The Role of Community College Attendance in Shaping Baccalaureate Recipients' Access to Graduate and Professional Education

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Abstract

Although community colleges have received increasing attention as a steppingstone to advanced degrees for a diverse pool of students, empirical work around these institutions as a pathway to graduate and professional education is practically nonexistent. Using national longitudinal data from the Baccalaureate and Beyond Longitudinal Study (B&B:08/12) and propensity score matching techniques, this study examined the impact of having attended a community college on baccalaureate recipients' access to graduate and professional schools in general and how previous community college attendance influenced student enrollment in different professional and graduate programs. Our findings revealed that there was no significant negative or positive effect of community college attendance on access to graduate or professional school, or program enrollment choices. These results imply that baccalaureate recipients having attended a community college are as likely as those who have not to advance to graduate and professional programs, suggesting that community colleges can indeed serve as a viable pathway to graduate and professional education.

Keywords: Community colleges, graduate and professional education, graduate school access, quasi-experimental methods, propensity score matching

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Broadening access to graduate and professional education has been a long-standing national concern (Council of Graduate Schools, 2016; English & Umbach, 2016; Griffin, Muñiz, & Espinosa, 2012; Perna, 2004). In this endeavor, community colleges play an essential role in supplying and assisting a diverse pool of aspiring graduate and professional students. In recent decades, community colleges came under remarkable spotlight as a key sector in shaping how students participate in and progress through postsecondary education (American Association of Community Colleges, 2015a; Bell, 2012; Mooney & Foley, 2011; National Science Foundation, 2010). Nationally, 1,108 community colleges enroll approximately 7.3 million students annually (American Association of Community Colleges, 2016), including 46% of all undergraduates (American Association of Community Colleges, 2015b). The community college contribution to postsecondary attendance extends well beyond the sub-baccalaureate level into the graduate and professional levels (National Science Foundation, 2010, 2015). Nearly half of all science and engineering bachelor's and master's degree recipients (Mooney & Foley, 2011; National Science Foundation, 2010) and approximately 13% of doctoral recipients across all fields of study (National Science Foundation, 2015) had attended a community college. Indeed, about 50% of students starting at community colleges aspire to earn a graduate or professional degree (National Center for Education Statistics, 2011).

These national descriptive data make a strong case for conducting rigorous research to further understand the community college impact on access to graduate and professional education. However, other than the broad descriptive accounts, the empirical base on this topic is virtually nonexistent. This is a critically important gap in the literature that this research intends

to fill. Drawing upon the latest national longitudinal survey of students who completed a bachelor's degree during 2007-2008, the current study investigates whether and how having attended a community college during their undergraduate years plays a role in baccalaureate recipients' access to graduate and professional education four years since their college completion.

This research topic is both timely and of significant national importance for several reasons. First, diversity in education, especially at the graduate and professional level, is critical for the U.S. to maintain a competitive edge in the global economy (Council of Graduate Schools & Educational Testing Service, 2010) and to make crucial advancements in technology, the environment, and other essential national and global needs (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2011). However, much remains to be done to improve diversity in graduate and professional education (Council of Graduate Schools & Educational Testing Service, 2010). To address this concern, community colleges represent a unique opportunity to diversify graduate and professional education, as a disproportionately large number of first-generation students and underrepresented students of color either start at or have attended community colleges (Cohen, Brawer, & Kisker, 2014).

Second, affordability of graduate and professional education remains a contested problem for both students and higher education policymakers and researchers (Council of Graduate Schools & Educational Testing Service, 2010; Malcom & Dowd, 2012). Offering much more affordable course and program options, community college attendance may appeal to students as it may lower the total costs of postsecondary attendance, including graduate and professional school. Historically, community colleges have sought to provide postsecondary studies with minimal financial consequences (Dowd & Coury, 2006) and transferability (Cohen et al., 2014),

which in turn may influence the diverse student populations enrolling at these institutions to continue their education at the four-year level and beyond with fewer financial constraints.

Third, the ways in which students participate in postsecondary education are increasingly complex, diverse, and nonlinear, including the path to graduate and professional education. As illuminated by the national descriptive data presented earlier, it is clear that community colleges are contributing to the broader scheme of students' education beyond these institutions. A more robust empirical understanding of how community college attendance impacts access to graduate and professional education will yield key policy implications for how to more fairly and holistically evaluate the success of community colleges, when the common metrics solely revolve around graduation and transfer rates (Mullin, 2011). In addition, findings from this research will reveal ways in which different postsecondary sectors, including community colleges and graduate and professional schools, can work together to cultivate more seamless educational pathways, especially for students accessing graduate and professional education.

Responding to these prominent and timely issues around access to graduate and professional education and by accounting for how community colleges may factor into a larger viable postsecondary pathway, this research will generate unprecedented empirical evidence on the multifaceted issue of access to graduate and professional education. Specifically, the following two research questions guide this study: First, what is the impact of having attended a community college on baccalaureate recipients' access to graduate and professional schools in general? Second, how does previous community college attendance influence student enrollment in different professional and graduate programs?

Since there is no previous research examining this topic, answering the first question will offer an overall estimate of the community college impact on access to graduate and professional

education in general. Following a more nuanced and discipline-specific approach, addressing the second question will yield findings that provide contextualized insights into access to varying graduate and professional programs and the specific ways in which community college attendance helps or hinders such access.

We examine these questions using the latest Baccalaureate and Beyond Longitudinal Study (B&B:08/12). Drawing upon a sample of nearly 17,000 students, we apply propensity score matching (PSM) techniques to address the inherent selection bias of attending a community college and enhance the causal inferences that can be made from the study. After matching, we conduct a binary logistic regression model to explore the community college effect on graduate and professional school access, and a conditional logit regression analysis to deal with the conditional effect of program-specific choice and enrollment in graduate or professional school.

Our findings show that there is no significant effect of community college attendance on the probability of enrollment in graduate or professional school; there is also no effect of community college attendance on enrollment in specific types of professional and graduate programs, suggesting that students attending a community college are as likely as those who did not to advance to graduate and professional programs. Taken together, our study shows that community colleges may indeed serve as a viable pathway to graduate and professional education.

Background Literature

Except for a few national descriptive reports pointing to the sizable number of graduate and professional students who have attended a community college (Mooney & Foley, 2011; National Science Foundation, 2014, 2015), there exists little to no empirical investigation of the

current study's topic. Nonetheless, prior literature on graduate and professional school enrollment and the impact of community colleges on educational outcomes informs the current study.

