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ABSTRACT

Community College Pathways for Disadvantaged Students*

In this paper we estimate the impacts of the "pathways" chosen by community college students - in terms of desired credentials and fields of study, as well as other choices and outcomes along the paths - on the attainment of credentials with labor market value. We focus on the extent to which students change their choices over time, whether students make well-informed choices, and the impacts of choices on outcomes. We find that several characteristics of chosen pathways, such as field of study and desired credential as well as early "momentum," affect outcomes. Student choices of pathways are not always driven by information about later chances of success, in terms of probabilities of completing programs and attaining strong earnings. Students also change pathways quite frequently, making it harder to accumulate needed credits in their fields. Attainment of credentials with greater market value could thus likely be improved by appropriate guidance and supports for students along the way, and perhaps by broader institutional changes as well.

JEL Classification: I2
Keywords: community college, pathways, labor market, earnings

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I. Introduction

Market returns to a number of associate's degrees and even some certificates are quite high, offering disadvantaged youth and adults unique opportunities to improve their earnings capacities and ultimately to gain self-sufficiency through employment (Jepsen et al., 2014; Stevens et al., 2018).

At the same time, the education and earnings outcomes we observe for many community college students – especially minorities and/or low-income students – are often poor. Specifically, these students have very low credential completion rates, and often attain credentials with little labor market value (like terminal associate's degrees in "General Studies" or "Liberal Studies") when they complete them (Backes et al., 2015; Baum and Holzer, 2017). The relatively weak outcomes apparently reflect both student characteristics, such as limited academic preparation and social capital; and they also reflect characteristics of the institutions they attend, such as limited resources and weak incentives to generate labor market success, plus a lack of appropriate guidance for the students there (Scott-Clayton, 2011; Bailey et al., 2015).

Yet these findings also raise a number of important questions. For instance, why do some disadvantaged students, including those with low achievement, attain credentials with labor market value while others do not? In what fields of study do they do so, and how often do students choose such fields? Do they change fields frequently, and if so, at what cost? How important is early performance, in terms of credit attempted and attained? Overall, do students there appear to be making well-informed choices?

To an extent, these questions involve the "pathways" students choose in community college, and the extent to which various pathways generate success. When discussing these, we do not mean the "career pathways" that many states are now creating for their most disadvantaged and lowest-

achieving students and workers; nor do we mean the "guided pathways" that Bailey et al. (2015) have advocated to improve the choices community college students make.

Instead, we consider a "pathway" to include one's choice of field of study and desired credential (e.g., certificate, associate's or bachelor's degree), as well as a range of additional choices they make along the way and outcomes they generate – such as whether they take and pass developmental classes, how many courses or credits they enroll in and attain per semester, what grade point average (GPA) they achieve, and how often they change field of study and degree program. These pathways are somewhat less explicitly structured by college administrators and education policy makers, and more organically chosen by students - conditional on the courses and programs offered by institutions they attend and the information they have – than the more formalized "career pathways" or "guided pathways" now being created.[1]

We study the choices of pathway made and outcomes achieved by a full cohort of community college students in Kentucky over a six-year period. We analyze initial choices of fields of study plus subsequent changes, and what characteristics of chosen pathways and outcomes along the way appear to contribute to successful completion of credentials of value. To ascertain the extent to which pathway choices and outcomes *causally* affect ultimate educational outcomes, we estimate student fixed effects models as well as regression discontinuity models by exploiting the requirements in Kentucky that students maintain GPAs of 2.0 or higher to continue their studies, with mixed success.

Our main findings are as follows:

[1] Our definition of "pathways" is similar to that used by Jenkins and Weiss (2011), as we note below. By explicitly tying all of our "pathways" to planned credentials, we define them somewhat differently than Bahr and Booth (2012), whose "skill-builders" take few classes and never intend to obtain a credential. As we note below, we find far fewer of these students in our data.

- Some sub-BA pathways, such as health, applied STEM and those to gaining certificates, are consistently associated with greater likelihood of sub-BA credential attainment and higher earnings afterwards than other pathways;
- Some student choices of fields of study, and especially differences by gender and academic readiness, do not seem well-informed by these probabilities of later success;
- Student choices of programs of study change frequently, which appear to be at least somewhat costly to student outcomes (by limiting their ability to accumulate needed time within pathways); and
- Early "momentum," generated by enrolling in and attaining credits in the first year (controlling for total credits attempted and passed), affect credential completion rates as well.

The above findings are novel (at least within the rigorous empirical research literature on community college) and provide some of the most direct evidence to date that students at these institutions – especially those deemed not "college ready" – seem to make poorly informed choices. Their success rates could almost certainly be improved with more guidance towards appropriate paths of study plus a range of supports that could help them gain early momentum towards credential attainment.

II. Previous Literature

It is well known that the labor market rewards to completing college degrees in the US are very high (Autor, 2014), and also that completion rates vary widely across both students (by demographic and income groups) and type of institutions (by public v. private, 2-year v. 4-year, and resources

available).[2] We also know that a student's field of study has quite large impacts on her subsequent earnings within each type of institution and degree (Altonji et al., 2014; Backes et al., 2015; Holzer and Baum, 2017).

