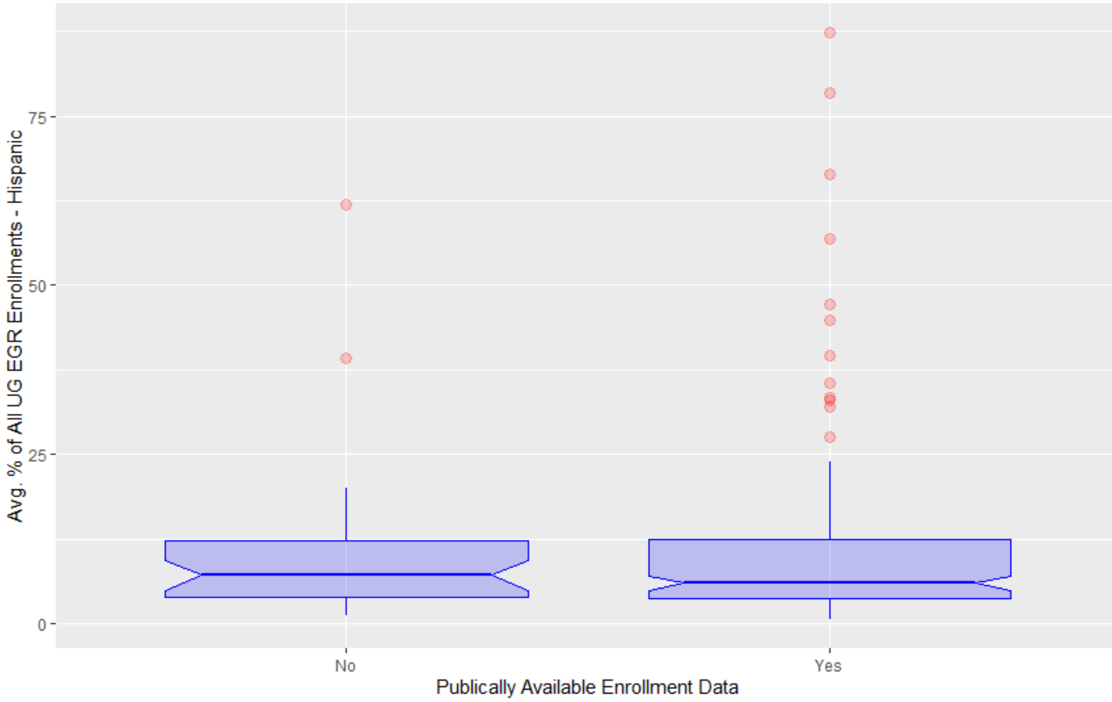


Figure E23. Comparing Hispanic/Latinx Enrollment in Engineering by Engineering Transfer Enrollment Data



Appendix MS2-F: Plots for Non-Significant Results Related to Availability of Engineering Transfer Graduation Information

Figure F1. Comparing Statewide Guaranteed Transfer of Associate Degree by Engineering Transfer Graduation Data

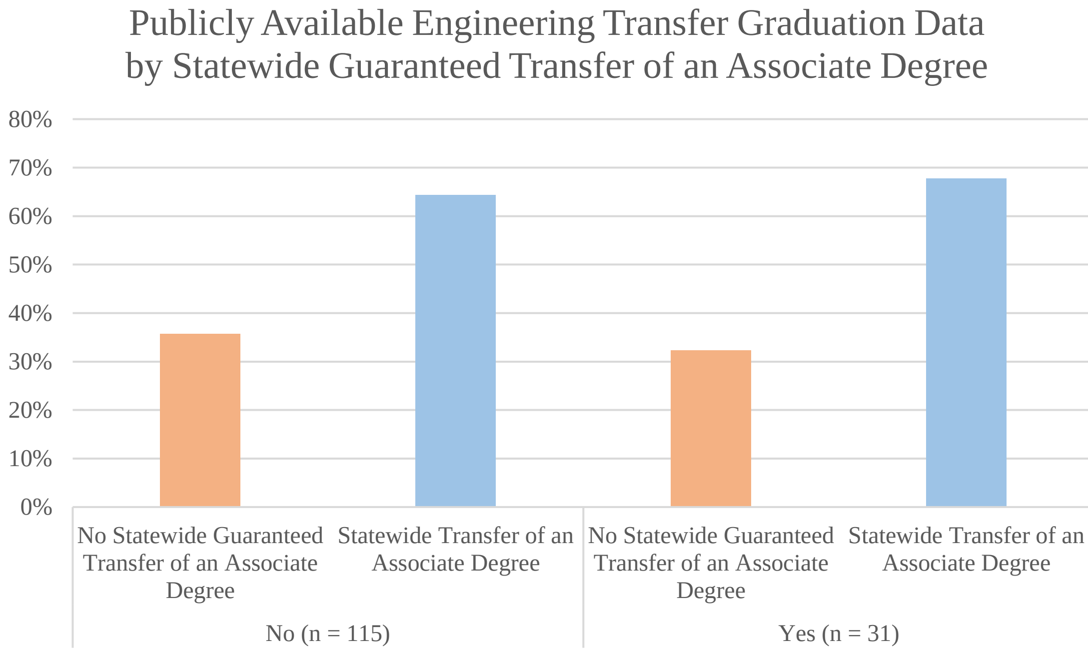


Figure F2. Comparing Land Grant Institution by Engineering Transfer Graduation Data

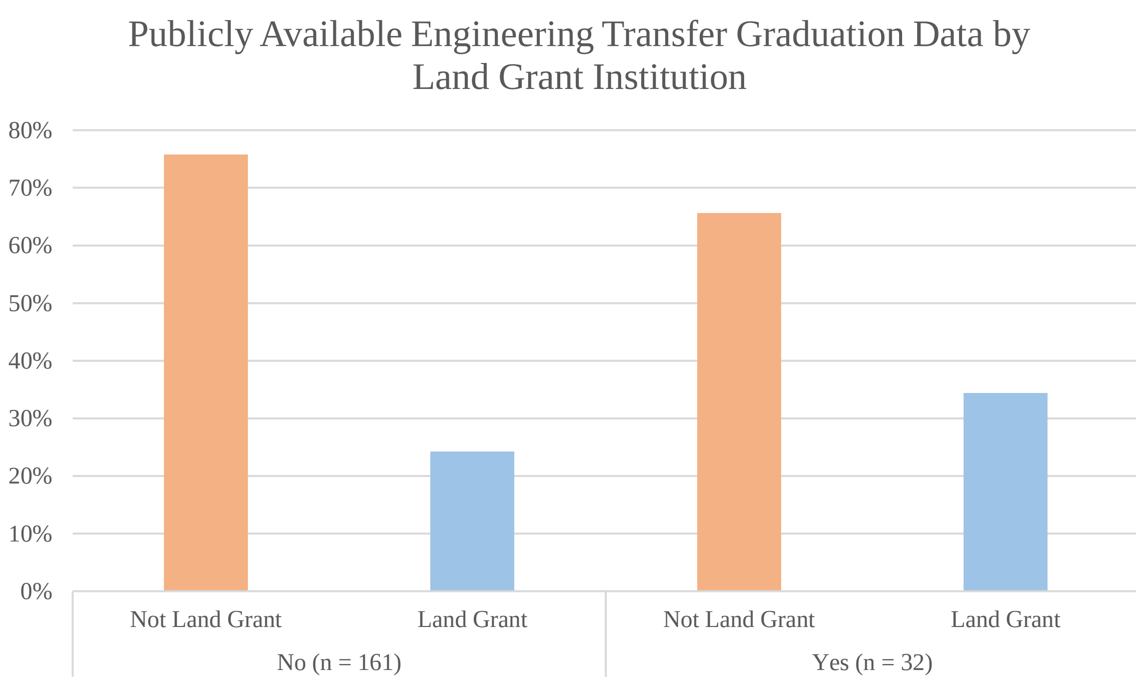


Figure F3. Comparing Carnegie Basic by Engineering Transfer Graduation Data

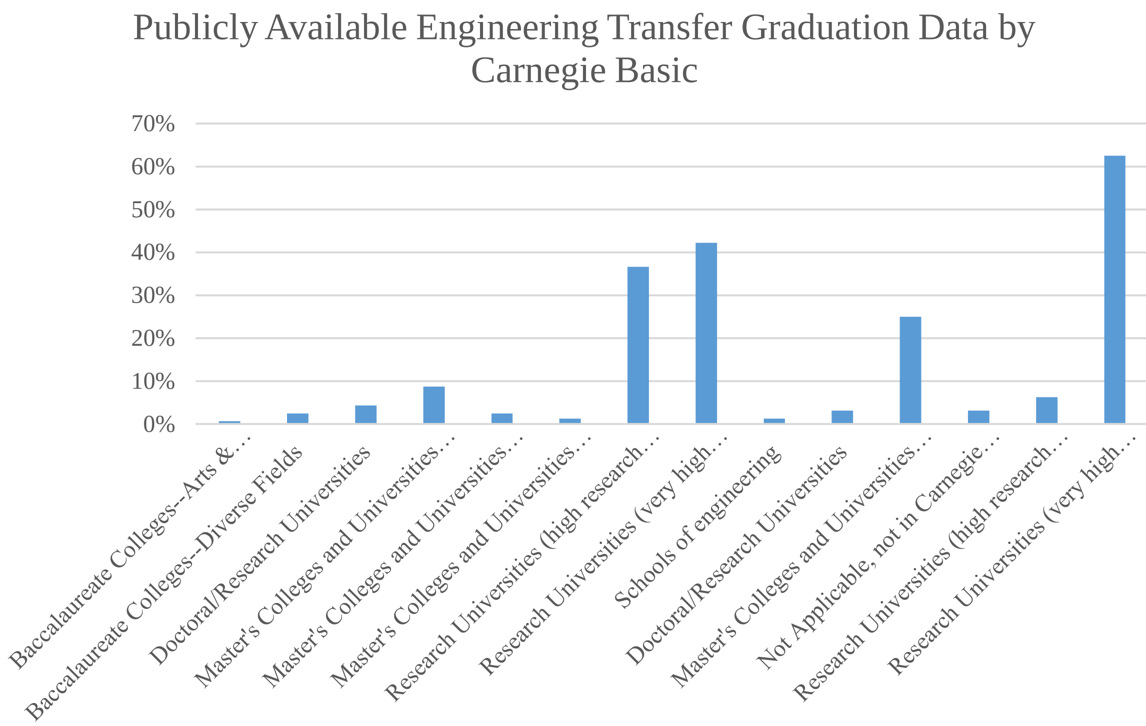


Figure F4. Comparing Carnegie Undergraduate Profile by Engineering Transfer Graduation Data

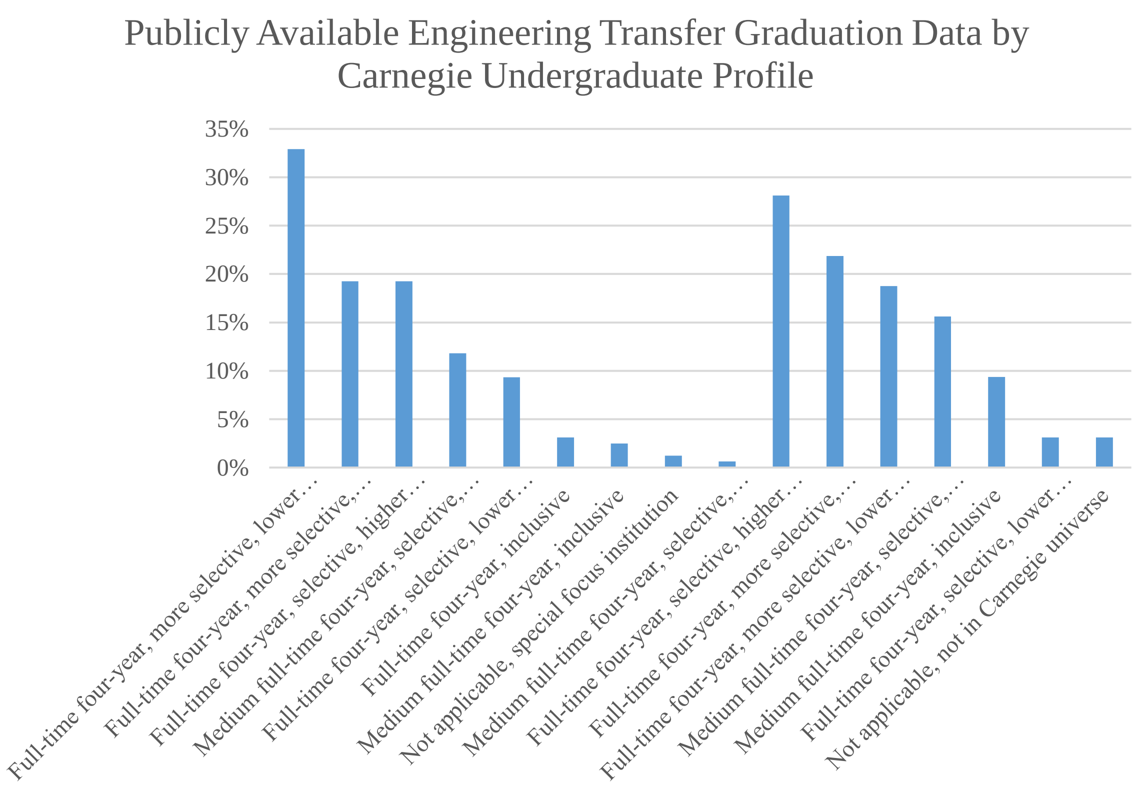


Figure F5. Comparing Degree of Urbanization by Engineering Transfer Graduation Data