For decades, community colleges have been viewed as a major sector that democratizes higher education through their transfer function. Accordingly, there is a long line of research that evaluates whether attending community colleges affects transfer students' success at receiving four-year institutions. While earlier studies claimed that community colleges "cool out" students' aspirations and the probability of earning a baccalaureate degree (e.g., Clark, 1960; Dougherty, 1992; Doyle, 2010; Pascarella, Edison, Nora, Hagedorn, & Terenzini, 1998; Rouse, 1995), more recent evidence suggests that, once students successfully transfer from community colleges to four-year institutions, they enjoy comparable educational attainment in comparison with their counterparts beginning at four-year institutions (e.g., Melguizo & Dowd, 2009; Melguizo, Kienzl, & Alfonso, 2011). In particular, departing from earlier studies, recent research leverages rigorous quasi-experimental designs to better account for the issue of self-selection in studying the impact of community college attendance. For example, Melguizo and Dowd (2009) controlled for self-selection by using an instrumental variable approach and estimated a fixed-effects model using two-stage regression techniques. Their study revealed that community college transfer students were as likely to succeed as beginning four-year students.

Community colleges have also been studied as a major contributor to students' larger postsecondary attendance patterns. For example, research on postsecondary co-enrollment by Crisp (2013), Wang and McCready (2013), and Wang and Wickersham (2014) points to the potentially positive influence of having attended a community college on students' progression toward their longer-term educational goals. Taken together, the body of research on the impact of

community college attendance highlights these institutions' unique potential in helping students advance beyond a community college credential. However, how community college attendance affects students' access to graduate and professional education is not well understood.

There is a fair amount of literature that has uncovered a plethora of factors related to enrollment in graduate and professional programs. At the individual student level, background characteristics at play include socioeconomic status (e.g., Ethington & Smart, 1986; Millett, 2003; Walpole, 2003), gender (e.g., English & Umbach, 2016; Hearn, 1987; Perna, 2004), race/ethnicity (e.g., English & Umbach, 2016; Millett, 2003; Nettles, 1990; Perna, 2004; Zhang, 2005), parental education (e.g., Hearn, 1987; Pascarella, 1984), as well as the primary language spoken in students' homes (e.g., Perna, 2004). Also, academic preparation and performance through schooling is a consistently strong predictor of graduate or professional enrollment (e.g., English & Umbach, 2016; Heller, 2001; Zhang, 2005).

As students transition through college, a number of other factors further underlie access to graduate and professional schools. Specifically, undergraduate educational experiences (e.g., Ethington & Smart, 1986; Heller, 2001; Mullen et al., 2003; Hathaway, Nagda, & Gregerman, 2002; Zhang, 2005), and educational expectations (e.g., Mullen et al., 2003) are important college factors to consider. In addition, students' financial support and barriers influence their pursuit of graduate and professional education (e.g., English & Umbach, 2016; Heller, 2001; Millet, 2003; Perna, 2004). In regard to institutional characteristics, baccalaureate institutions' selectivity, type, control, and location were found to influence graduate school enrollment. (e.g., English & Umbach, 2016; Ethington & Smart, 1986; Millett, 2003; Perna, 2004).

Theoretical Grounding

This study is informed by the theoretical perspectives of human capital and rational choice, as well as extant literature on factors contributing to access to graduate and professional education. Human capital theory (Becker, 1975) represents an appropriate lens to examine the influence of specific types of postsecondary attendance on educational attainment and outcomes at both undergraduate and graduate levels (Dale & Krueger, 2002; Paulsen & Toutkoushian, 2008). Human capital theory suggests that students choose educational options and how they invest in these options in order to maximize their utility. In this sense, a baccalaureate recipient's decision around whether to attend a community college during their undergraduate years as well as whether to pursue graduate or professional education can both be informed by expected monetary or nonmonetary costs and benefits (Becker, 1993; Ellwood & Kane, 2000).

In particular, the decision regarding whether to attend a community college can be viewed from a rational choice perspective. Rational choice theory posits that individuals form a conclusion about the outcomes of an action based on an assessment of available information, and when the perceived incentives are strong, will consistently choose the perceived best action (Tierney & Venegas, 2009; Yu, 2012). In the context this study, students may consider information related to the cost, academic rigor, availability, and scheduling options associated with community college program and course offerings when making decisions around whether to attend a community college. Similarly, the rationale choice process approaches graduate or professional school enrollment as a cost-benefit analysis.

Research Design

Data and Sample

This study is based on restricted-use data from the 2008-12 Baccalaureate and Beyond Longitudinal Study (B&B:08/12), the third and latest administration of the national longitudinal

survey of students' education and work experiences after completing a bachelor's degree. Conducted by the U.S. Department of Education's National Center for Education Statistics (NCES), B&B:08/12 follows a nationally representative sample of bachelor's degree recipients who completed their degree requirements during the 2007-08 academic year and who were first interviewed as part of the 2007-08 administration of the National Postsecondary Student Aid Study (NPSAS). Two follow-up studies have been conducted with this cohort, with the first follow-up administered one year after graduation that focused on undergraduate experiences and early post-baccalaureate outcomes, and the second completed in 2012 that closely examined students' enrollment in graduate and professional programs as well as labor market experiences through the fourth year since college graduation.

This research includes all three data waves of the B&B:08/12 sample of nearly 17,000 respondents. Of this sample, 33.96% had ever attended a community college (defined as a public 2-year institution) before completing baccalaureate degrees in 2007-08, and 18.04% of the total sample began postsecondary education at a community college. As of 2012, about 19.10% of the total sample enrolled in a graduate program, 15.76% enrolled in a professional degree program, and 1.95% of them enrolled in a law program.

Measures

Outcome measures. The dependent variable for the first research question is a dichotomous indicator of whether or not respondents had enrolled in graduate or professional schools as of 2012. The dependent variable for the second research question is a multi-categorical variable indicating the following areas of graduate and professional school enrollment as of 2012, with no graduate or professional enrollment as the reference category: (a)

humanities; (b) social sciences; (c) science, technology, engineering, and mathematics (STEM); and (d) professional fields, including law and other programs.

Independent variables. The key independent measure of interest is whether baccalaureate recipients had attended a community college. To mirror the complex ways in which community colleges factor into the larger scheme of postsecondary attendance, two alternative approaches were used to construct this "treatment" variable, with one defined as having ever attended a community college during one's undergraduate years regardless of where students began postsecondary education (1 = ever attended a community college, 0 = never attended a community college; Definition 1) and the other restricted to beginning postsecondary education at a community college (1 = began postsecondary education at a community college, 0 = began postsecondary education at a 4-year institution; Definition 2). These two approaches were adopted and tested throughout all phases of the analysis to generate nuanced findings.