Yet earnings differences across fields seem to have quite modest impacts on choice of field of study (Wiswall and Zafar, 2013; Long et al., 2015). This is likely due to imperfect information among students about these returns and their likely future trends, varying preferences across students for fields of study (e.g., some like studying math/science and some do not), and different aptitudes for such work. The latter, in turn, reflect choices of what to study often made years earlier by elementary and secondary students with very little information or foresight about what they will be good at in the future and what the labor market will reward (Altonji et al., 2011).

In addition, a relatively recent literature on behavioral effects on education outcomes suggests that a range of short-term rewards and "nudges" can have fairly large effects on student choices and success over long periods of time (Lavecchia et al., 2014; Castleman et al., 2015), in ways that seem inconsistent with students being fully rational and informed.

To the extent that these forces operate for students in four-year colleges and universities, they are likely even more important for community college students – where completion rates are much lower, average earnings afterwards are lower, and many more students are from disadvantaged or first-generation college families who might lack the needed information and "social capital" for success (Holzer and Baum, op. cit.). In such circumstances, providing more guidance to students as they make critical choices could improve their success.

[2] For recent analyses of the determinants of degree completion, and of the effects of student and institutional effects as well as resources, see Bound et al. (2010) and Deming and Walters (2017). The former consider only 4-year institutions while the latter separately considers 2-year and 4-year schools.

Indeed, given the very high variance in student abilities to complete different programs as well as the labor market rewards to different sub-BA fields and credentials (Jepsen et al., 2014; Grosz et al., 2015; Backes et al., 2015), such guidance could be critical to their choosing fields and credentials that they can master and obtain appropriate rewards afterwards. And given the large gaps between aspirations among community college students for transfers to four-year colleges and universities and their success rates in achieving BAs (Jenkins and Fink, 2015), assistance in this process is likely needed for many students as well.

For these reasons, Rosenbaum et al. (2006) and Scott-Clayton (2011) have both argued that too little structure and too much unguided choice can easily hurt students at community colleges, leaving them to wander aimlessly in course-taking and credit attainment, and to not gain the early momentum needed for progress towards and completion of desired credentials (Tinto, 2012).

In response to such concerns, Bailey et al. (2015) have developed the concept of "guided pathways" to build more institutional structure and help students make more informed choices at each step of their journeys through community college and perhaps onto four-year institutions. According to this argument, such pathways will help students choose fields of study which they will both like and where they can succeed, while gaining more momentum in terms of credit attainment, progress through "gateway" courses and into their programs of study (Jenkins and Bailey, 2017).

While sensible and appealing, the evidence provided in support of these ideas to date is mostly descriptive, and based primarily on summary data or Ordinary Least Squares (OLS) regressions of student outcomes on characteristics of their pathways. Attempts to use panel data to control for fixed student (or institutional) effects, regression discontinuity models to establish causality, or even fairly complete controls for earlier and current achievement in this literature have been rare to date. And the exact mechanisms by which momentum in one's program of study is stalled, such as the effects of

frequently switching programs of study or attempting too few credits, have mostly not been rigorously identified or estimated as well.[3]

III. Data and Pathways: Definitions and Summary Findings

A. Data and Population Characteristics

We use individual-level administrative panel data on the universe of students who attended public colleges in Kentucky in the past decade. Specifically, we focus on the entire cohort of students who began community college in Kentucky in the academic year 2010-11, and we follow each of them for six years through the spring of 2016.

For all students, we have data on their chosen field of study and desired credential each semester; every course in which they enrolled, the grade obtained, and credits attained over the six-year period; whether they took developmental classes and passed them; and any credentials they earned – which could be certificates, diplomas, associate's degree or bachelor's degrees. If they transferred to another institution, and in particular a four-year one, we can track them there as well.[4]

In addition, we have data on the high school experiences and outcomes of each student, including courses taken and grades, as well as test scores. The latter are used by the state of Kentucky to determine whether each student is viewed as "college ready" in English, reading and math, as well as

[3] Jenkins and Bailey op. cit. review the various studies of the impacts of early "credit," "gateway," and "program" momentum on educational outcomes. Virtually all of these studies provide only summary data or based their results on OLS regressions or propensity score matching with limited covariates. Most studies do not control for total credit attainment while separately estimating credit attainment early on, do not control for both secondary and postsecondary grade point average (GPA), and do not control for both student "readiness" and experience in remedial classes for those considered "not ready" as we do below.

[4] Jepsen et al. op. cit. also estimate returns to BA and sub-BA credentials in Kentucky, and our estimates are broadly consistent with theirs, though we focus much more on pathways and determinants of successful completion than they do. Out-of-state transfers can be tracked using the National Student Clearinghouse data, though we did not have access to these data for this study.

overall (based on perceived "readiness" in the other three categories).[5] The data also include demographics, such as age, race and gender.

Finally, though we do not have direct access to micro-level earnings data that could be linked to each educational record, the Kentucky Center for Statistics was willing to estimate earnings measures for whatever categories of students we requested and for any year in the past decade. We present some summary data below, by field of study and credentials earned, of those in the 25-34 age range in 2017, who would have been approximately the ages of younger students beginning community college in 2010.

The characteristics of the population of students beginning community college in Kentucky in 2010-11 appear in Table 1. Approximately 85 percent of Kentucky community college students are white. Perhaps most notably, relatively few of these students meet Kentucky's standards for college readiness based on their test scores – those deemed ready in English and reading were approximately 60 percent of the population of students or a bit below, but those ready in math were only 28 percent, and therefore just a fourth of the total were deemed college-ready overall.