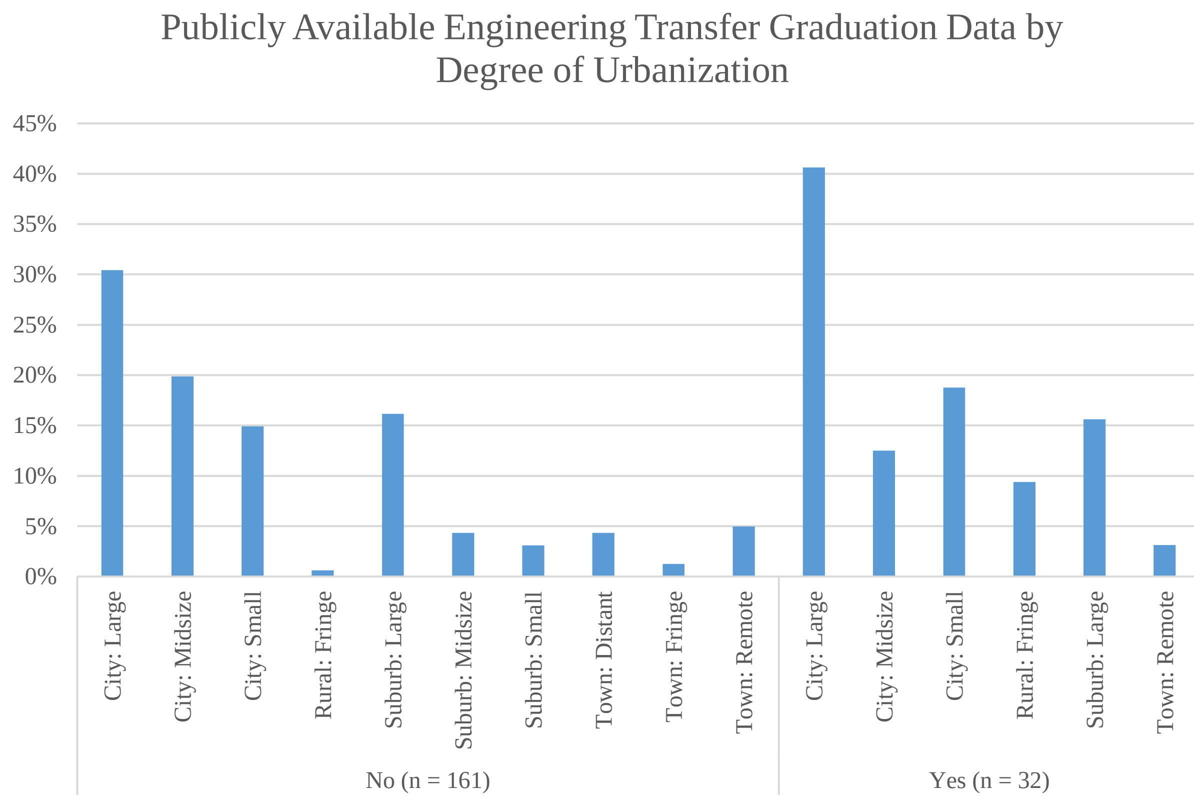


Figure F6. Comparing Admit Rate by Engineering Transfer Graduation Data

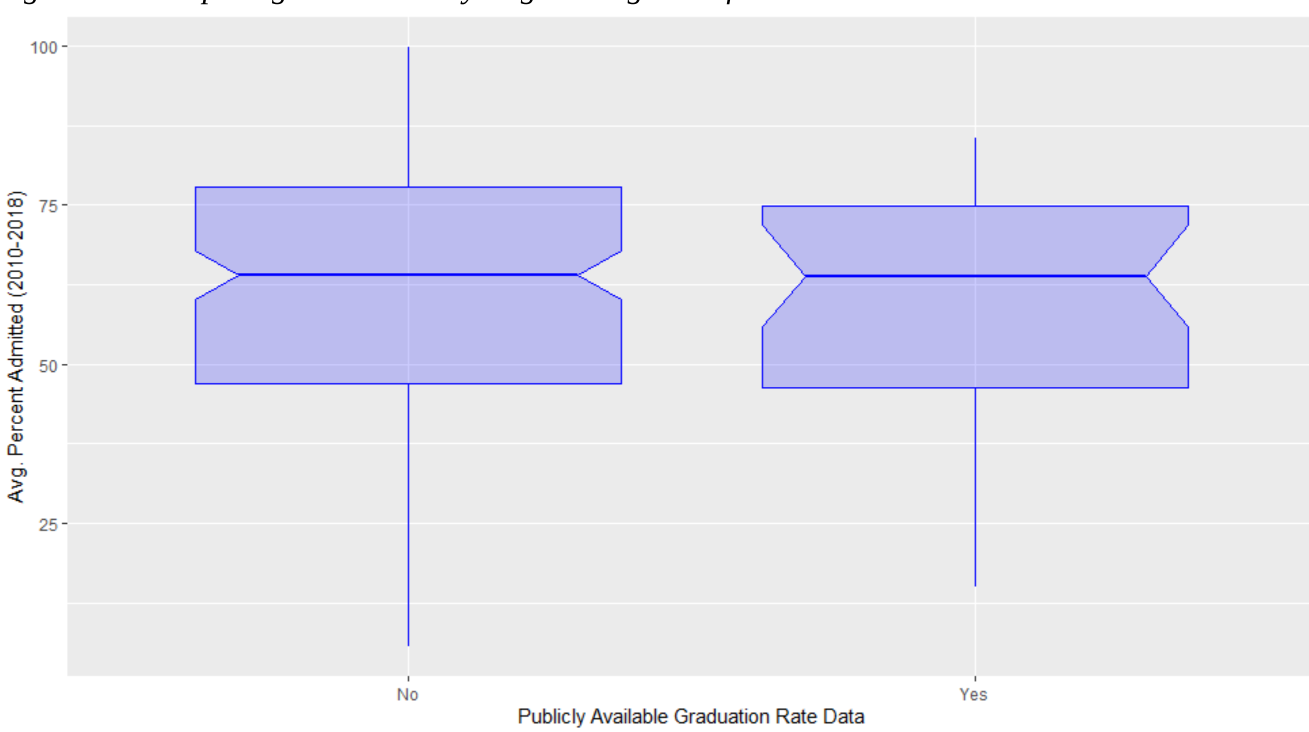


Figure F7. Comparing In-State Tuition and Fees for Publics by Engineering Transfer Graduation Data

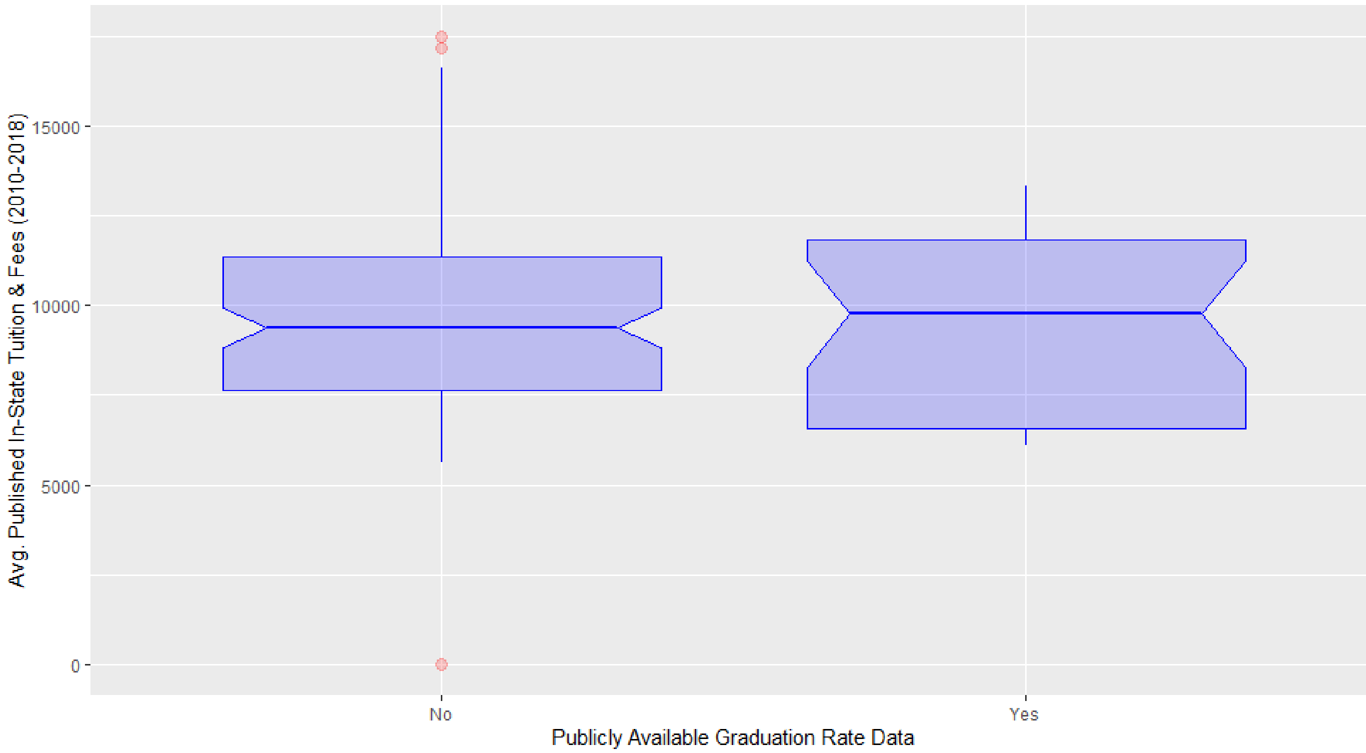


Figure F8. Comparing Net Price for Publics by Engineering Transfer Graduation Data

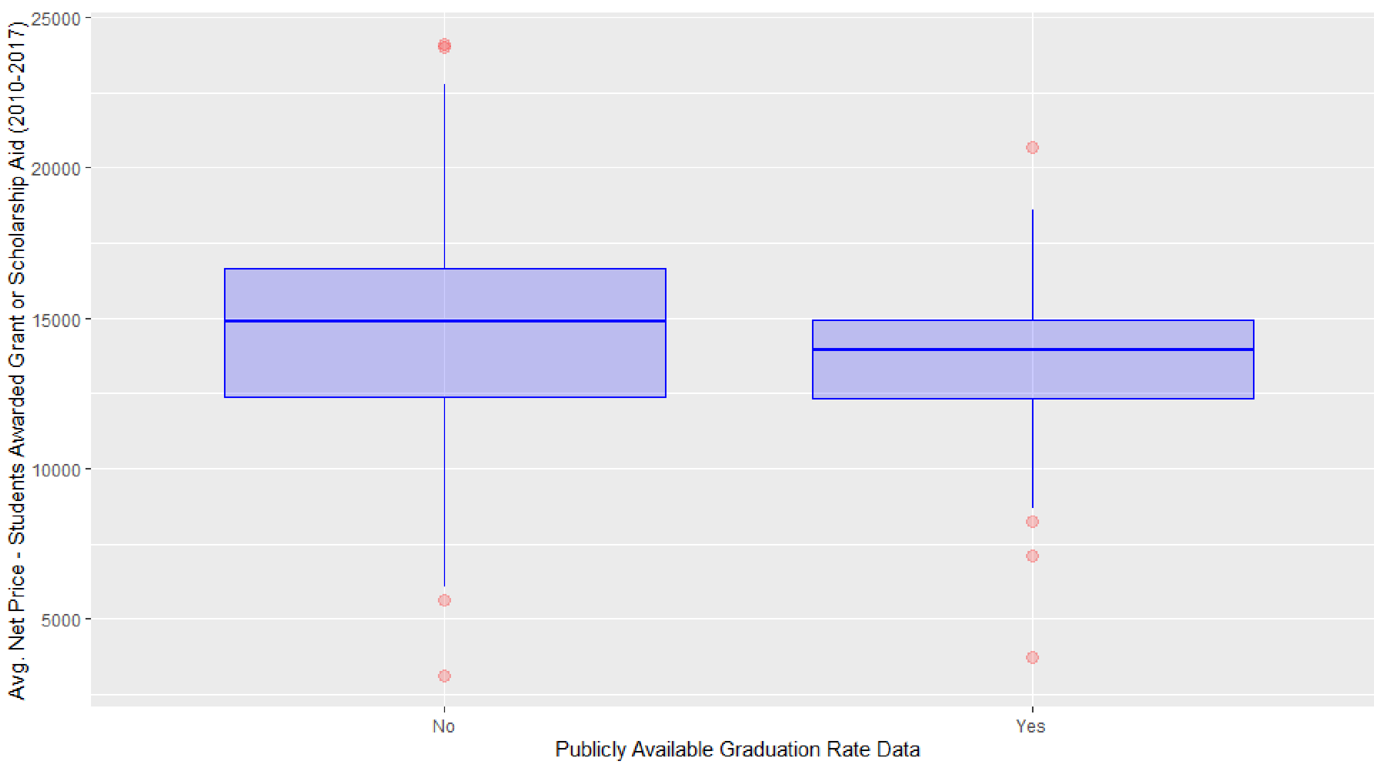


Figure F9. Comparing Total Price for Publics by Engineering Transfer Graduation Data