Covariates. Two sets of covariates were employed in each of the two main analytic procedures described below. The first set of covariates were used in the propensity score matching (PSM) process to predict student selection into either the "treatment" (community college attendance) or "control" (no community college attendance) condition. Based on prior literature, these covariates center around students' pre-college socio-demographic and academic backgrounds. The second set of covariates were included in the regression analyses based on the matched sample to investigate the impact of community college attendance on graduate and professional school access. It included the first set of pre-college covariates and additional variables indicating undergraduate performance, educational expectations, college experiences, employment status upon graduation, and institutional characteristics as informed by previous

literature on graduate and professional school enrollment. See Table 1 for the full list of the measures and their descriptions.

Missing Data

About 5,160 (35.45%) of the students in the dataset had at least one missing value in the covariates. The "mice" package in R (Buuren & Groothuis-Oudshoorn, 2011) was applied to generate five imputed datasets that we used in all data analysis where estimated coefficients were combined across the imputed datasets using Rubin's rule (Rubin, 2004). For the multiple imputations, we employed predictive mean matching, an efficient imputation method for data exhibiting patterns of non-normal distributions (White, Royston, & Wood, 2011).

Analytic Procedures

The research design followed two main steps: (1) PSM to establish the "treatment" and "control" groups based on students' community college attendance and (2) binomial logistic regression and conditional logit regression to answer the two main research questions.

PSM. The gold standard to investigate causal inference is through randomized controlled trials (RCT). However, an RCT approach is infeasible in many realistic education settings when students self-select into their educational options, such as in our study. Given the self-selection inherent in students' choice regarding whether to attend a community college, these two groups of students may have systematic differences in a host of pre-existing backgrounds, characteristics, and experiences that traditional analysis cannot account for, resulting in a potentially biased estimate of the treatment effect (i.e., community college attendance). To deal with self-selection, we resorted to PSM, a technique that balances the pre-existing differences between treatment and control groups through the propensity score (PS; Rosenbaum & Rubin,

1985)—the conditional probability of selection into the treatment or control condition given observed pre-treatment characteristics.

While not able to completely remove self-selection, PSM is a way to balance the covariates to reduce the bias when evaluating the treatment effect by ensuring the baseline equivalence of observed covariates. We used a logistic regression to estimate the PS for having attended a community college based on the following equation (Austin, Jembere, & Chiu, 2018):

$$logit\ P(Z = 1|\boldsymbol{X}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k$$

where $Z = 1$ indicates having attended a community college and $Z = 0$ no community college attendance. We have k pre-treatment characteristics, $X_1, X_2, \ldots, X_k$, with $\boldsymbol{X}$ denoting the collection of these characteristics. Derived from this formula, the average PS based on the five imputed datasets was used to represent the PS for students (Cham & West, 2016; Mitra & Reiter 2011).

After obtaining the PS, we applied the "Matching" package in R to conduct the PSM (Sekhon, 2011). The students were matched with logit PS using nearest neighbor matching without replacement, with a caliper size of 0.20 standard deviation, falling well under 0.25 standard deviation as recommended by Rosenbaum and Rubin (1985). This smaller caliper size we adopted helped further reduce selection bias (Austin, 2011; Lunt, 2013). We also examined the overlapped logit PS ranges and checked the balancing properties of the baseline covariates to ensure the quality of the matching process. The covariates were considered balanced if their absolute SMD across the five matched datasets were all smaller than 0.25 (Austin, 2009). Since all of our covariates for matching were categorical, we examined the standardized mean difference (SMD), calculated using the following formula:

$$\text{SMD} = \frac{\hat{p}_{treatment} - \hat{p}_{control}}{\sqrt{\frac{\hat{p}_{treatment}(1-\hat{p}_{treatment}) + \hat{p}_{control}(1-\hat{p}_{control})}{2}}}$$

where $\hat{p}_{treatment}$ and $\hat{p}_{control}$ refers to the probability of being in a specific option in the matched treated and control groups, respectively.

Analyses post-matching. To answer our first research question on the effect of community college attendance on baccalaureate recipients' access to graduate and professional schools, we estimated a binary logistic regression model based on the matched sample. To address the second research question on community college attendance's influence on student enrollment in different graduate and professional programs, we conducted a conditional logit regression. We applied conditional logit regression based on the rationale that program-specific choice was contingent upon enrolling in graduate or professional schools, and that conditional regression enabled us to understand this conditional effect (Denters & Van Puijenbroek, 1989). For law school enrollment, we investigated the effect of community college attendance conditional upon student enrollment in professional programs.

We conducted these analyses using Stata. To account for the complex survey design features (such as clustering and unequal probabilities of selection) associated with B&B:08/12, we used the "svy" package of STATA 15 (StataCorp, 2017) that allowed us to take into account sampling weight, WTF000, clustering, and stratification. Since we had single primary sampling units (PSU) in the matched data, the traditional linearized variation estimator was unable to compute the standard error. Thus, we applied the bootstrap variation estimator where 200 bootstrap replicated weights (WTF001-WTF200, available in the B&B:08/12 dataset) to fit the model 200 times to estimate the standard error.

Sensitivity analysis. An important assumption underlying PSM is the conditional independence assumption, which implies that students' selection into the treatment or control group is only influenced by variables that simultaneously affect treatment assignment and outcomes, and these variables are all observed by the researcher and employed in PSM. To check the extent to which this strong assumption held, we conducted a sensitivity analysis by controlling two parameters, Λ, the relationship between the unobserved variable and treatment assignment, and Δ, the relationship between the unobserved variable and the outcome. These two parameters can be summarized by Γ, the sensitivity parameter indicating the extent to which the probability of treatment departs from random assignment of treatment (Rosenbaum, 2010). The relationship among Λ, Δ, and Γ can be expressed as follows:

$$\Gamma = \frac{\Lambda\Delta + 1}{\Lambda + \Delta}$$

Accordingly, when Γ gets larger, the potential true treatment effect falls within a wider range, implying that the estimated effect becomes less reliable. In other words, the larger Γ is, the more likely our findings will be influenced by hidden bias.

In our analysis, Γ was set from 1 to 2 with a 0.1 increment to show its influence. The permutation t-test was computed using the "sensitivitymw" package (Rosenbaum, 2014) in R to obtain the *p*-value and its upper and lower bounds for each odds ratio condition. It is worth noting that, given the nature of conducting t-tests, we compared the students enrolled in each of the four areas of graduate/professional study to the non-enrolled students separately. The parameter estimates and p-values are presented in the Appendix.