Following Jenkins and Weiss (2011), we have constructed a range of broad student "pathways" for these students, based on their desired credentials and field of study, where the latter is based on Classification of Instructional Programs (CIP) from the National Center on Education Statistics (NCES); the pathway categories are listed in Table 2a, while some specific examples of the more applied categories are listed in Table 2b.

[5] Specifically, college readiness for high school students in Kentucky is based on test scores on the mandatory 11th grade ACT tests. The benchmarks are 19 for math, 20 for reading, and 18 for English. Students who miss the benchmarks have the opportunity to become "college ready" by taking the COMPASS or KYOTE test in the 12th grade.

We have classified five broad pathways to an associate's degree – four of which are in the most popular applied or occupational categories (which are health, applied STEM, business, and other occupational) while the fifth represents all liberal arts fields outside of science.[6] Comparing across these popular occupational fields enables us to test for whether completion in some are more difficult than others, controlling for earlier student preparedness, as well as the extent of differences in their labor market value. Another pathway combines all diploma and certificate programs into one, though most students there (about 85 percent) are enrolled in the certificate programs.[7] One other category is for those who plan to transfer to a four-year college very quickly and seek no credential in community college. Finally, a reference category is created for all those who have not yet declared a major or program of study.

The more detailed breakdowns in Table 2b indicate that students in the applied STEM pathway mostly choose computer or informal sciences or a range of other technical occupations. The mixed occupational category includes criminal justice administration, teacher aide, and child care assistant most frequently; while most in health care pathways choose a type of nursing or some smaller health technician categories.

B. Pathway Choices

The distribution of broad pathways first chosen by students in 2010-11 appears in Figure 1. The figure shows that health care (pathway 4) is chosen by nearly a fourth of all students, while the next two largest categories are liberal arts and certificates/diplomas (pathways 6 and 7), each of which is chosen by another 15-20 percent of entering students. But very few students appear in the BA category, while nearly a quarter of all students fail to choose any pathway during their first year.

[6] Majors in biology, biomedical sciences and other academic STEM fields appear in the Applied STEM pathway as well, though most choosing this pathway are in an applied technical field.
[7] Diplomas almost always require a year or more of study, while certificates can be shorter-term.

Table 3 presents the distributions of chosen pathways by demographic characteristics including gender, age, and college readiness (based on the Reading category). We find one striking difference by gender: nearly a third of females choose the associate degree in health pathway, while less than a tenth of men do so. This very large difference may indicate some "identity mismatch," as Katz (2017) has called the unwillingness of males to enroll in categories of studies and employment they associate with females.[8] And, since job opportunities in health care remain very strong (with high employment growth now and in the near future driven by the aging Baby Boom cohort), the relative unwillingness of men to enroll in this field likely denies them some potentially important labor market opportunities.[9]

One other interesting comparison involves pathways chosen by those who are or are not categorized as college-ready. Overall, their choices are remarkably similar to one another, despite a major difference in academic preparedness. We note, in particular, that the not-ready group chooses the Diploma/Certificate pathway more frequently, but with a difference of only 7 percentage points. Their relative lack of greater self-selection into what is likely a less academically demanding pathway is noteworthy, especially as we consider different success rates across groups and pathways below.

In short, the extent to which pathway choices among large groups of students, such as males and those who are not deemed college ready, are not always driven by odds of completion and subsequent earnings is quite striking.

C. Pathway Completion

[8] Conversely, "identity mismatch" is also reflected in the fact that only 1.4 percent of female students choose the STEM associate's degree pathway, compared to 12 percent of male students.

[9] While a fairly low responsiveness of college majors to labor market changes has been observed elsewhere in the literature (Long et al., 2015), suggesting limited student information about these outcomes, the very large differences in health pathway choices by gender suggest that low information may not be a primary cause of the male unwillingness to choose health in this case.

Figure 2 presents overall completion rates of credentials at Kentucky community colleges over six years. We present completion rates for each credential category separately and for combinations of them (like certificate/diploma and AA/AS degree or AA/AS and BA/BS) in the left-most graph, while we present highest credential achieved in the rightmost figure. These rates are calculated for the entire cohort of 2010-11, rather than conditional on enrollment in pathways observed above.

The results show that the overall completion rate over 6 years in Kentucky community college is just under 30 percent, and only about 22 percent for associate's or bachelor's degrees. This is somewhat lower than what we find in other states (Holzer and Baum, op. cit.). Of those receiving certificates, about a fourth go on to attain associate's degrees as well, while a third of those receiving associate's degrees go on to attain bachelor's degrees.

Table 4 presents credential completion rates by the demographic categories we used above – gender, age and college-readiness. Consistent with Holzer and Baum (op. cit.), we observe that females are more likely than males to complete sub-BA credentials (though attainment of bachelor's degrees are similar), as are older students compared to younger ones (while the latter attain more bachelor's degrees). In the latter case, the differences perhaps suggest that older students are more focused on attaining a specific credential, likely for career reasons, while younger students may be less ambitious or focused. This is also consistent with the fact that older students are more likely (by 10 percentage points) to have chosen any pathway in their first year than younger students.