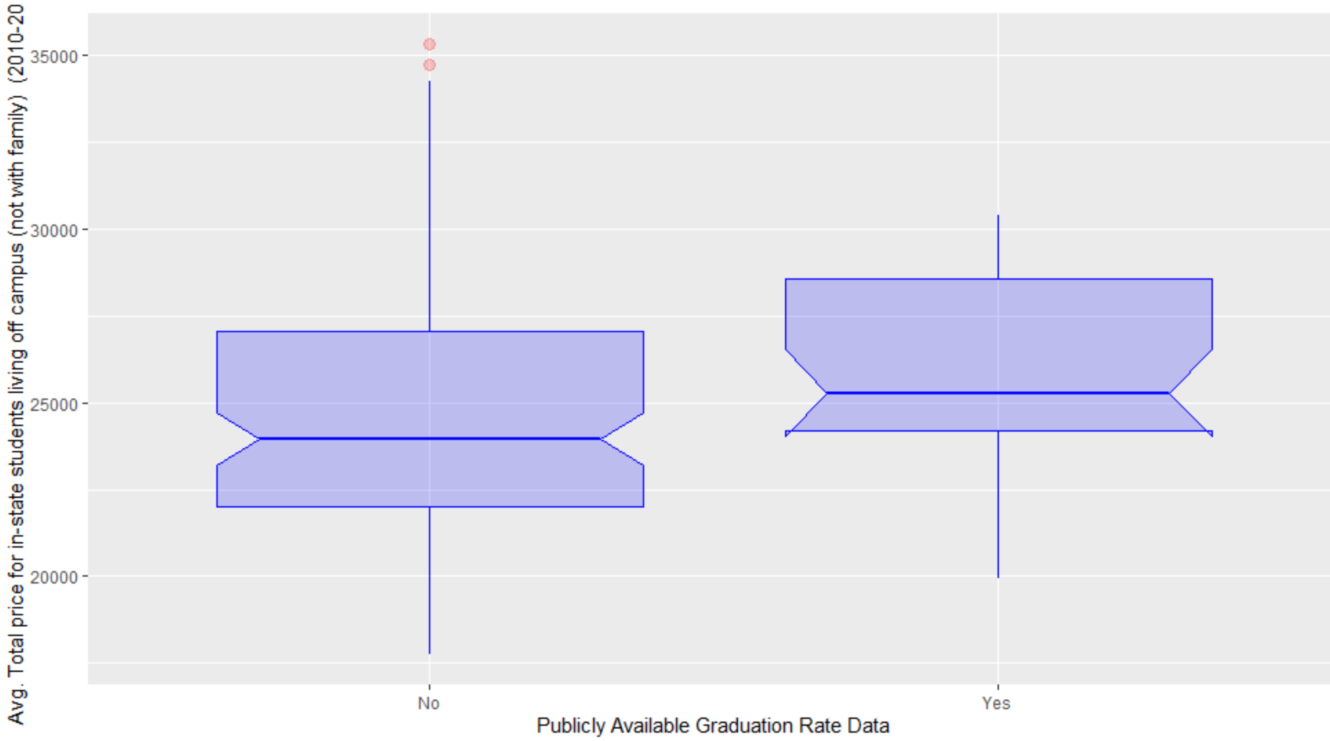


Figure F10. Comparing Endowment Assets for Publics by Engineering Transfer Graduation Data

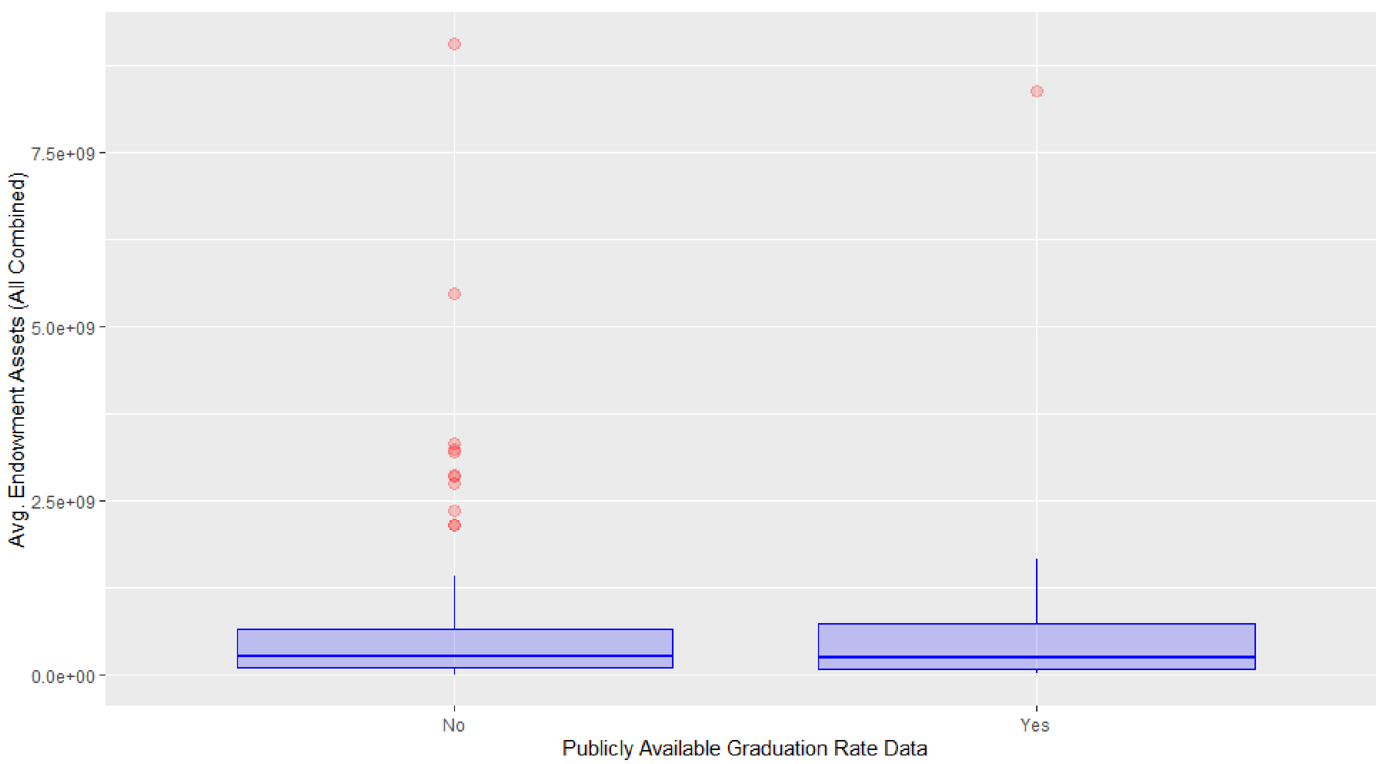


Figure F11. Comparing Engineering Program Rank for Schools with Doctoral Programs by Engineering Transfer Graduation Data

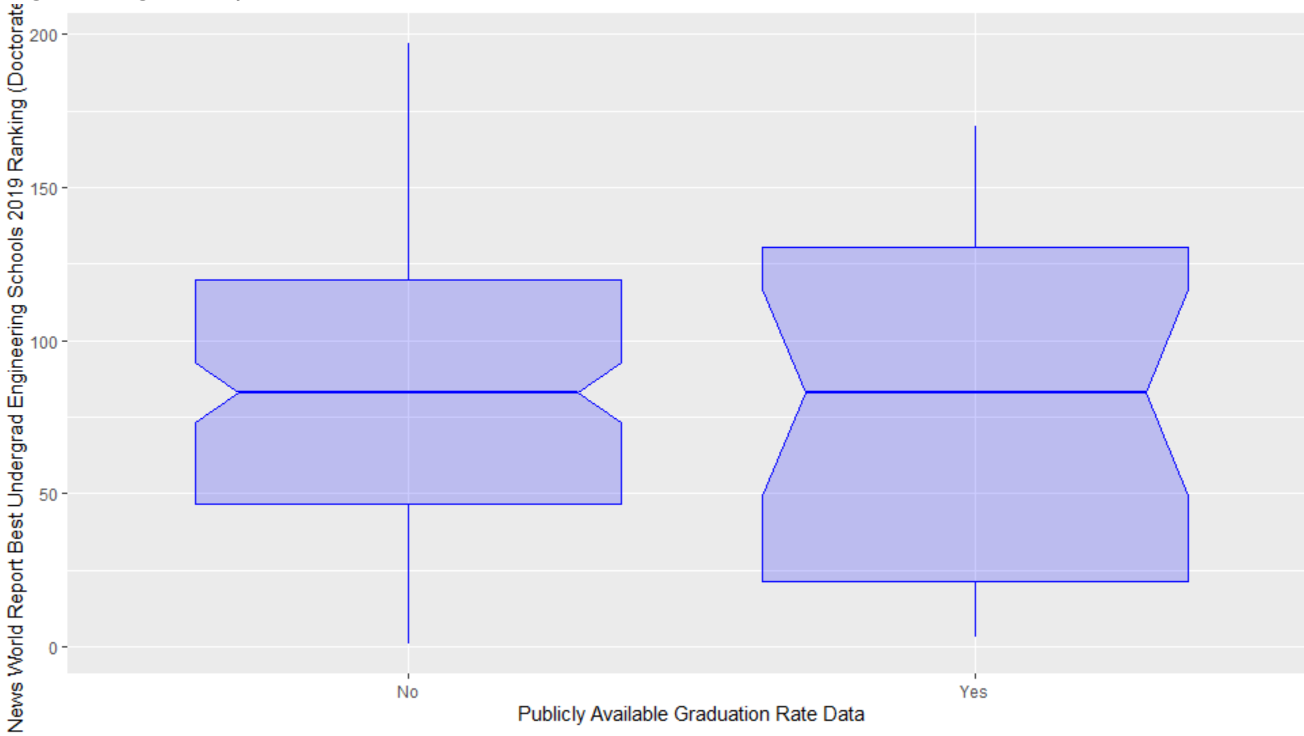


Figure F12. Comparing Engineering Program Rank for Schools with No Doctoral Programs by Engineering Transfer Graduation Data

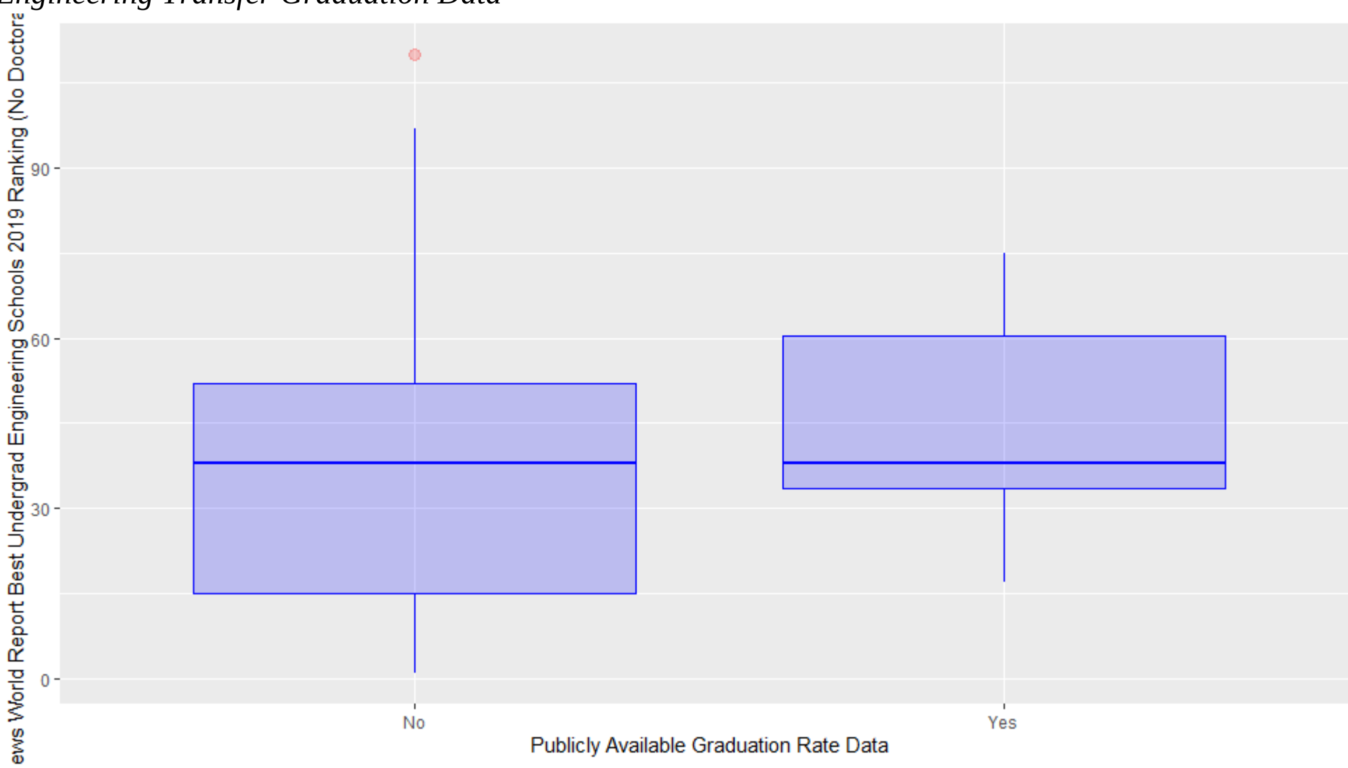


Figure F13. Comparing Transfer-In Full Time by Engineering Transfer Graduation Data