Results

Descriptively, 57.45% of the sample are female, 72.88% White, 30.93% low-income, and 33.86% first-generation college students. In regard to the characteristics of the baccalaureate

institutions from which sample members graduated, 62.86% graduated from a public university, 64.05% from a teaching institution, and 51.63% from a moderately selective university. Among the sample, 35.57% had attended a public 2-year institution, and 19.75% started their postsecondary education at a community college. Upon graduation, the vast majority (74.44%) were employed in 2009. Over two-thirds (73.39%) of the sample expected to receive a master's degree or above. Approximately one-third (35.33%) ever enrolled in any graduate or professional programs as of 2012. Detailed descriptive statistics of the sample are presented in Table 1.

Results from PSM and Sensitivity Analysis

Over 95% of the students who had attended a community college (about 5,010 out of 5,270 students based on Definition 1 and 2,760 out of 2,770 students based on Definition 2; regarding weighted sample size, about 573,340 out of 591,310 students based on Definition 1 and 328,140 out of 328,320 students based on Definition 2) were successfully matched and analyzed. The balancing test results (see Table 2) show that all of the covariates were balanced after matching, with the maximum value of all absolute SMDs smaller than 0.10. The common support for each definition presented in Figure 1 also confirms that there is a sufficient overlap between the two groups, with all the "treated" students' logit PS falling inside the common support area and successfully matched.

The results from the sensitivity analysis are presented in the Appendix. Findings suggest that the estimated ATT values were fairly stable as compared with the condition that the conditional independence assumption held and the results would not be altered substantively in the presence of an unobserved covariate.

Findings from Binary Logistic and Conditional Logit Models

We did not find any significant main effect of community college attendance on the probability of enrollment in graduate or professional programs based on either of our definitions ($\beta = 0.01, p = .93, OR = 1.01\ for\ Definition\ 1$; $\beta = 0.08, p = .46, OR = 1.08\ for\ Definition\ 2$).

Regarding the potential impact of previous community college attendance on student enrollment in the types of professional and graduate programs, we did not uncover a significant relationship either ($Humanity: \beta = 0.16, p = 0.41, OR = 1.17; Social\ Science: \beta = -0.04, p = 0.73, OR = 0.96; STEM: \beta = -0.17, p = 0.34,\ OR = 0.85; Professional: \beta = -0.02, p = 0.85, OR = 0.98; Law: \beta = 0.46, p = 0.08, OR = 1.07, Definition\ 1$) or ($Humanity: \beta = -0.18, p = 0.55, OR = 0.84\ ; Social\ Science: \beta = 0.19, p = 0.20, OR = 1.21;\ STEM: \beta = -0.13, p = 0.61, OR = 0.88; Professional: \beta = 0.01, p = 0.93, OR = 1.01; Law: \beta = 0.18, p = 0.71, OR = 1.20, Definition\ 2$).

The full set of results can be found in Tables 3 and 4. Pertaining to law school enrollment, expecting to earn a professional degree was significantly and positively associated with the likelihood of enrolling in law school as compared with other professional programs. Based on Definition 2, undergraduate GPA was positively correlated with the probability of enrolling in law school. Age did not significantly predict enrollment probabilities of any programs except law, with younger students being more likely to enroll in law school.

Discussion and Conclusion

Our study presents preliminary evidence on the role community colleges play in baccalaureate recipients' access to graduate and professional education as a whole, and enrollment in specific graduate and professional programs. Further unpacking the nuances of community college enrollment, we investigated these effects based on two definitions of

community college attendance, one restricted to beginning postsecondary education at a community college, and the other, more liberal definition referring to ever attended a community college at any point in time during students' undergraduate study. Regardless of these distinctions, our findings revealed that community college attendance does not act as a deterrent from or detour away from enrollment in graduate or professional studies, including law school.

In fact, students having attended or started at a community college were as likely as those without such experiences to enroll in graduate and professional programs. This result echoes prior empirical work highlighting the tangible role played by the community college in shaping students' larger undergraduate pathways (e.g., Crisp, 2013; Wang & McCready, 2013; Wang & Wickersham, 2014) and baccalaureate attainment (e.g., Melguizo & Dowd, 2009; Melguizo et al., 2011). Further, our study extends this line of work by illuminating community colleges as a viable path beyond the undergraduate level and toward graduate and professional degrees. Other than signifying community colleges as an equal pathway to graduate and professional education, our study reinforces the role these institutions play as a democratizing and diversifying force that extends beyond undergraduate education to graduate and professional education.

Taking a deeper look into these findings within the framework of human capital and rational choice, the ways in which community college attendance is related to access to graduate and professional education appears to play out in a highly nuanced fashion. Students who chose to attend community colleges may likely to be sensitive to the costs as well as the economic returns to their education. For example, they may focus on the expediency of baccalaureate attainment in order to immediately enter the workforce, thus forgoing graduate and professional educational options following undergraduate completion. Students may opt for this route in order to earn an income right away to pay off any incurred debts from college or toward other life

goals. On the other hand, aspiring graduate or professional students, such as aspiring law students for example, may assess available information and potential incentives around a law degree. Subsequently, by perceiving greater returns of an advanced degree over time, these students may be willing to delay entrance into the workforce in order to pursue graduate or professional degrees. Taken together, these two opposing choices, seeking immediate benefits or longer-term advantages, essentially cancel one another out, creating the null effect that emerged from our study.

Given the complexity of choice and access to graduate and professional education, community colleges may prove feasible for some students considering advanced degrees since these institutions offer much more affordable course and program options. As such, community college attendance may lower the overall costs of education as students progress toward graduate and professional school. This would not only alleviate the financial burden for students already aspiring graduate or professional education, but also encourage other students who tend to begin at community colleges due to significant financial constraints and may not have considered an advanced degree for this very reason. These students may then be able to consider such options due to the lower overall cost of choosing the community college in general and as a pathway to graduate and professional studies, and benefit from the longer-term benefits and returns of obtaining an advanced degree.

In order to ensure that community colleges successfully factor into a larger viable pathway to graduate and professional education for students, community colleges and graduate and professional schools need to work together to cultivate more seamless educational pathways. Although community colleges provide foundational, affordable coursework, it is important that these courses fit within the larger scheme of students' educational programs beyond transfer and

align with advanced studies. Community colleges also offer research and internship experiences, which should be leveraged toward later professional and graduate education. Drawing upon these strategies, learning opportunities, and relevant policies can enhance the community college pathway to advanced education.