Interestingly, those who are deemed *not* college-ready complete certificates at about the same rates as do college-ready students, but they complete degrees at much lower rates. Indeed, comparing completion to enrollment figures presented earlier indicates quite high success rates for the non-ready who enroll in certificate/diploma programs than in the associate or bachelor's paths. Certificates are thus a more viable option than associate's programs for many non-ready students, yet these much

higher success rates for certificates translate into just small differences in enrollment rates across the respective pathways, as we noted earlier.

How do overall credential attainment rates vary by initially chosen pathway? These rates appear in Figure 3. The highest completion rate is in the BA degree pathway (P8) at 51 percent, though this category of students is extremely small. Of the other pathways, we find higher completion rates in the health pathway (P4) (37 percent) than elsewhere. These findings suggest that the refusal of males to enter health care fields likely results in lower completion rates for them overall. Furthermore, completion rates in health relative to other pathways appear higher at both the certificate and associate's degree levels. Other pathways, such as those for applied STEM (P2) and certificates/diplomas (P7) also appear to generate certificates or diplomas at moderately high rates; we will show below that these credentials are relatively well-compensated in most (though not all) cases in the labor market as well. On the other hand, completion rates across fields could be driven by differences in the skills and behaviors of the students who select into them, for which we try to control in our estimates below.

One benign interpretation of low completion rates in general is that some students never intend to complete a credential, and perhaps come to just take a course or two which employers might reward – for instance, if someone learns a new computer language or mechanical task – or perhaps they take a course or two strictly for their own interest. Indeed, Bahr and Booth (2012) find that these students constitute about a third of new community college students in California, and that their non-completion should not be regarded as being particularly problematic.

One measure of this might be the percentage of students who take at most one class per semester during their first year. We therefore calculated the percentage of our population of students who took at most one class in the fall semester and one in the spring of 2010-11. In our data, this group constitutes just 11 percent of all enrollees, and they are not numerous enough to fundamentally change

completion rates and patterns. In addition, about a fourth of students in this group do not declare a pathway; others do choose pathways, perhaps reflecting some interest in pursuing a credential.[10]

In Figure 4, we present not only credential completion rates in each of the six years, but also persistence from one year to the next in community college enrollment among students. The data show large attrition rates in enrollment each year; indeed, only about 60 percent of students enrolled in the first year return during the second, and only 40 percent of the original group (and two-thirds of second year enrollees) return the third year. Certificates and diplomas are attained by small percentages of students in the first two years, and we begin to see some associate degree attainment as well in the second, though much more of the latter occurs in years 3-5.

In sum, we find relatively low persistence and completion rates among community college students, with substantial variation across pathways. Certificate pathways offer more promising odds of success for non-ready students**.**

D. Frequent Pathway Transitions

How often do students change their chosen pathways, and might such changes occur more frequently or less efficiently than is possible? The first question is addressed in Figure 5. It shows the rates at which students stay in their initially chosen pathways until the end, switch pathways, or transfer to a different institution (usually a four-year college or university) for each pathway initially chosen.[11]

[10] Our definition of this group is slightly different from that of Bahr and Booth, who count students as "skill-builders" if they take one or two courses per year over the first few years. In our view, someone taking two courses a semester is more likely seeking a credential, while taking one course or none per semester more likely indicates lack of interest in credential attainment. We also believe that declaring a pathway defined by a particular credential signals intent to achieve that credential, so that as few as 3 percent of our cohort (.25 times .11) might be considered "skill-builders."

[11] If students drop out, we include them in their last pathway for all subsequent years.

The results show, as expected, that transfer rates are very high in the small BA pathway (P8), and that nearly 60 percent of students with pathways initially undeclared (P1) change or transfer as well. Of those initially choosing the certificate/diploma pathway, nearly 40 percent switch or transfer, with most of these switching into an associate's pathway. In most of the initially chosen associate's pathways, 30-40 percent switch or transfer, with more of these switching (except for the liberal arts pathway, P6, where larger numbers transfer to 4-year institutions).

Of course, switching pathways can occur for many reasons. Students might find material in the starting pathways too difficult, especially for those not deemed academically ready; they might switch to a less technical field, or simply from an associate's to a certificate pathway, to improve their odds of successfully finishing the program. They might also simply find the material uninteresting or unappealing, or they might become more worried about job prospects afterwards. Perhaps some such pathway switches make sense, as students gain more information and more personal experience within them, though it is possible that some such information could be provided to students earlier by advisors. This also implies that we should separately consider the impacts of pathways chosen on completion by student readiness or by demographics like gender, since we know choices vary along these dimensions.

And how often do students successfully obtain a credential when they stay or switch pathways? Figure 6 shows in-pathway completion (of associate's degrees in pathways 2-6, of certificates/diplomas in P7, and of BAs in P8), as well as certificates/diplomas, out-of-field associate's degrees, and bachelor's degrees in various beginning pathways. The total sample in each case represents all of those who obtained some credential after starting in the given pathway.

The results show that fairly large percentages of credential attainers do so after switching pathways. Well under half of students who started in AA/AS pathways obtain intended degrees in their initial field of study within six years. Many students beginning in associate's degree pathways obtain

certificates/diplomas instead. This is most pronounced among students who initially chose the health pathway (P4), with over 40 percent ultimately obtaining a certificate/diploma instead of an associate's degree in health (30 percent). Another 15-20 percent of students in other associate pathways obtain a degree in a different field of study from the ones that they chose in the first year. The result thus show students can be successful after changing pathways, though these results do not yet indicate at what cost (in terms of longer time to completion) these changes occur.

