



The Diversity of College Engineering Degrees: The Role of Geography and the Concentration of Engineering Degree Production

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Executive Summary

Introduction

To meet the growing demand for a larger technological and scientific labor force in the United States, a prominent policy goal is to expand and broaden participation in science and engineering college programs (e.g., [1], [2]). Previous research has found numerous barriers to the participation of women and underrepresented minorities in engineering fields, including the climate of schools and classrooms, academic achievement and academic preparation, self-confidence, and career goals (see [3] for a literature review). The roles of geography and the concentration of engineering degrees have received relatively less attention.

In this study, we examine how college student engineering participation—particularly the racial and ethnic diversity of college engineering students and graduates—corresponds to: (1) the geographic distribution of colleges in a state; and (2) the concentration of institutions that have engineering programs. This work advances our understanding of how the structure of the postsecondary engineering education system within a state relates to the diversity of the students that earn engineering degrees.

We use national data from the Integrated Postsecondary Education Data System (IPEDS) maintained by the U.S. Department of Education on all graduates from four-year colleges and universities in all 50 states over the past twenty years. We use geographic information system (GIS) software to map the location of schools that produce engineering graduates and compare the distribution of engineering degree-producing colleges to the distribution of racial/ethnic minority students in the state. Next, we compute an engineering degree production concentration index for each state and year, which measures the extent to which engineering degrees are concentrated at a limited number or wide variety of postsecondary institutions. We analyze whether cross-state and within-state, over time variation in the concentration of engineering degree production corresponds to the diversity of the students that earn engineering degrees in the state.

Background

Although there have been several initiatives and calls to increase participation in engineering, the proportions of women, Black, Hispanic, and Native American students have remained stagnant or grown relatively slowly. While previous studies have document several factors that have stalled the progress of women and underrepresented minorities (URM) in engineering, few studies have looked at the role of access and opportunities for engineering based on geography. Engineering education research have largely focused on issues and challenges, such as unsupportive academic environments, dissonant cultures; lack of role models; limited student-faculty interactions; and individual differences in levels of self-efficacy, sense of belonging, and engineering identity [3] – [13]. Some studies have tied high school level factors to participation in engineering. For example, Tyson et al. [14], [15] investigate course-taking in high school and find that more courses high school math and science courses is associated with majoring in a college STEM field. Other pre-

college factors, such as math achievement and levels of self-efficacy also contribute to students' college major choice [5], [10], [16], [17]. However, an overlooked area in the antecedents of student participation in engineering education is the geographical distribution of postsecondary engineering programs.

Previous studies have found that geographical distribution of postsecondary institutions matters (for example, [18], [19], [20], [21]). Distance to the nearest postsecondary institutions can play a role in college going rates. Greater distances from a college may impose larger costs (financial and otherwise) that may limit students' likelihood of applying for and/or attending colleges farther away. It may be that students who attend colleges closer to home may be able to continue to live at home and minimize room, board, and travel costs. Proximity to colleges can also influence students' college going decisions because there may be a spillover effect where students living nearby may be more likely to be exposed to the opportunities available at postsecondary institutions or from the influence of more peers (peer-effects) attending nearby postsecondary institutions. In addition to diversity in terms of socioeconomic backgrounds, the geographical distribution of postsecondary institutions also matters for diversity in terms of race and class [22]. Therefore, the geographical distribution of colleges has important implications for the equity of educational opportunities of the state's residents.