Extending existing descriptive work around community college access to graduate and professional school, our study reveals that baccalaureate recipients who attended a community college were as likely as their counterparts who did not experience community colleges to advance to graduate and professional studies. Taken together, community colleges hold the potential to both provide access to graduate and professional education and expand and diversify the student populations completing these types of degrees.

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Table 1

List of Variables

		Unweighted (N= 17,170)		**Weighted** (N=1,162,275)		
	Options	N / Mean	% / SD	N / Mean	% / SD	Categories
Have ever attended a community college (Definition 1)	*Never attended public 2-year institution*	11,340	(66.04%)	1,070,970	(64.43%)	Independent
	Attended public 2-year institution	5,830	(33.96%)	591,310	(35.57%)	
Beginning postsecondary education at a community college (Definition 2)	*Did not begin at a public 2-year*	14,070	(81.96%)	1,333,950	(80.25%)	Independent
	Began at a public 2-year	3,100	(18.04%)	328,320	(19.75%)	
Grad or Professional Programs	*Didn't Attended*	11,190	(65.14%)	1,074,930	(64.67%)	Dependent
	Attended	5,990	(34.86%)	587,350	(35.33%)	
Grad or Professional Area	STEM	1,130	(6.57%)	74,990	(4.51%)	Dependent
	Humanities	370	(2.14%)	51,330	(3.09%)	
	Social Science	1,780	(10.39%)	193,800	(11.66%)	
	Professional	2,710	(15.76%)	267,230	(16.08%)	
	Law	330	(1.95%)	51,560	(3.1%)	
	Socio-Demographic Background					
Age	Over 20	13,890	(92.30%)	1,541,350	(92.73%)	Matched Vbl, Covariates
	Under 20	1,160	(7.70%)	120,920	(7.27%)	
Gender	*Male*	6,670	(41.38%)	707,340	(42.55%)	Matched Vbl, Covariates
	Female	9,450	(58.62%)	954,940	(57.45%)	
Ethnicity	*White*	11,480	(71.24%)	1,211,410	(72.88%)	Matched Vbl, Covariates
	Black or African American	1,520	(9.46%)	143,850	(8.65%)	
	Hispanic or Latino	1,490	(9.23%)	153,330	(9.22%)	
	Asian	1,070	(6.63%)	96,200	(5.79%)	
	Other (American Indian, Alaska Native, Native Hawaiian, pacific islander, multi races or others in the original survey)	560	(3.44%)	57,490	(3.46%)	
Income	*Not in Low Income Range*	9,670	(60.00%)	1,148,070	(69.07%)	Matched Vbl, Covariates
	Low Income	6,450	(40.00%)	514,210	(30.93%)	
First Generation Student / Parent's Education Level	*No*	10,200	(63.29%)	1,099,350	(66.14%)	Matched Vbl, Covariates
	Yes	5,920	(36.71%)	562,930	(33.86%)	
Language	*English*	14,290	(88.68%)	1,495,010	(89.94%)	Matched Vbl, Covariates
	Not-English	1,820	(11.32%)	167,260	(10.06%)	
	Pre-College Academic Background					
High School Type	*Not-Private*	13,580	(87.54%)	1,381,280	(86.57%)	Matched Vbl, Covariates
	Private	1,930	(12.46%)	214,290	(13.43%)	
Living more than 50 miles from high school in 2009	*No*	7,910	(52.53%)	890,730	(53.59%)	Matched Vbl, Covariates
	Yes	7,140	(47.47%)	771,540	(46.41%)	
Earned Advanced Placement credit in high school	*No*	9,440	(67.71%)	974,070	(68.93%)	Matched Vbl, Covariates
	Yes	4,500	(32.29%)	438,970	(31.07%)	
Earned any college credits in high school	*No*	7,450	(53.46%)	782,290	(55.36%)	Matched Vbl, Covariates
	Yes	6,490	(46.54%)	630,750	(44.64%)	
Calculus Completion	*No*	11,070	(64.44%)	1,070,770	(64.42%)	Matched Vbl, Covariates
	Yes	6,110	(35.56%)	591,500	(35.58%)	
	Undergraduate Performance and Post-College Experience					
Employed in 2009	*Non-employed*	4450	(27.62%)	424910	(25.56%)	Covariates
	Employed	11,670	(72.38%)	1,237,360	(74.44%)	
# of Remedial courses taken		0.48	(1.14)	0.48	(22.06)	Covariates
Federal Pell grant in 2007-08, $1000 as unit		1.09	(1.59)	0.59	(22.58)	Covariates
Undergraduate GPA as of 2007-08		3.33	(0.46)	3.26	(59.14)	Covariates
	Educational Expectations					
Highest level of education ever expected as of 2007-08	*Bachelor's, post-bachelor's or post-master's certificate*	14,120	(24.38%)	442,310	(26.61%)	Covariates
	Master's degree	7,760	(48.14%)	871,790	(52.45%)	
	First-professional degree	1,810	(11.21%)	124,930	(7.52%)	
	Doctoral degree	2,620	(16.27%)	223,240	(13.43%)	
	Institutional Characteristics					
Attended private university /	*No*	9,310	(57.78%)	1,044,860	(62.86%)	Covariates
	Yes	6,800	(42.22%)	617,420	(37.14%)	
Attended research university	*No*	9,500	(66.34%)	998,830	(64.05%)	Covariates
	Yes	4,820	(33.66%)	560,680	(35.95%)	
Urbanicity	*Urban*	9,300	(57.74%)	1,003,040	(60.34%)	Covariates
	Suburban	6,060	(37.58%)	597,650	(35.95%)	

	Rural	750	(4.68%)	61,580	(3.7%)	
Selectivity of 2007-08 bachelor's degree institution	*Others*	3,120	(19.63%)	302,300	(18.51%)	Covariates
	Moderately Selective	8,530	(53.59%)	843,200	(51.63%)	
	Very Selective	4,260	(26.78%)	487,700	(29.86%)	

Note. The reference category is italicized.

Table 2

Results from Balancing Tests

CC Attendance Definition	Definition 1		Definition 2	
Variables / Matching	Before	After	Before	After
Age over 20	0.29	0.03	0.42	0.06
Female	0.10	0.01	0.05	0.01
Race				
African American	0.03	-0.02	-0.01	-0.02
Latino	0.06	-0.03	0.12	-0.01
Asian	0.00	-0.03	-0.03	0.00
Others	0.06	0.00	0.08	0.01
Low Income	0.26	-0.04	0.32	-0.06
First Generation	0.28	-0.03	0.36	-0.04
Other Language	0.06	-0.03	0.13	-0.03
Private High School	-0.18	-0.02	-0.27	-0.03
Lived 50 mile Away From School	-0.04	0.03	-0.11	0.02
Taken Advanced Placement Test	-0.33	-0.01	-0.39	0.02
Taken College Credits	-0.22	-0.02	-0.24	0.01
Competed Calculus	-0.42	-0.01	-0.52	0.02

Note. SMD $\leq$ .25 indicates that the covariate is balanced.