Clearly, the journey through college is complex. The complexity of the journey, starting with initial choices of pathway, through frequent pathway transitions and/or persistence to completion, can be visually captured by a Sankey diagram (Figure 7). From left to right, the diagram depicts the flow of students from initial enrollment to the end of Year 6, with the width of the links between nodes proportional to the number of students making that specific transition. As discussed above, the flow of students dwindles quickly, representing the number of students who drop out and never to return. Pathway switching is common, and completion is relatively rare. We also notice that a considerable number of students take a break each year before re-enrolling at some point later.

E. Earnings by Credential and Field

To consider the extent to which different college credentials have labor market value, we consider the mean earnings of enrollees who either complete or don't complete credentials in community college. Table 5 presents mean quarterly earnings of those aged 25-34 in 2017. We first present mean earnings for each category of credential attained, as well as for non-attainers of credentials who enrolled in community college, and for high school graduates who never enrolled in college.

We also report the labor market returns to community college enrollment, credential completion, and separately by field or pathway among those who have obtained AA/AS degrees. We measure these as the ratio of their earnings to those of high school graduates only. These estimates do not adjust for earlier achievement or other personal characteristics, like work experience or presence of a child (which is important for earnings among females).[12] All of our estimates are presented for the entire population in each group and then separately by gender.

The results indicate quite strong returns in earnings to college attainment in Kentucky. Returns to BA/BS degrees are highest, though not yet double those for AA/AS degrees, which we typically see in other data.[13] Returns to diplomas are much higher than for certificates, and for the latter the returns for males are much higher than for females. Indeed, the somewhat lower returns for female likely indicate a large fraction with low-paying certificates in fields such as medical assistant or nursing aides. Still, even among females, the returns to certificates compared to high school only look substantial, especially since these credentials frequently take less than a year to complete.

And returns to "some community college" with no credential are just a bit lower than those to certificates for women but substantially lower for men. Returns to community college attendance without credential completion do not appear very strong overall, which further confirms the notion that credential completion still matters importantly for earnings, even when the credential is just a certificate or diploma.

By field, returns to associate's degrees are highest for STEM and health, where completion rates are also high. These results are broadly consistent with those observed in Jepsen et al. (op. cit.) for

[12] For young workers who recently completed college, their labor market experience might lag behind that of non-students, potentially creating a downward bias.

[13] The relative labor market returns to a bachelor's degree relative to sub-BA credentials usually grows over time for any cohort, with earnings to credentials "fanning out" with labor market experience (e.g., Autor, 2014).

Kentucky, and those of Grosz et al. and Backes et al. for the states of California and Florida respectively. Both the returns and completion rates likely reflect (at least partially) student self-selection on abilities, motivations, and other unobservable factors that affect both pathway choices and outcomes. Nevertheless, the very large returns to associate's degrees in these fields for males raise further questions about their low rates of enrollment in health, though their observed earnings there might also be partially elevated by their selection primarily into higher-earning degree programs. Still, returns in health are relatively high for females as well, despite their much higher rates of enrollment than males in this field.

It is noteworthy that the labor market returns to terminal associate's degrees in liberal arts are relatively low for both males and females. If the liberal arts pathway makes a substantial contribution to the earnings of BA/BS degrees for large numbers of students, we would regard this pathway as having more positive expected value. However, there are very few community college enrollees who attain a bachelor's degree; the terminal AA in liberal arts is a much more common outcome for those completing this pathway, and its expected labor market returns are therefore low.

Overall, the summary results suggest that some fields, like applied STEM and health associate's programs as well as those in certificates/diplomas, generate relatively higher completion rates of credentials with labor market value, and at least the latter are easier to complete for those who are not academically ready. The failure of more men to enroll in health, and for more non-ready students to enroll in certificate programs, appears costly to them. And very substantial numbers of students change pathways over time, with costs that we must consider too.

IV. Determinants of Credential Completion

To what extent do choices of pathways, and early outcomes along those pathways, determine credential completion? Below we present estimated impacts of chosen pathways, and of behaviors and intermediate outcomes along the pathways, on credential attainment, while trying to control for both observed and unobserved skills and behaviors of students who self-select into these pathways.

Our first estimates in Section A are based on purely cross-sectional logit equations - binomial for any credential or multinomial for certificates, associate's or bachelor's degrees - in which each student is observed once at the end of the 6-year period, though we control for a wide range of characteristics like achievement and college readiness. In Section B we attempt to control for unobserved heterogeneity of students using fixed effects versions of the binomial logit equations, where students are observed at each semester over the six years. We also explore the use of regression discontinuity (RD) by using the requirement that students maintain GPAs of at least 2.0. Each of these analyses, as we elaborate upon below, has its limitations, but together they strongly suggest that the estimated effects of pathway choices and outcomes on credential attainment described below can be interpreted as being at least partly causal.