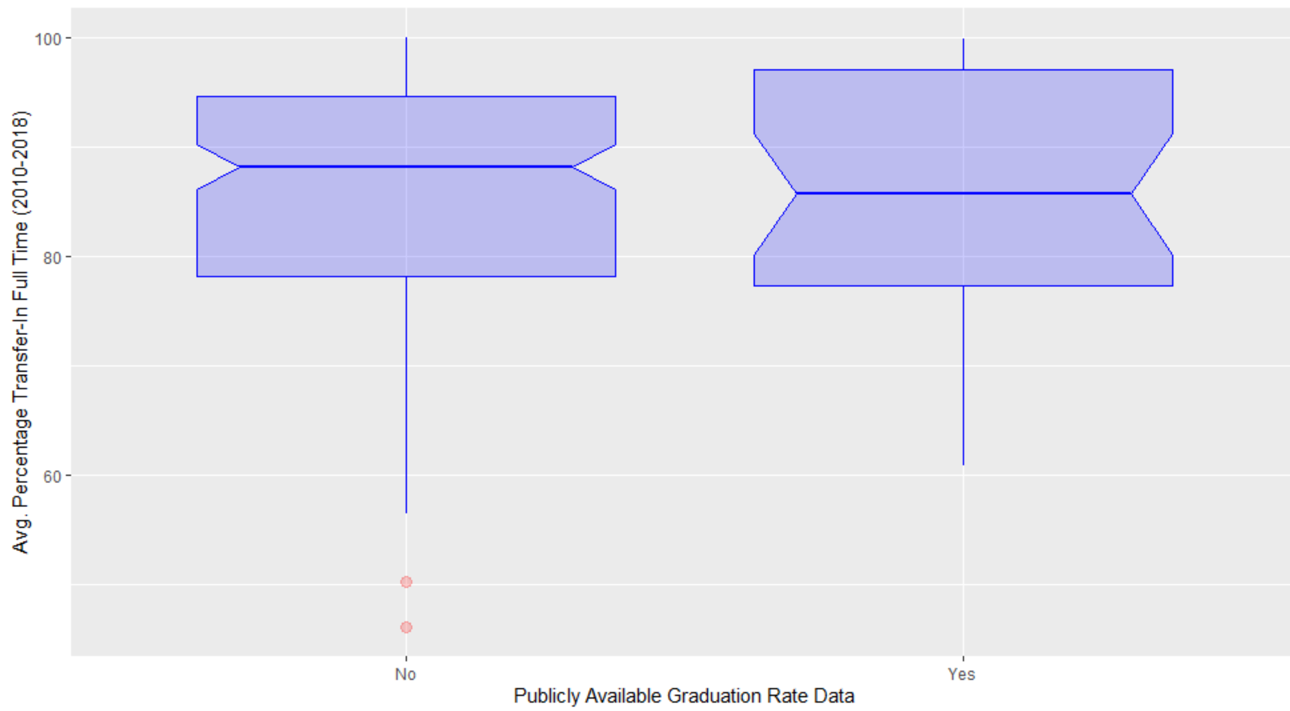


Figure F14. Comparing Hispanic/Latinx Enrollment at Institution by Engineering Transfer Graduation Data

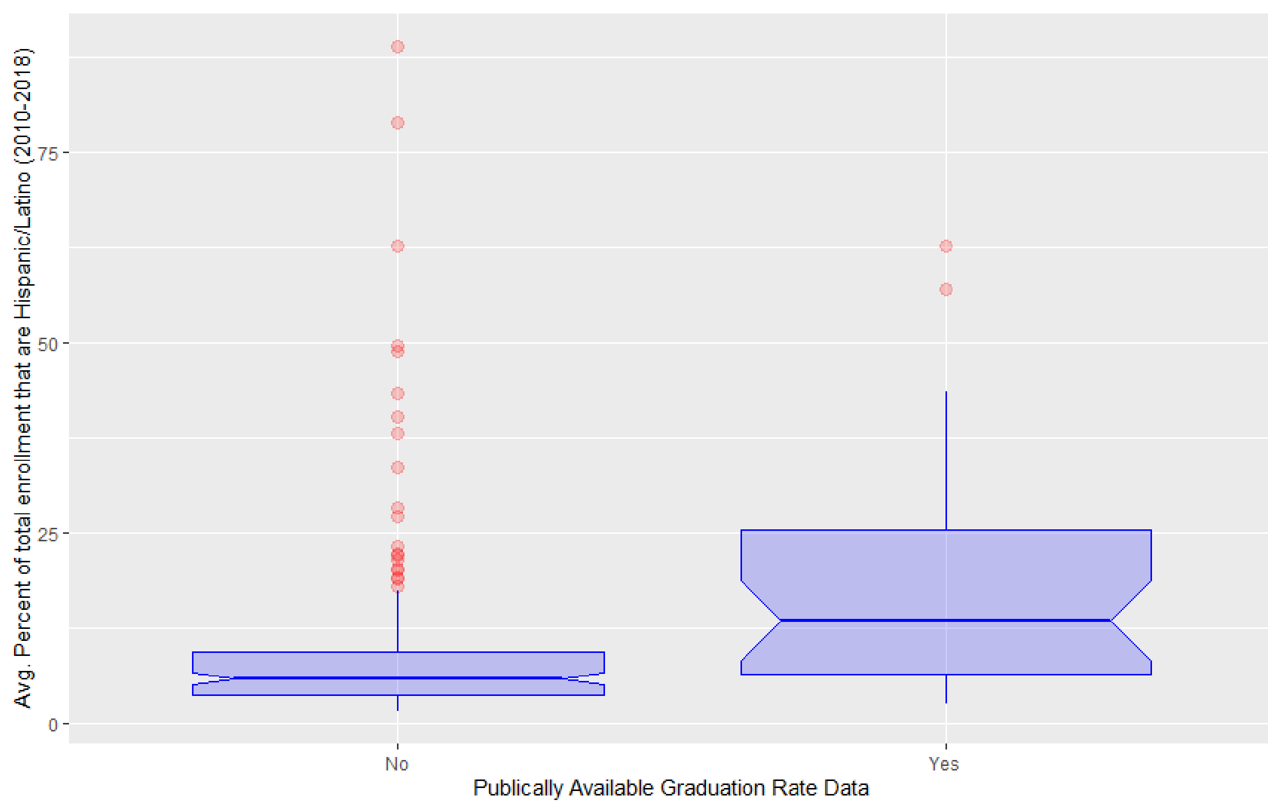


Figure F15. Comparing Hispanic Enrollments in Engineering by Engineering Transfer Graduation Data

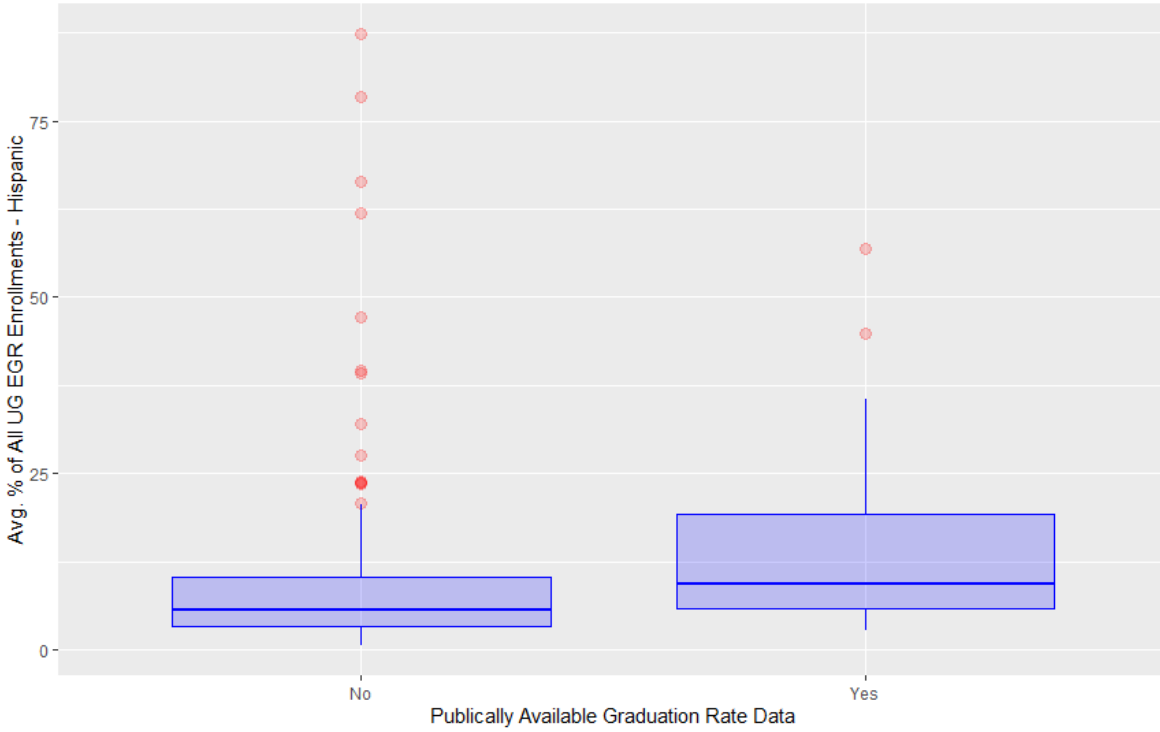


Figure F16. *Comparing Minoritized Enrollments at Institution by Engineering Transfer Graduation Data*

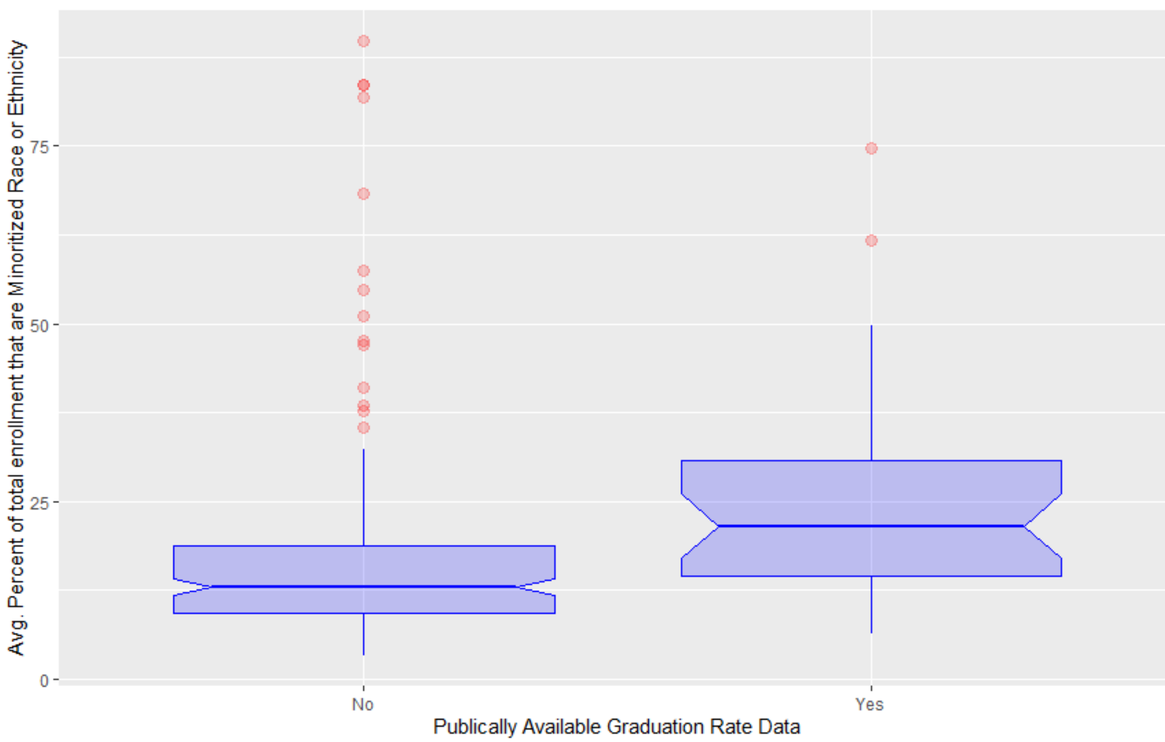


Figure F17. Comparing Institution-Wide Black/African American Enrollments by Engineering Transfer Graduation Data