Table 3

Logistic and Conditional Logit Regression Results (Based on Definition 1 of Community College Attendance)

Have Ever Attended a Community College (*Definition 1*)	RQ1	RQ2				
	Grad/professional school attendees (N=3,870/ 374,580)	Humanities (N=210/ 29,730)	Social Science (N=1,250/ 128,270)	STEM (N=660/ 44,260)	Professional (N=1,750/ 172,320)	Law (N=187/ 28,660)
Reference Group (in parentheses)	Non-attendees (N=6,140)					
Intercept	-4.29***					
Graduate or Professional Programs		-5.92***				
Professional Programs		0.34				
Law		0.66				
Attended Public 2-Year Institution	0.01	0.16	-0.04	-0.17	-0.02	0.46
Undergraduate Performance and Post-College Experience						
Employed	-0.02	-0.12	0.12	-0.53**	0.11	-0.45
Number of remedial courses took	0.04	-0.02	0.01	0.15	0.03	0.02
Undergraduate GPA as of 2007-08	0.59***	0.29	0.65***	0.45**	0.67***	-0.32
Federal Pell grant in 2007-08, $1000 as unit	0.02	0.15	-0.00	0.01	0.02	0.02
Educational Expectations						
Highest level of education ever expected as of 2007-08 (Bachelor's degree)						
Master's Degree	1.30***	1.07**	1.46***	1.54***	1.33***	-1.78***
First-professional degree	2.24***	1.72**	0.99***	1.73***	2.21***	1.46***
Doctoral degree	2.18***	2.73***	2.24***	2.73***	1.88***	-0.45
Institutional Characteristics						
Private University	-0.14	-0.15	-0.37**	0.03	-0.00	-0.03
Research University	0.22*	0.11	0.05	0.33	0.28*	0.40
Selectivity of 2007-08 bachelor's degree institution (Others)						
Very selective	0.35*	0.77	0.54**	0.75	0.06	-0.04
Moderate selective	0.21	0.57	0.33*	0.53*	0.00	-0.39
Urbanicity (Urban)						
Suburban	-0.02	-0.11	0.02	-0.18	0.03	-0.03
Rural	-0.11	-0.42	0.15	-0.99*	-0.01	-1.23
Socio-Demographic Background						
Age (Under 20)	-0.11	0.00	-0.28	0.43	-0.06	-1.70**
Female (Male)	0.10	-0.41	0.59***	-0.92***	0.22	-0.69*
Race (White)						
African American	0.55***	0.73	0.50**	-0.01	0.73***	-0.62
Latino	-0.09	0.30	0.32	-0.58	-0.39	-0.38
Asian	-0.02	-0.20	-0.44	0.02	0.18	-0.47
Others	0.34	0.71	0.01	-0.54	0.72*	-0.99
Low-Income (Not Low Income)	-0.13	-0.53	0.06	-0.09	-0.21	-0.19
First Generation Student (Not First Generation Student)	0.08	-0.45*	0.09	0.23	0.18	-0.57
Use Language other than English (English)	0.19	-0.19	-0.08	0.46	0.34	0.25
Pre-College Academic Background						
Private High School (Public)	-0.12	-0.15	-0.03	-0.53	-0.18	0.12
Lived 50 mile Away From School (No)	0.06	0.43	-0.06	0.16	0.05	0.17
Taken Advanced Placement Test (No)	0.10	0.80*	0.05	0.31	-0.18	0.95*
Taken College Credits (No)	0.10	0.04	0.06	0.02	0.26	-0.87*
Competed Calculus (No)	0.05	-0.27	-0.08	0.44*	0.09	-0.09

Note. Reference category is in parentheses.
* $p \leq .05$; ** $p \leq .01$; ***$p \leq .001$

Table 4

Logistic and Conditional Logit Regression Results (Based on Definition 2 of Community College Attendance)

Beginning Postsecondary Education at a Community College (Definition 2)	RQ1	RQ2				
	Grad/professional school attendees (N=2,030/ 200,810)	Humanities (N=122/ 15,160)	Social Science (N=690/ 73,260)	STEM (N=360/ 23,480)	Professional (N=870/ 88,910)	Law (N=74/ 12,590)
Reference Group (in parentheses)	Non-attendees (N=3,480/439,990)					
Intercept	-4.61***					
Graduate or Professional Programs		-6.07***				
Professional Programs		0.62				
Law		-6.63*				
Attended Public 2-Year Institution	0.08	-0.18	0.18	-0.13	0.01	0.18
Undergraduate Performance and Post-College Experience						
Employed	-0.14	0.09	-0.07	-0.56*	-0.13	0.25
Number of remedial courses took	0.05	-0.18	-0.05	0.23*	0.07	-0.02
Undergraduate GPA as of 2007-08	0.68***	0.31	0.74***	0.45*	0.63***	1.62*
Federal Pell grant in 2007-08, $1000 as unit	0.06	0.27*	0.02	-0.04	0.07	0.02
Educational Expectations						
Highest level of education ever expected as of 2007-08 (Bachelor's degree)						
Master's Degree	1.15***	0.81	1.48***	0.89*	1.13***	-1.37
First-professional degree	2.15***	0.40	1.63**	1.31*	2.11***	1.81**
Doctoral degree	2.10***	2.56***	2.31***	2.17***	1.80***	0.02
Institutional Characteristics						
Private University	-0.05	-0.33	-0.40*	0.10	0.25	-0.22
Research University	0.10	0.25	-0.00	0.33	0.02	0.63
Selectivity of 2007-08 bachelor's degree institution (Others)						
Very selective	0.60**	0.60	0.58*	0.98	0.60*	-0.47
Moderate selective	0.30*	0.69	0.27	1.01	0.13	-0.06
Urbanicity (Urban)						
Suburban	0.01	0.16	-0.05	-0.09	0.11	-0.39
Rural	0.13	-0.01	-0.04	0.36	0.32	-1.87
Socio-Demographic Background						
Age (Under 20)	-0.01	0.31	-0.21	0.42	0.12	-2.26**
Female (Male)	-0.01	-0.08	0.48**	-1.05***	-0.00	-0.95*
Race (White)						
African American	0.29	0.30	0.08	-0.09	0.45	0.58
Latino	-0.13	-0.08	0.19	-0.97*	-0.37	0.88
Asian	-0.10	0.41	-0.42	-0.15	0.02	-0.25
Others	0.37	0.70	-0.00	-0.11	0.75*	-2.72*
Low-Income (Not Low Income)	0.05	-0.01	0.18	0.15	-0.10	0.27
First Generation Student (Not First Generation Student)	0.09	-0.60*	0.18	0.07	0.17	-0.39
Use Language other than English (English)	0.13	-0.02	-0.12	0.78	0.27	-1.75
Pre-College Academic Background						
Private High School (Public)	0.20	-0.26	0.22	0.26	0.26	-0.62
Lived 50 mile Away From School (No)	0.04	0.23	-0.10	0.38	-0.01	0.02
Taken Advanced Placement Test (No)	0.16	0.78	0.19	0.52	-0.26	2.03**
Taken College Credits (No)	0.05	-0.32	-0.12	0.06	0.38	-1.72*
Competed Calculus (No)	0.18	0.11	0.10	0.62*	0.13	0.07