A. Cross-Sectional Estimates

In Table 6 we present estimates from binomial and multinomial logit regressions of the following forms:

$$(1) \qquad Y_{ij} = f(X_i, PW_{ij}, Z_{ij}) + u_{ij}$$

where Y denotes whether individual *i* in pathway *j* has obtained any credential in the 6-year period; *X* refers to demographic and early achievement characteristics of the individual; *PW* reflects her chosen

pathway, and *Z* refers to other intermediate outcomes along the pathway.[14] *Y* reflects either a dichotomous variable for the attainment of any credential in a binomial logit equation, or the attainment of a certificate/diploma, associate's or bachelor's degree in the multinomial version (relative to no credential). With only one observation per enrolled student, this version of the equation is purely cross-sectional.

The coefficients on *PW* and *Z* appear in Table 6 for the entire population of students beginning community college in 2010-11; separate estimates by gender or by readiness (for reasons we note earlier) appear in Appendix Tables 1-4.[15] All *PW*s are interpreted relative to no chosen pathway. Separate results appear for the first and last pathways declared by the student. The variables in *Z* include whether the student was college-ready in English and, if not, whether they ever passed a developmental education class;[16] the cumulative numbers of credits taken and percent passed by the end of their time in college; the same variables measured at the end of year 1; the numbers of semesters spent in the first or last pathway, to measure potential costs of switching pathways; and dummies for GPAs of 3.0 and above or 2.0-3.0. Our standard errors have been adjusted for the clustering of students in specific community colleges.

The inclusion of controls for measured college readiness[17] at the end of high school and college GPA is designed to account for differences in cognitive achievement and relevant non-cognitive characteristics across students. And, since we include controls for *overall* credits attempted and passed,

[14] PW and Z are simultaneously determined, and likely affect each other, in some cases – such as cumulative GPA while in college. We have therefore estimated these equations with only one or the other set of these variables, to obtain more complete estimates of effects for each. Results do not differ greatly from those presented here.
[15] Providing separate estimates by readiness makes more sense than doing so by contemporaneous GPA, which is very endogenous to chosen pathways.
[16] Passing is defined as receiving a grade C or higher in developmental classes, defined as sub-100 level courses.
[17] We could have also controlled for high school GPAs and test scores. Doing so, however, limits our analytic sample to recent high school graduates and cuts the sample size by nearly half, while generating qualitatively similar results. When readiness and other measures we use are missing, we have imputed a score of zero and added a dummy variable to represent missing values.

we interpret the coefficients on credits attempted and passed *in the first year* as measures of early "momentum" rather than overall ability to accumulate credits. All estimates in Table 6 appear as odds ratios.

The results of Table 6 indicate a strong association between chosen pathways and credential attainment. The last pathways have stronger effects than the first – presumably because having no declared pathway (the reference category) is more costly in later semesters - though patterns of impacts on credential attainment are similar. The coefficients for attainment of any credential show that the health and certificate/diploma pathways have the most positive associations with credential attainment, while the applied STEM pathway and other occupational fields have stronger impacts than liberal arts. Specifically, in odds ratios, students in health and certificate/diploma pathways are 77 and 69 percent more likely respectively to attain a credential than students who fail to choose a pathway in freshman year. By contrast, students in liberal arts are no more likely than students with undeclared pathway to attain any credentials in a 6-year period.

The coefficients from the multinomial logits for different credential attainment show that the health, applied STEM and certificate/diploma pathways have the strongest associations with certificate attainment, while health and business pathways appear most positive for the attainment of associate's degrees. Compared to students with no chosen pathway in freshman year, students choosing the health and certificate/diploma pathways are 2-3 times as likely to attain certificates/diplomas, while students choosing the applied STEM pathway are 50 percent more likely to do the same. Choosing health and business pathways in one's freshman year is associated with a 50 percent increase in the likelihood of obtaining an associate's degree. The various associate pathways chosen initially also have positive associations with BA attainment, relative to no chosen pathway, while the final ones do not (except for choosing the actual BA pathway). This implies that, early on, students aspiring for a bachelor's degree

can succeed by choosing a sub-BA pathway; but at the end, those without any chosen pathway perhaps transfer more readily to 4-year institutions.

Table 6 also presents estimated effects of choices along these pathways through community college and intermediate outcomes on credential attainment. College readiness at the end of high school is associated with large increases in the likelihood of attaining degrees (by 50 percent for bachelor's degree and 18 percent for associate's degree) but not certificates, where readiness appears less important for completion. Interestingly, for those not ready, passing developmental education does not raise the probability of any credential attainment, and perhaps even reduces the likelihood of certificate attainment by 25%. This is consistent with Clotfelter et al. (2015), who show negative effects from taking developmental education in North Carolina community colleges, and with a broader need for reforms that has been stressed by Long (2014) and Scott-Clayton (2017), among others.

Not surprisingly, credits taken and passed also are positively associated with credential attainment. Each additional credit taken appears to increase the likelihood of credential attainment by 3 percent, and each percentage point increase in credit passing rate increases credential attainment by 2 percent. But, in addition to effects of overall credits taken and attained, those in the first year have positive effects on attainment of all credentials (3 percent increase in likelihood), which are largest for degrees and especially the BA (6 percent increase in likelihood). While passing the credits taken in the first year has no differentially larger impact, passing them (as measured by the overall pass percentage variable) still matters in that year as well. These results clearly suggest that early momentum in credit accumulation can be important for credential attainment.