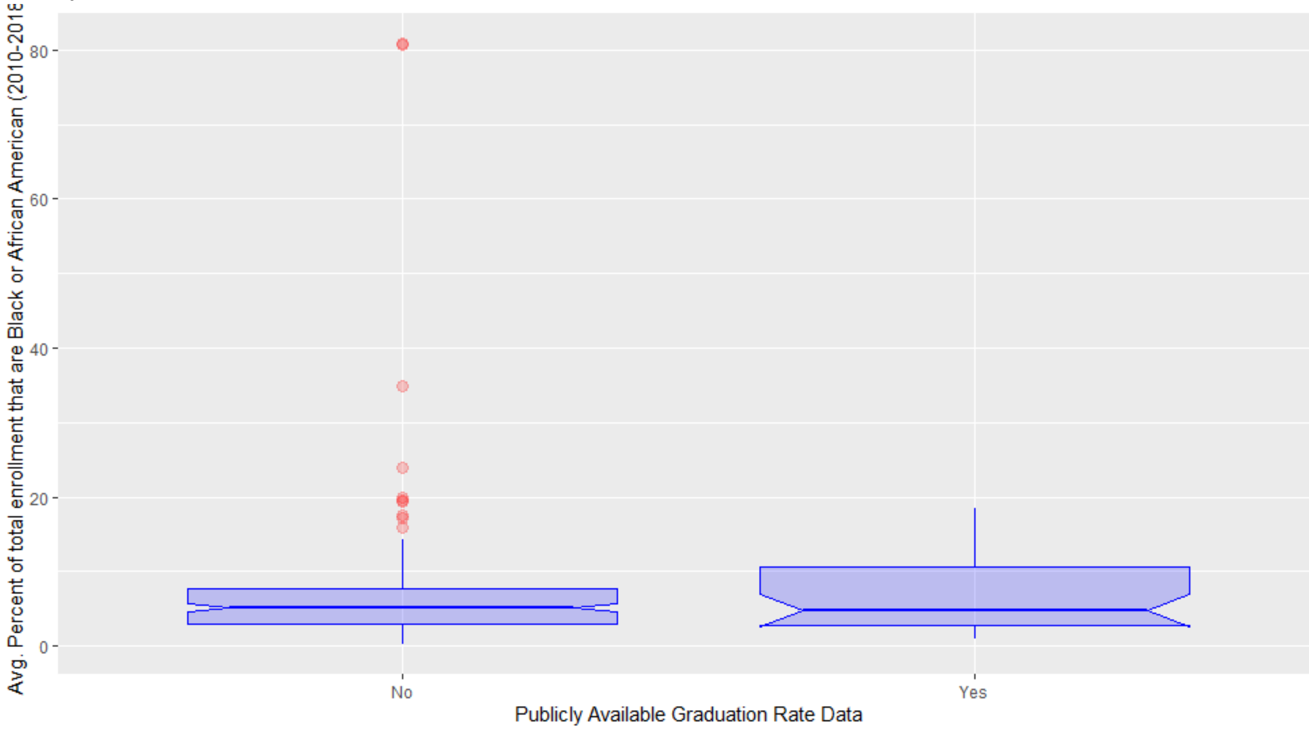


Figure F18. Comparing Black/African American Enrollments in Engineering by Engineering Transfer Graduation Data

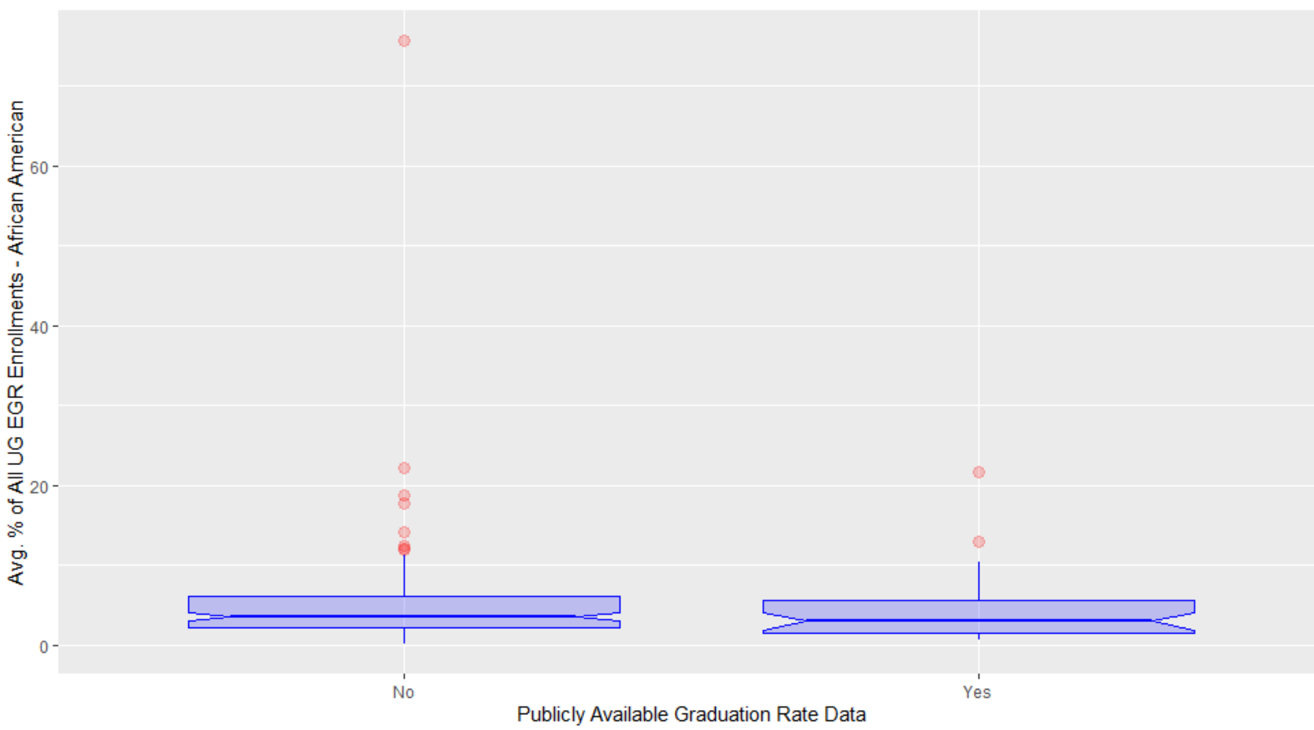


Figure F19. Comparing Institution-Wide Women Enrollments by Engineering Transfer Graduation Data

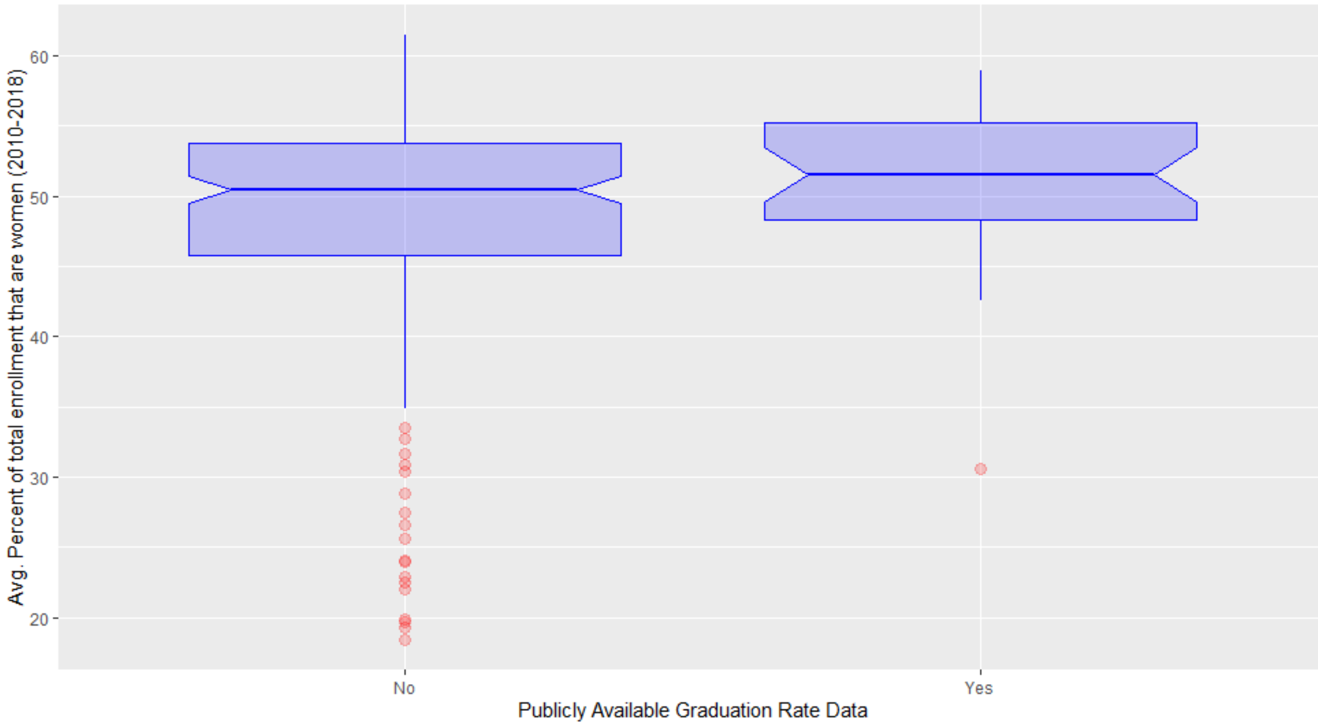


Figure F20. Comparing Women Enrollments in Engineering by Engineering Transfer Graduation Data

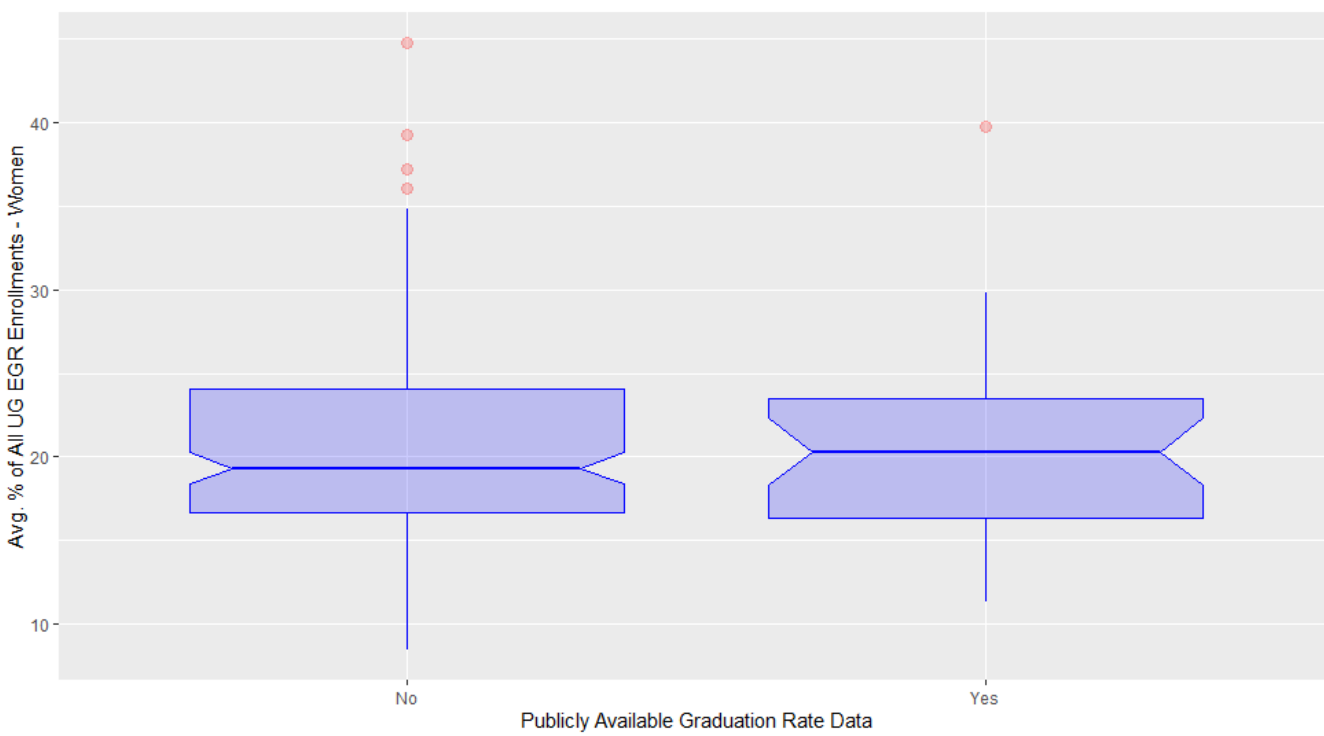


Figure F21. Comparing Avg. Full-Time Retention Rate by Engineering Transfer Graduation Data

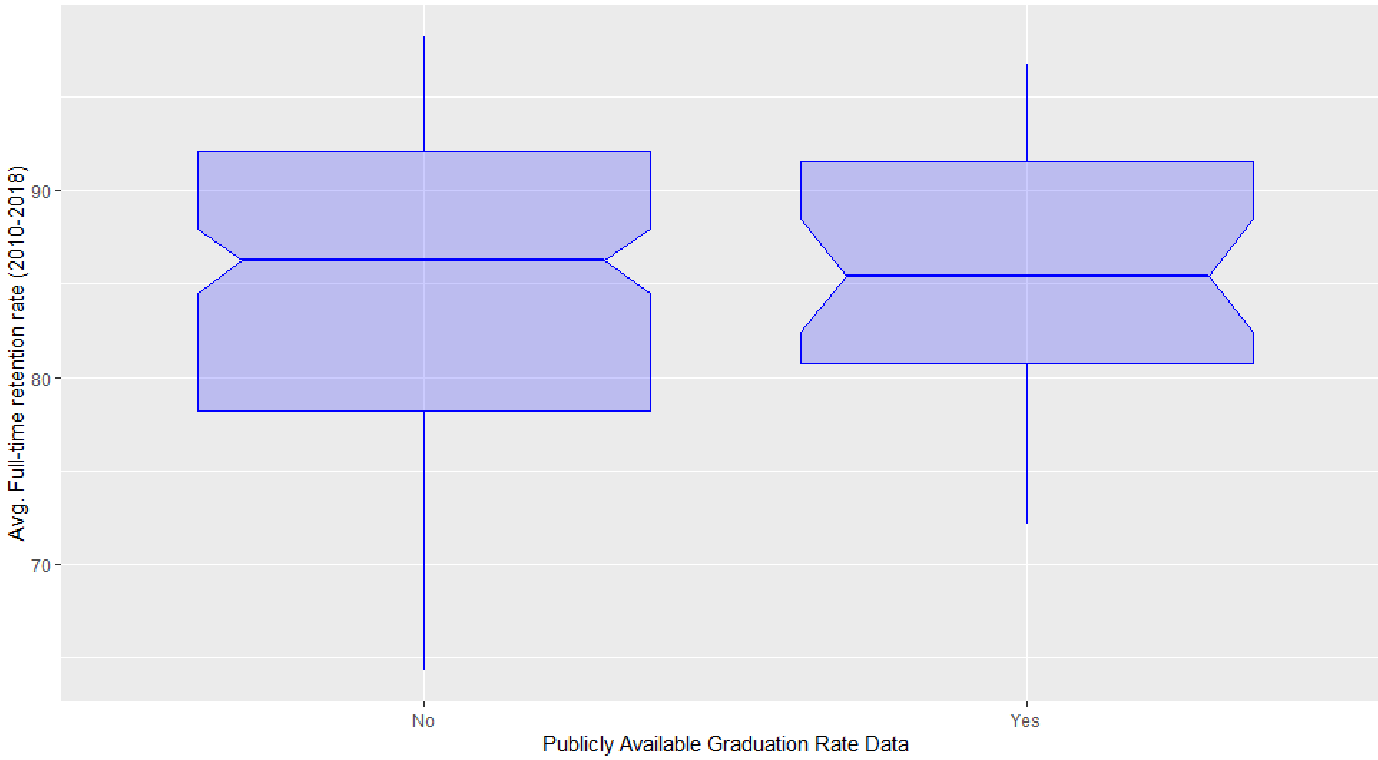


Figure F22. Comparing Avg. 4-Year Graduation Rate by Engineering Transfer Graduation Data