Note. Reference category is in parentheses.

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

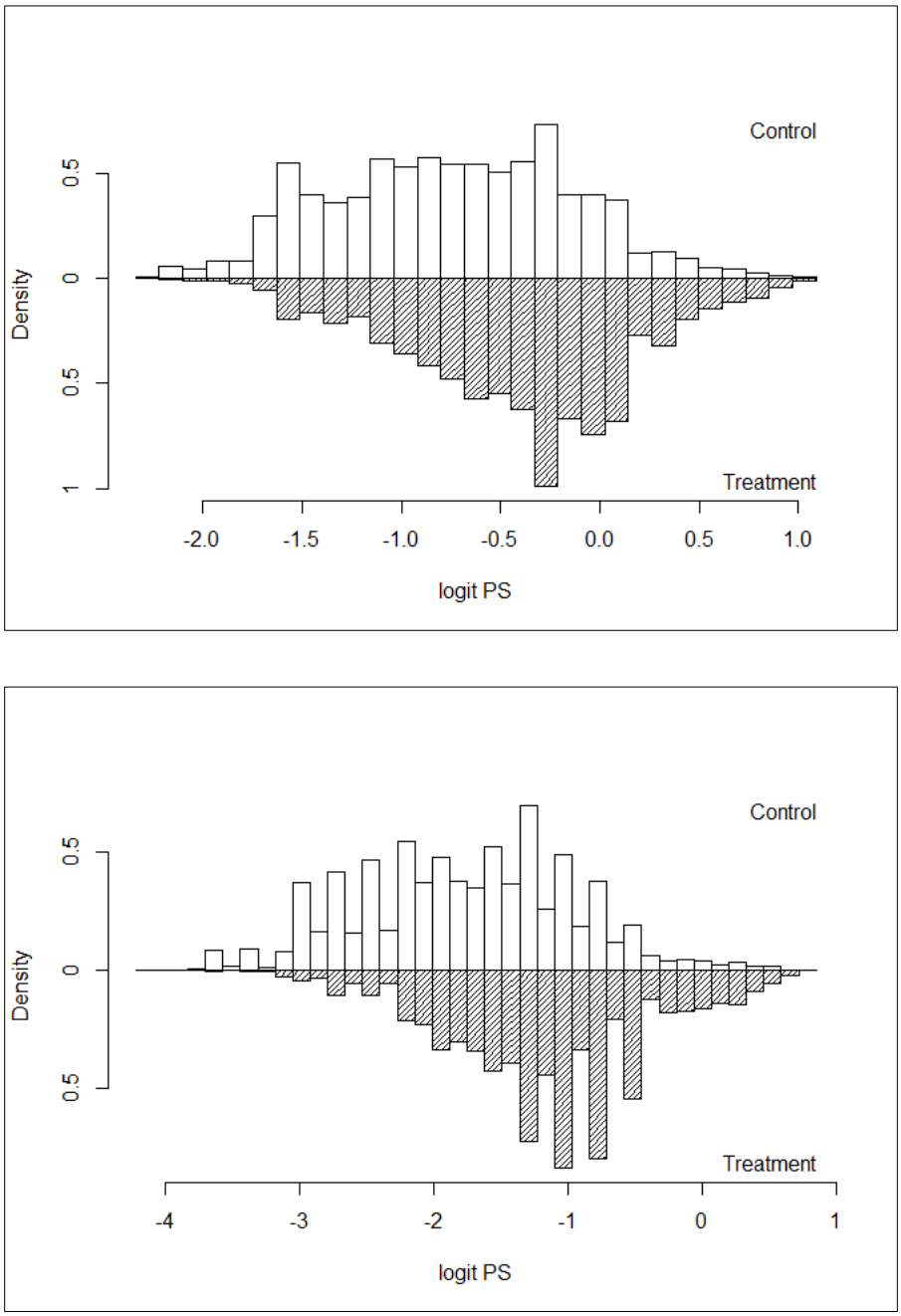

Figure 1. Logit propensity scores and common support plots for Definition 1 (top) and Definition 2 (bottom).