Also not surprisingly, community college GPA is strongly associated with attainment, with the largest for AA and especially BA acquisition. For example, relative to students with average GPAs below

2.0, those averaging 2.0-3.0 are twice as likely to attain postsecondary credentials and those averaging above 3.0 are almost 5 times as likely to do so.

Importantly, the numbers of semesters spent in pathways are strongly positively associated with credential attainment as well. The latter findings suggest that, while switching into a pathway that is a better match for any individual can have positive impacts on completion, there is an opportunity cost for doing so. Thus, if such switches could be made earlier, the loss of pathway time spent would not be as great for students. Along with the estimated effects of pathway choice and early momentum, these results strongly suggest a need to help students make good early choices and monitor progress towards their goals.

The separate estimates of these measures by gender or by readiness in the Appendix indicate broadly similar impacts of pathways and outcomes across these groups. Estimated impacts for females in most AA pathways are a bit larger than those estimated for males, though being the certificate/diploma pathway appears to have more positive impacts for men; and the fact that being in the health pathway has strongly positive effects for both confirms the potential costs associated with men choosing this pathway less frequently. And, while coefficients among students who are ready are mostly similar or slightly larger than those estimated for non-ready students, pathway impacts for the latter are still sizable, especially when the certificate pathway is chosen first. The value of making the right choices early for less-ready students is strongly implied these estimates.

B. Attempting Causal Estimates: Fixed Effect Logits and Regression Discontinuities

The estimates in Table 6 are from equations that controlled for a range of demographics, college readiness and intermediate college outcomes (like GPA) but not for unobservable heterogeneity across

students. Table 7 therefore presents estimates from fixed effects binomial logit equations where each student is observed in each of 12 semesters.[18]

These estimated equations measure *contemporaneous* effects of chosen pathways and the other variables (for intermediate outcomes) on the probability of attaining a credential in each semester.[19] In the first few semesters, only certificates and diplomas are attainable, so estimates will mostly reflect pathway impacts on those outcomes; during later semesters, associate's and eventually bachelor's degrees are also attainable, with coefficients more likely to reflect those outcomes as well. On the other hand, since the latter degrees cannot be obtained in the first few semesters, we cannot allow the degrees to be separate outcomes, as we had in the cross-sectional multinomial logits described above.

Also, as in any fixed effects model, only those student who switch pathways are included in the relevant samples, and only time-varying characteristics are included. And, importantly, only students with variation in the dependent variable can be included as well – in other words, only those who attained a credential at some point over the six-year period are included here. The sample of students is thus considerably less representative and much smaller than those we use above, though we also gain many degrees of freedom by observing each student many times.[20]

The equations we estimated for results in Table 7 are similar to those presented in Table 6, except they take the following form:

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[18] For students who are not enrolled in all 12 semesters – either because they completed a credential or not – the values of key variables in semesters where they are not observed are usually the same as in the final semester in which they are observed.

[19] We omit the variables measuring credit attempts and passes in the first year, since "momentum" effects are not contemporaneous and presumably are felt only afterwards.

[20] For these reasons, we also do not provide separate estimates of the fixed effects models by gender or readiness, as we did for the cross-sectional models.

$$(2) \qquad Y_{ijt} = g(X_{it}, FPW_{ijt}, LPW_{ijt}, Z_{ijt}) + INDIV_i + YEAR_t + u_{ijt}$$

where *INDIV* denotes fixed personal effects, *YEAR* denotes year fixed effects, and t denotes any semester from 1 to 12. *FPW* and *LPW* measure first and last pathways declared respectively, and attain a value of one only in semesters when individuals declare that particular pathway. Under this coding scheme, a positive coefficient on FPW suggests higher likelihood of credential attainment in the original pathway relative to later pathways, and it indicates that switching away from a particular pathway lowers the likelihood of credential attainment. A positive coefficient on LPW, on the other hand, suggests switching into a particular pathway increases a student's chances of completion. The separate pathway variables thus enable us to measure their estimated associations with credentials attained both before and after the pathway switching occurs, giving us separate estimates of pathways chosen initially and later.

Intermediate outcomes, such as the number of credits taken, percent credits passed, and GPA, are now cumulative measures up to that particular semester. We include in the model the cumulative number of semesters a student has been in a pathway, so that the PW effects reflect the likelihood of credential attainment in the semester when students switch into a particular *PW* and after, relative to before the switch. The formats of the table are largely similar to the preceding one.

Because of the unusual and unrepresentative sample we generate using fixed effects models here, we have also estimated *random effects* models – in other words, the same models without the person fixed effects but over the same numbers of semesters for comparison purposes. We do so both for a broader sample that is comparable to that used in our cross-sectional estimates in Table 6, and also for the same sample as we used in the fixed effects models – which is limited to only students who switch pathways and who attain some type of credential. These random effects estimates appear in columns 1 and 2 of Table 7, and they allow us to infer how much of the changes in estimates we observe

between Tables 6 and 7 reflect changes in the structure of the data (from cross-sectional with only one observation per student to time-varying for each individual), changes in the samples used, and the introduction of fixed person effects respectively.