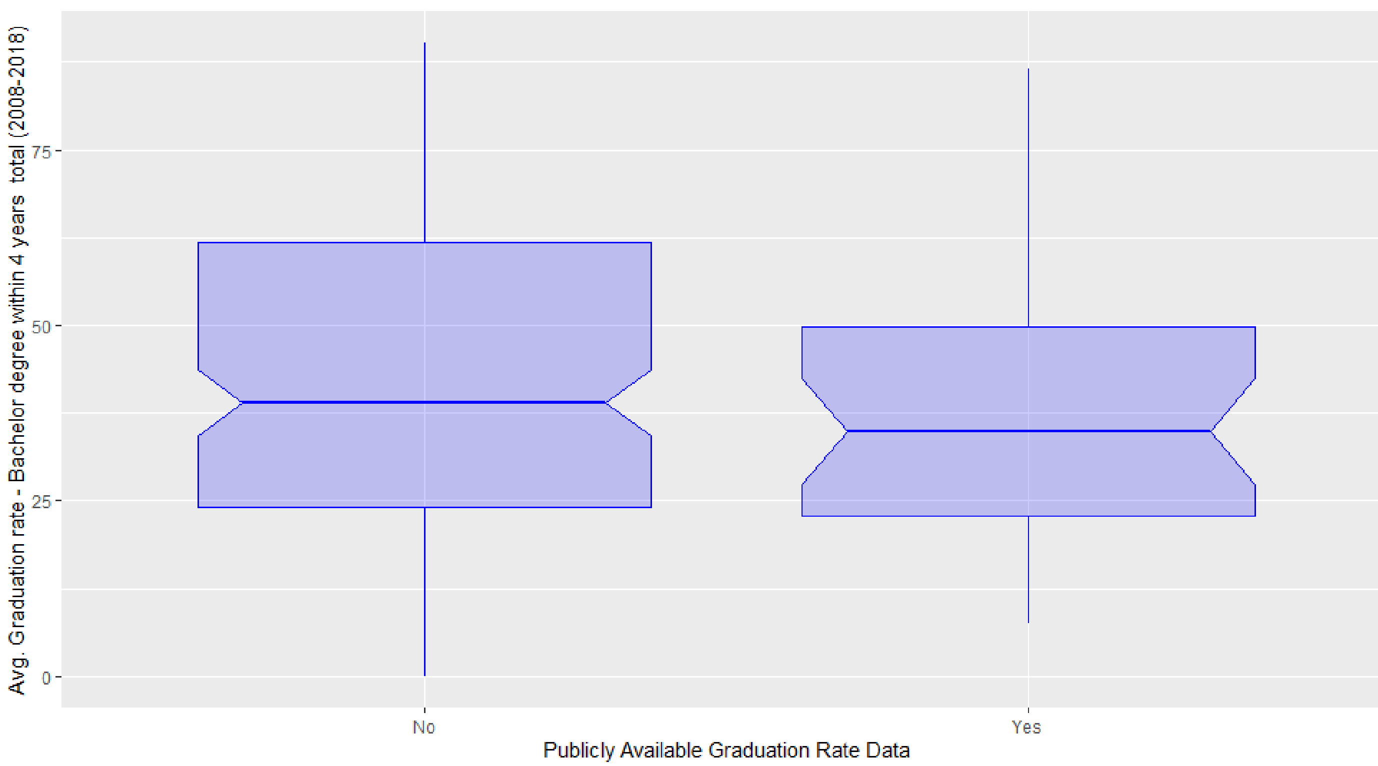


Figure F23. Comparing Avg. 5-Year Graduation Rate by Engineering Transfer Graduation Data

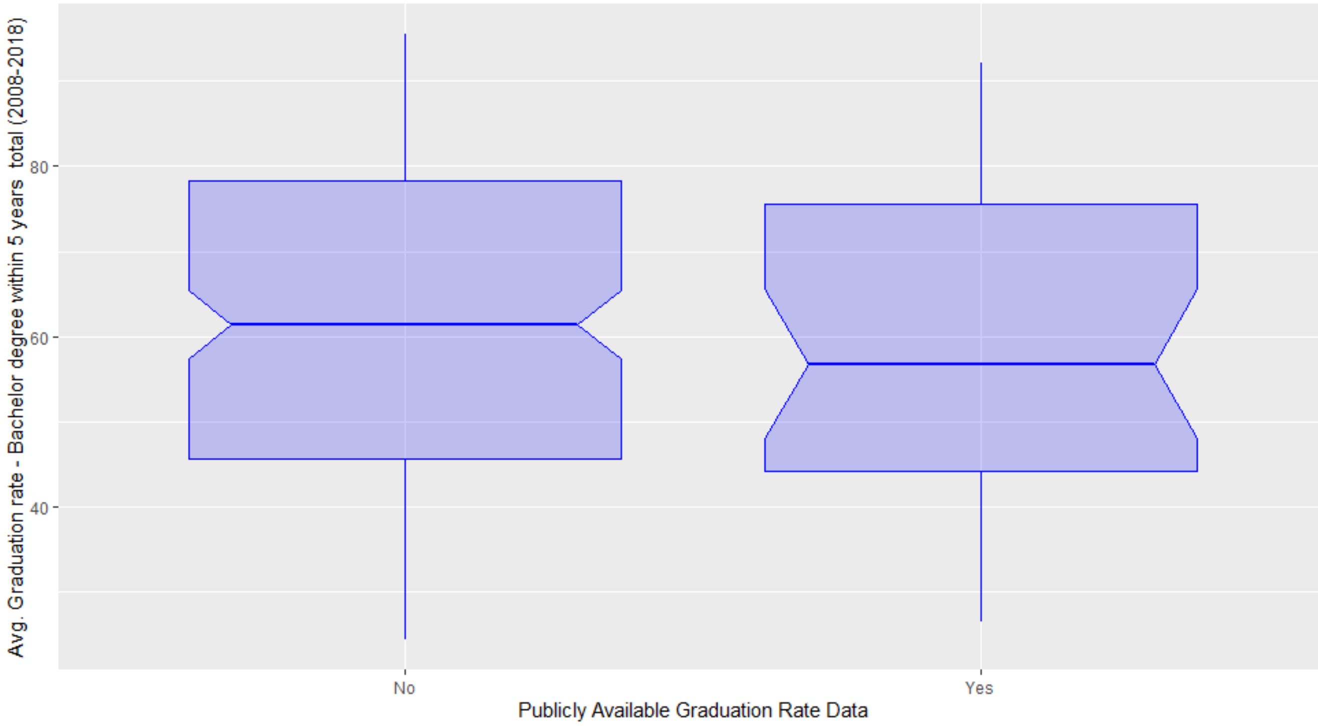
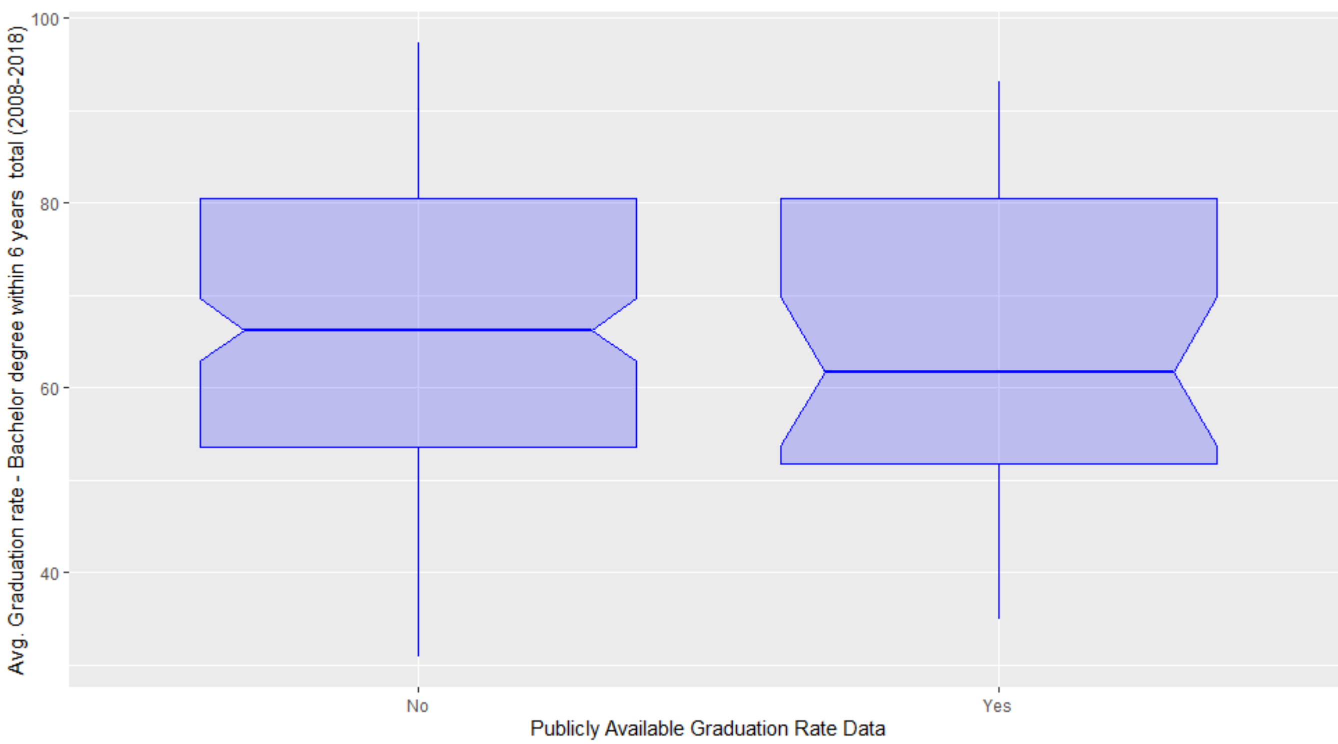


Figure F24. Comparing Avg. 6-Year Graduation Rate by Engineering Transfer Graduation Data



Appendix MS2-G: Plots for Non-Significant Results Related to Transfer Composition

Figure G1. Distribution of Transfer Composition Quartiles by Transferable Core of Lower Division Courses

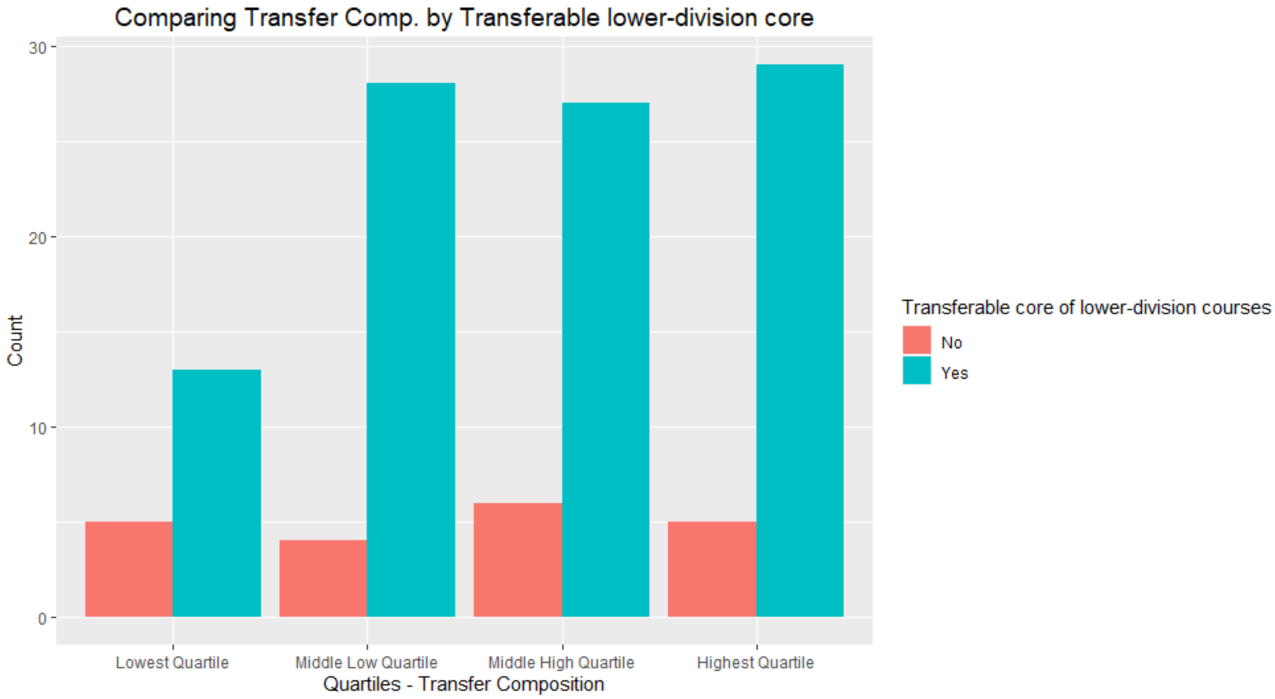


Figure G2. Distribution of Transfer Composition Quartiles by Statewide Guaranteed Transfer of Associate Degree