Appendix

Results from Sensitivity Analysis

			95% Confidence Interval						95% Confidence Interval		
	Estimation						Estimation				
Γ	Minima	Maxima	Lower	Upper	*p*	Γ	Minima	Maxima	Lower	Upper	*p*
having ever attended a community college						beginning postsecondary education at a community college					
Research Question 1: What is the impact of community college attendance on baccalaureate recipients' access to graduate and professional schools in general?											
1	-0.0162	-0.0162	-0.0350	0.0027	0.954	1	-0.0065	-0.0065	-0.0320	0.0190	0.692
1.1	-0.0392	0.0060	-0.0585	0.0253	1	1.1	-0.0294	0.0161	-0.0556	0.0422	0.986
1.2	-0.0611	0.0272	-0.0809	0.0470	1	1.2	-0.0513	0.0377	-0.0781	0.0645	1
1.3	-0.0821	0.0476	-0.1022	0.0678	1	1.3	-0.0722	0.0583	-0.0996	0.0858	1
1.4	-0.1021	0.0671	-0.1227	0.0877	1	1.4	-0.0923	0.0781	-0.1202	0.1061	1
1.5	-0.1213	0.0858	-0.1422	0.1069	1	1.5	-0.1114	0.0971	-0.1399	0.1256	1
1.6	-0.1397	0.1038	-0.1609	0.1252	1	1.6	-0.1298	0.1153	-0.1587	0.1443	1
1.7	-0.1573	0.1211	-0.1789	0.1429	1	1.7	-0.1474	0.1328	-0.1768	0.1623	1
1.8	-0.1742	0.1377	-0.1961	0.1598	1	1.8	-0.1644	0.1497	-0.1942	0.1796	1
1.9	-0.1905	0.1537	-0.2127	0.1762	1	1.9	-0.1807	0.1658	-0.2109	0.1962	1
2	-0.2061	0.1691	-0.2286	0.1919	1	2	-0.1963	0.1814	-0.2269	0.2122	1
Research Question 2: How does previous community college attendance influence student enrollment in different professional and graduate programs?											
			STEM						STEM		
1	-0.0210	-0.0210	-0.0377	-0.0043	0.993	1	-0.0066	-0.0066	-0.0289	0.0157	0.720
1.1	-0.0302	-0.0124	-0.0476	0.0040	1	1.1	-0.0156	0.0018	-0.0388	0.0251	0.907
1.2	-0.0393	-0.0051	-0.0573	0.0121	1	1.2	-0.0244	0.0101	-0.0485	0.0343	0.977
1.3	-0.0482	0.0013	-0.0668	0.0200	1	1.3	-0.0331	0.0183	-0.0580	0.0433	0.996
1.4	-0.0570	0.0086	-0.0762	0.0279	1	1.4	-0.0416	0.0263	-0.0673	0.0521	0.999
1.5	-0.0655	0.0157	-0.0853	0.0356	1	1.5	-0.0500	0.0342	-0.0764	0.0608	1
1.6	-0.0740	0.0227	-0.0943	0.0431	1	1.6	-0.0582	0.0420	-0.0854	0.0693	1
1.7	-0.0823	0.0296	-0.1031	0.0506	1	1.7	-0.0663	0.0497	-0.0942	0.0777	1
1.8	-0.0904	0.0364	-0.1117	0.0579	1	1.8	-0.0742	0.0572	-0.1028	0.0859	1
1.9	-0.0984	0.0432	-0.1202	0.0652	1	1.9	-0.0820	0.0646	-0.1113	0.0940	1
2	-0.1062	0.0498	-0.1285	0.0723	1	2	-0.0897	0.0719	-0.1196	0.1019	1
			Humanity						Humanity		
1	-0.0088	-0.0088	-0.0307	0.0131	0.784	1	-0.0068	-0.0068	-0.0339	0.0203	0.689
1.1	-0.0156	-0.0026	-0.0385	0.0201	0.909	1.1	-0.0127	-0.0014	-0.0411	0.0268	0.811
1.2	-0.0223	0.0031	-0.0462	0.0270	0.967	1.2	-0.0186	0.0037	-0.0482	0.0333	0.892
1.3	-0.0290	0.0090	-0.0538	0.0338	0.989	1.3	-0.0244	0.0089	-0.0552	0.0397	0.941
1.4	-0.0356	0.0149	-0.0614	0.0406	0.997	1.4	-0.0302	0.0141	-0.0621	0.0460	0.969
1.5	-0.0422	0.0207	-0.0688	0.0473	0.999	1.5	-0.0360	0.0193	-0.0689	0.0522	0.985
1.6	-0.0488	0.0265	-0.0762	0.0539	1	1.6	-0.0417	0.0244	-0.0757	0.0584	0.993
1.7	-0.0553	0.0322	-0.0835	0.0605	1	1.7	-0.0474	0.0295	-0.0824	0.0646	0.996
1.8	-0.0618	0.0380	-0.0908	0.0670	1	1.8	-0.0531	0.0346	-0.0891	0.0706	0.998
1.9	-0.0682	0.0437	-0.0980	0.0734	1	1.9	-0.0588	0.0397	-0.0957	0.0767	0.999
2	-0.0746	0.0493	-0.1051	0.0799	1	2	-0.0644	0.0447	-0.1023	0.0826	1
			Social Science						Social Science		
1	0.024	0.024	-0.034	0.082	0.208	1	0.038	0.038	-0.04	0.115	0.17
1.1	-0.015	0.065	-0.075	0.125	0.683	1.1	-0.002	0.08	-0.082	0.16	0.516
1.2	-0.052	0.104	-0.115	0.166	0.951	1.2	-0.04	0.121	-0.123	0.203	0.829
1.3	-0.089	0.142	-0.153	0.206	0.997	1.3	-0.077	0.16	-0.163	0.245	0.963
1.4	-0.125	0.18	-0.191	0.245	1	1.4	-0.114	0.199	-0.202	0.286	0.995
1.5	-0.16	0.216	-0.228	0.283	1	1.5	-0.149	0.236	-0.24	0.326	1
1.6	-0.194	0.251	-0.264	0.32	1	1.6	-0.184	0.273	-0.277	0.365	1
1.7	-0.228	0.286	-0.299	0.356	1	1.7	-0.218	0.309	-0.313	0.403	1
1.8	-0.26	0.319	-0.333	0.392	1	1.8	-0.251	0.343	-0.348	0.439	1
1.9	-0.292	0.352	-0.366	0.426	1	1.9	-0.283	0.377	-0.382	0.475	1
2	-0.323	0.384	-0.398	0.459	1	2	-0.315	0.41	-0.415	0.51	1
			Professional						Professional		
1	-0.057	-0.057	-0.139	0.024	0.917	1	0.038	0.038	-0.04	0.115	0.17
1.1	-0.125	0.007	-0.209	0.091	0.998	1.1	-0.002	0.08	-0.082	0.16	0.516
1.2	-0.191	0.069	-0.277	0.156	1	1.2	-0.04	0.121	-0.123	0.203	0.829
1.3	-0.255	0.13	-0.343	0.219	1	1.3	-0.077	0.16	-0.163	0.245	0.963
1.4	-0.316	0.188	-0.407	0.279	1	1.4	-0.114	0.199	-0.202	0.286	0.995
1.5	-0.375	0.245	-0.468	0.338	1	1.5	-0.149	0.236	-0.24	0.326	1
1.6	-0.433	0.3	-0.528	0.396	1	1.6	-0.184	0.273	-0.277	0.365	1
1.7	-0.489	0.354	-0.585	0.451	1	1.7	-0.218	0.309	-0.313	0.403	1

1.8	-0.543	0.406	-0.641	0.505	1	1.8	-0.251	0.343	-0.348	0.439	1
1.9	-0.595	0.456	-0.695	0.557	1	1.9	-0.283	0.377	-0.382	0.475	1
2	-0.646	0.505	-0.748	0.608	1	2	-0.315	0.41	-0.415	0.51	1

Note. The *p* indicates a two-tailed *p*-value.