Data

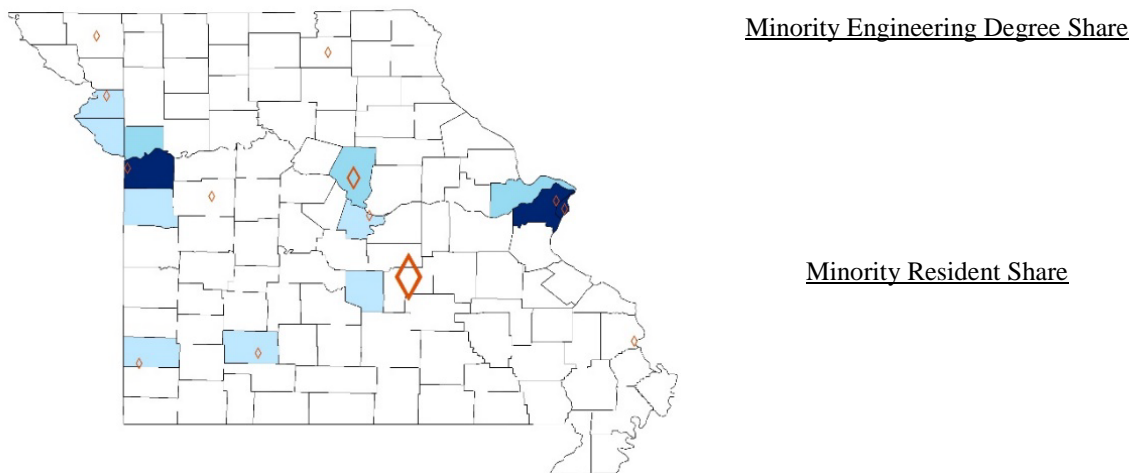
The source of postsecondary institution-level data is the Integrated Postsecondary Education Data System maintained by the US Department of Education. We focus on public four-year universities and examine the ten-year period from 2006-2015. From the IPEDS data, we obtain the number of students who obtain engineering degrees based on the Department of Education's classification of instructional programs codes (CIP; for the purposes of this study we classify engineering disciplines as those with a two-digit series of 14 and do not include computer science or applied engineering technology degrees). Also from the IPEDS data, we observe the institution-level number of bachelor's degrees in total and by demographic group. Because we are focused on understanding the link between high school and college, we exclude students from the analysis who are not US domestic students. We also remove students with missing race or ethnicity. To calculate the total number of engineering graduates within each state, we sum the institution-level data across all public four-year institutions within the state.

The geographic distribution of engineering producing colleges

We first create maps to visually depict the location of the universities that produce engineering graduates. The size of the marker signifies the proportion of engineering graduates in the state from each campus. Additionally, using data from the 2010 Census, we shade each county based on the distribution of minority residents in the state. We calculate the share of minority residents in each county by dividing the number of minority residents in that county by the total number of minority residents in the state. This shading is based on standard deviations from the state mean: no shading indicates that the number of minority residents in the county is at least 0.5 standard deviations from the state mean; light blue shading indicates that the county minority resident share is within 0.5 standard deviations of the state mean; and the shading gets progressively richer from 0.5—1.5 SDs, 1.5—2.5 SDs, and >2.5 SDs from the mean.

Figure 1 displays the geographic distribution of engineering graduates at four-year colleges in a representative state, Missouri. The counties with the largest number of minority residents are on the edges of the state: in Kansas City to the west and St. Louis to the east. The absence of shading throughout most of the rest of the state demonstrates that relatively very few minority residents live outside of the two large urban areas. Over 90 percent of engineering graduates in the state come from the flagship campus, the University of Missouri-Columbia, or the engineering focused Missouri University of Science and Technology, both in the center of the state. To the extent that students, or particularly minority students, are less likely to attend or succeed in college far from home, the observed spatial distribution has the potential to hinder engineering attainment.

Figure 1: Graduates with an Engineering Degree at 4-year colleges in Missouri



Source: IPEDS data from 2006-2015.

Engineering degree concentration and the diversity of engineering degrees

We next examine the relationship between the concentration of engineering degree producing colleges in the state and the diversity of the engineering degrees in the state. We first compute an engineering degree production concentration index for each state and year, which measures the extent to which engineering degrees are concentrated at a limited number or wide variety of postsecondary institutions. We then examine the how the relationship between the concentration of engineering degree production relates to the percentage of engineering degree recipients in the state who identify as a minority race or ethnicity in each year and state. In these regressions, we use underrepresented minority engineering share as an outcome, i.e., the proportion of engineering graduates in the state and year who do not identify as non-Hispanic White or Asian/Pacific Islander. In our estimates we account for year and state fixed effects and control for a limited vector of state-level covariates (racial composition of residents and the total number of graduates in the state). We cluster standard errors by state. We emphasize that our methods are not suited for causal inference, i.e., we cannot whether concentration *affects* the diversity of engineering degree production. With that caveat in mind, our estimates indicate that states with less concentration generally have more diverse engineering production.

Discussion

We study how the distribution of engineering degree production across universities and geography relates to college engineering participation and success. We view our descriptive results as an important first step to document and highlight broad patterns of the distribution of engineering degrees. It is important for future work in this line of inquiry to push further to identify causal relationships that can provide deeper insights into the impacts of geography on students and can help to determine whether policies related to postsecondary geography can be used to improve diversity conditions in engineering.

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