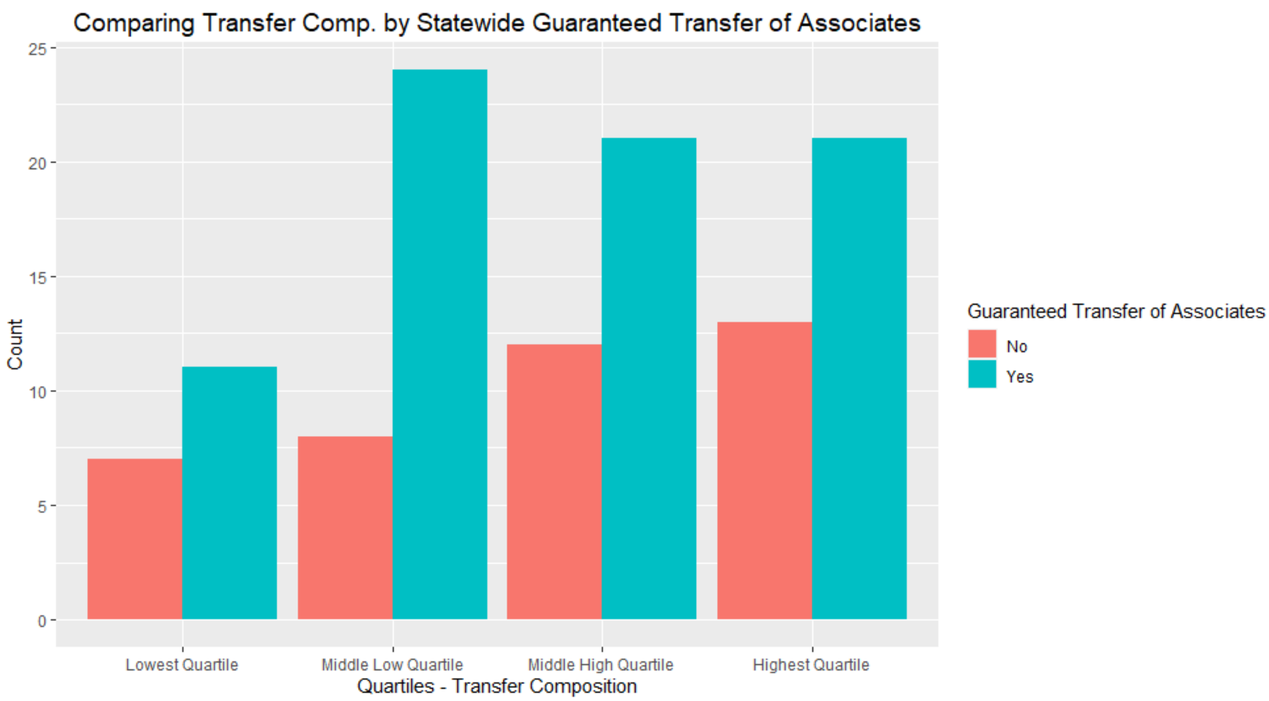


Figure G3. Distribution of Transfer Composition Quartiles by Statewide Reverse Transfer

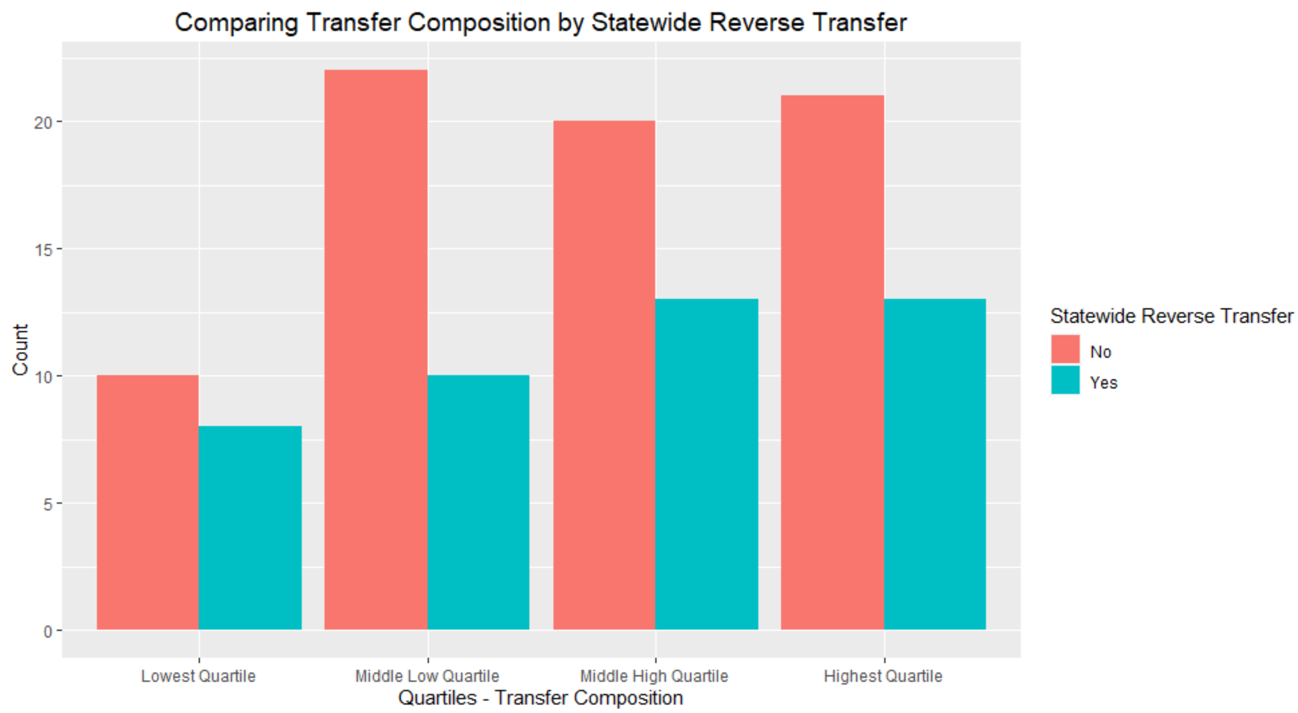


Figure G4. Distribution of Transfer Composition by Average Admit Rate

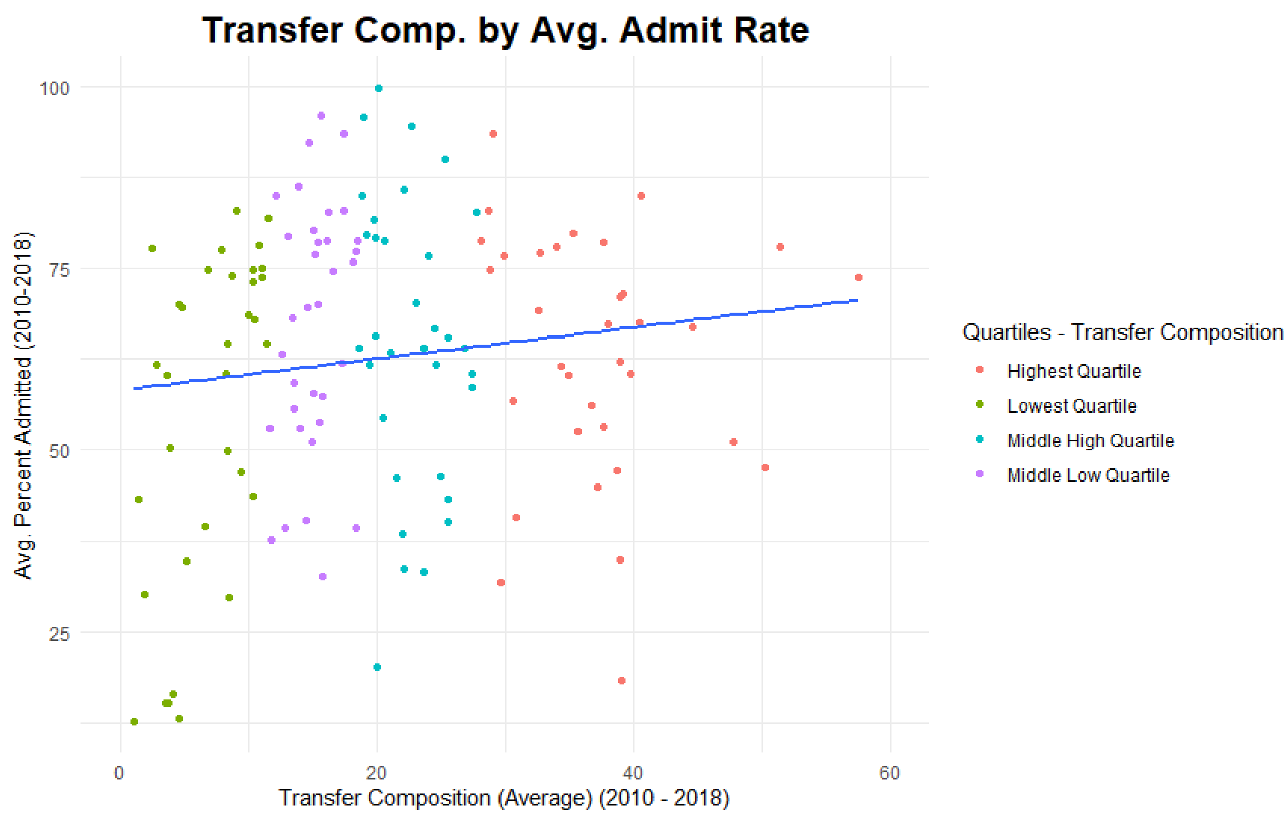


Figure G5. Distribution of Transfer Composition by Average Net Price for Privates

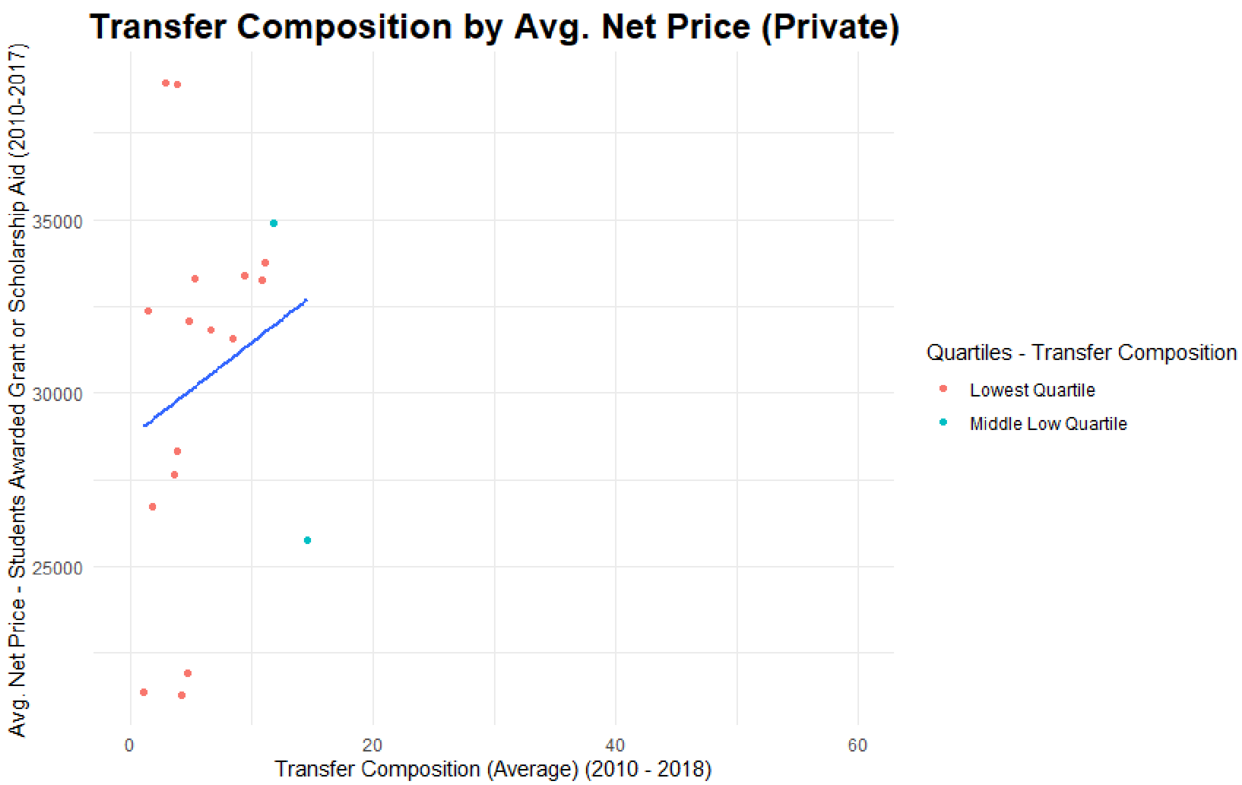


Figure G6. Distribution of Transfer Composition by Average Total Price for Publics

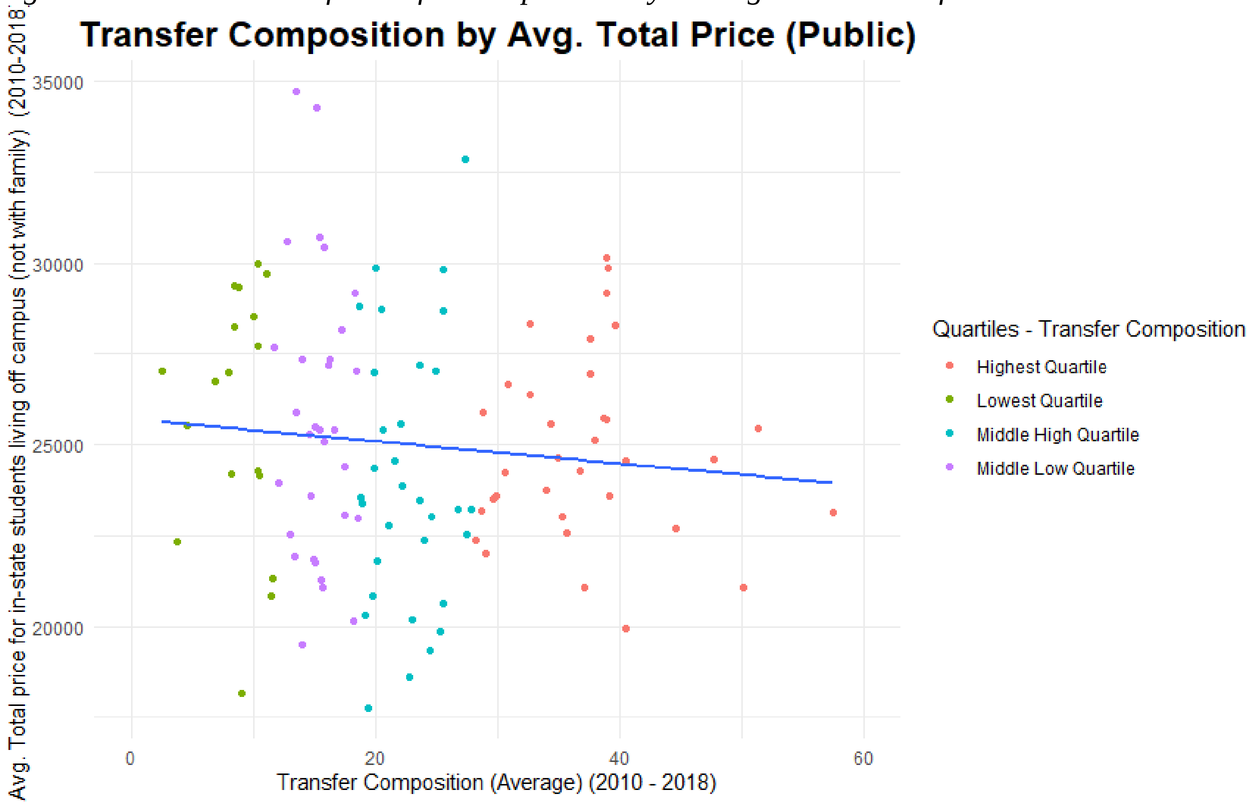


Figure G7. Distribution of Transfer Composition by Average State Appropriations

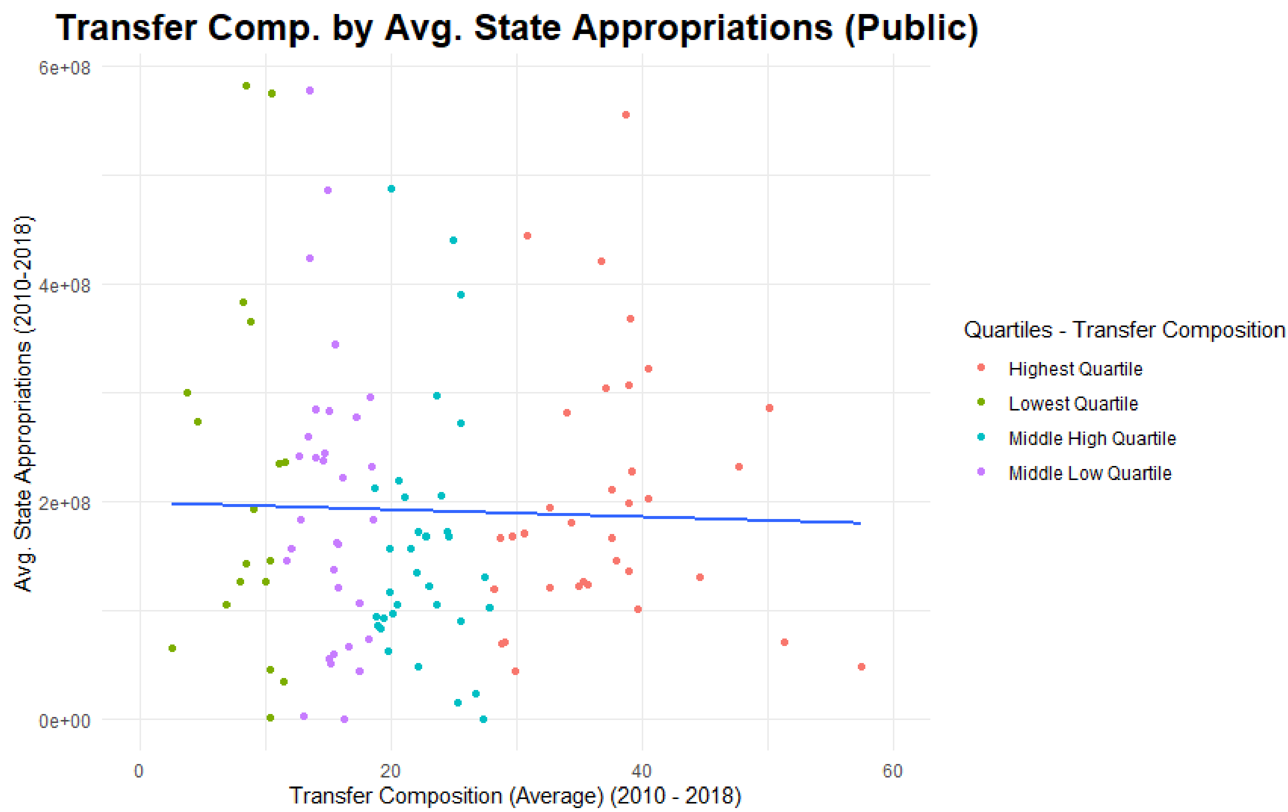


Figure G8. Distribution of Transfer Composition by Endowment Assets for Privates

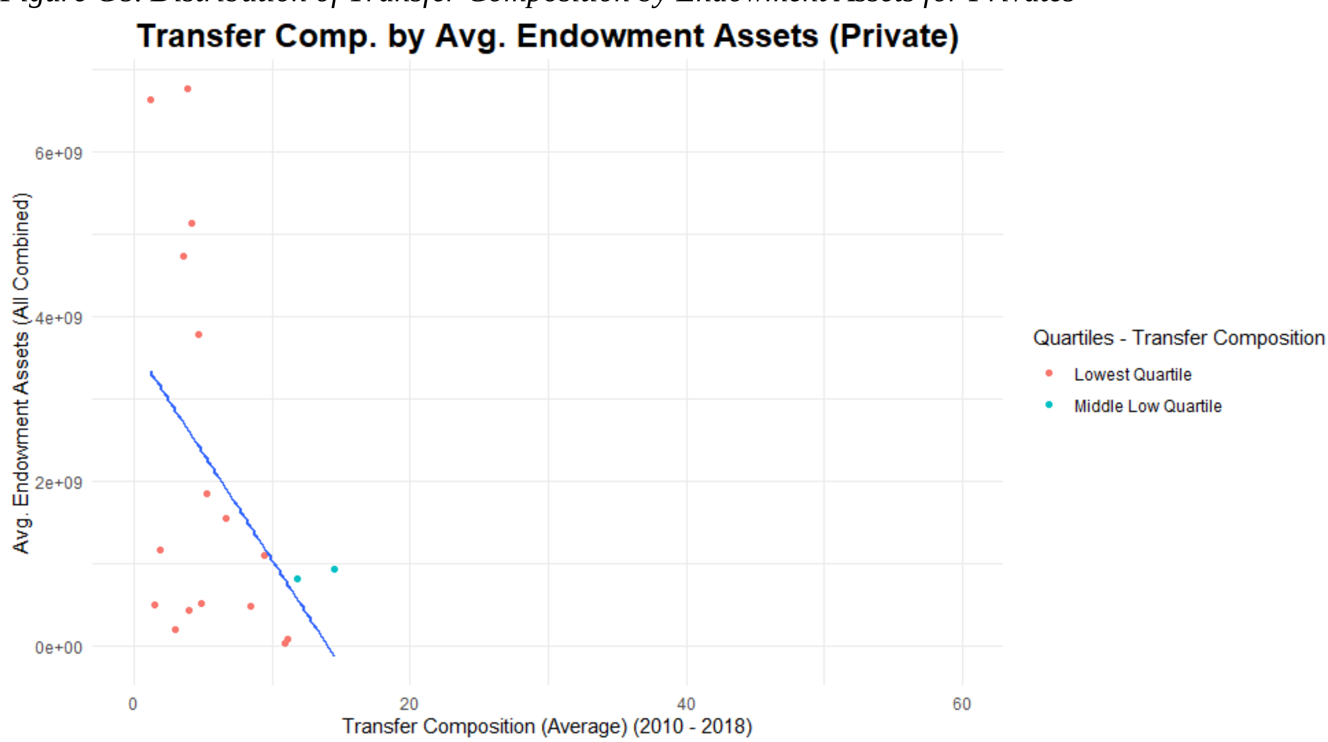
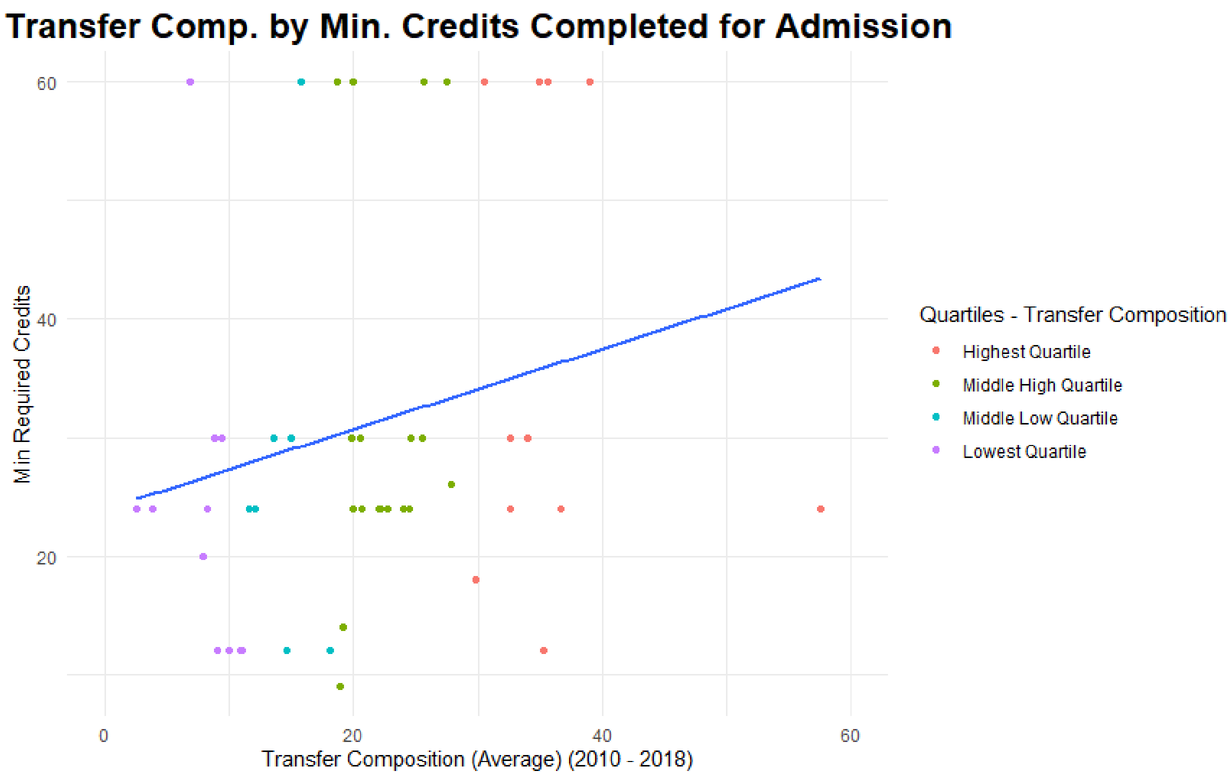


Figure G9. Distribution of Transfer Composition by Average Minimum Number of Credits Required for Completion Prior to Admissions Consideration in Engineering


Transfer Comp. by Min. Credits Completed for Admission
Min Required Credits
60
40
20
0
20
40
60
Transfer Composition (Average) (2010 - 2018)
Quartiles - Transfer Composition
Highest Quartile
Middle High Quartile
Middle Low Quartile
Lowest Quartile