Overall, the random effects findings in Column 1, based on the full sample, are similar to those presented in Table 6. The certificate and health pathways continue to be the surest routes to obtaining a credential when chosen initially, while STEM and other occupational pathways have positive effects when chosen later. Credits taken and passed remain strong determinants of credential attainment, and the number of semesters spent in each pathway remains an important predictor of credential attainment. When random effects estimates are presented in Column 2, and only for the smaller sample of pathway switchers and credential attainers, most results found for the full sample continue to be observed, though the magnitude of being in the health pathway is reduced, and much larger standard errors render most estimates here not significant.[21]

The fixed effects coefficients in column 3 of Table 7 indicate that choice of pathway still matters. Estimated impacts of first pathway on credential attainment are positive and significant only for certificates/diplomas; coefficients for starting in health pathways remain positive but are smaller than in the RE estimates and are no longer significant. The coefficients on last pathway indicate that, relative to the pathways students switched away from, switching into the certificate pathway increases the likelihood of credential attainment the most, and switching into STEM and other occupational pathways have positive effects too. But the estimated effects of switching into liberal arts pathways are now also sizable.

[21] The much larger standard errors in the smaller sample reflect adjusting for clustering both within the individual and within institutions. But, while estimated pathway effects are no longer significant, the magnitudes of the estimated effects of switching into applied STEM and other occupational fields are larger than in the fuller sample.

Regarding other estimates in column 3, credits taken and passed overall still increase the likelihood of credential attainment (by 5 and 3 percent, respectively). Cumulative GPA until any semester still has positive estimated impacts, as do the numbers of semesters spent in the pathway. Overall, our fixed effects logit estimates – while based on a small and unusual sample - confirm many (though not all) of the results that appear in the cross-sectional and random effects estimates.

Finally, to further test for whether our estimated impacts are truly causal, we use the 2.0 GPA requirements – both overall and within fields of study – to set up a "regression discontinuity" test of the results presented above. There are two different requirements for minimum GPA: one is for overall grades, where continuation in the program requires a 2.0 average; and one is within one's field, where a 2.0 average in field-specific classes is needed in order to receive the specified credential. The idea is that falling below an average GPA of 2.0 may nudge some students to switch pathways and change their credit-taking behavior, thus creating an abrupt discontinuity between otherwise similar student groups (i.e., those with average GPA just above and below 2.0.

The estimated results from a range of RD tests we performed, using both GPA cutoffs we describe above, appear in Appendix Table 5.[22] Indeed, after controlling for GPAs, falling just below 2.0 predicts abrupt, statistically significant changes in credits taken or passed as well as pathway choices. For example, falling just below 2.0 in GPA reduces students' likelihood of choosing the STEM or health pathways in the following year by 4 percentage points.

To the extent that the likelihood of credential attainment would have been a continuous function of GPAs, and that no determinants of attainment change abruptly at the cutoff other than

[22] Due to the presumed "fuzziness" of the discontinuity around the 2.0 cutoff, created by the fact that students who fall below might be put on probation or allowed to stay for other reasons rather than being asked to leave, we estimated a two-stage RD procedure. In the first stage, we use the discontinuity to predict credit attempts and passing, as well as pathway choices; in the second stage, we estimate impacts of these predicted outcomes on credential attainment. More information on our estimates is available from the authors.

treatment (i.e., credits taken or passed and pathway choices), RD estimates represent the causal effect of these treatments on credential attainment for students within the immediate vicinity of the cutoff GPA of 2.0. Unfortunately, because the underlying assumptions of an RD appear to be violated here, [23] we view the RD results, which suggests marginally significant relationships between credits taken or passed and pathway choices and credential attainment, as suggestive or exploratory at best.

Though we were not able to generate RD estimates with strong internal validity, the existence of 2.0 GPA cutoffs both overall and within field – and both for program persistence in any year and for attainment of a credential – create many further opportunities for generating credible RD estimates beyond those we explored. Thus, we regard RD as a promising strategy in studying the determinants of credential attainment, though not really convincing in the current context.

V. Conclusion

Community colleges have the potential to substantially raise the earnings of disadvantaged youth and adults, if they complete associate and certificate programs there with strong rates of return in the labor market. But to what extent is that potential unrealized, and where along their paths of study can improvements be made?

In this paper, we use administrative longitudinal micro-data on students in Kentucky community colleges in the years 2010-16 to estimate associations between pathway choice and outcomes on the attainment of credentials with labor market value. We present cross-sectional estimates based on equations with a wide range of controls for student observable characteristics, as well as estimates

[23] For example, students who are at risk of falling below 2.0 but sufficiently motivated to avoid academic probation may be overrepresented in the just passing group, while students with similar academic proficiency but less motivated may be more prevalent in the just failing group. This type of self-sorting will result in unbalanced treatment and control groups. In addition, students with GPA below 2.0 are subject to academic probation which, like motivation, can also affect student attainment. In other words, credits taken/passed and pathway choices are not the only potential determinants of credential attainment that change abruptly around 2.0.

based on student fixed effects, where we attempt to control for unobserved heterogeneity and estimate causal impacts. We also present some preliminary and exploratory regression discontinuity results, based on the requirement that students maintain GPAs of 2.0 or higher to remain in college and earn a credential. We thus present the most rigorous treatment of pathway effects on outcomes to date, with the greatest effort to control for factors driving student selection in these pathways. Though each of these attempts has its limitations, together they imply that at least some of what we present is causal.

Our main results can be summarized as follows:

- Some pathways, such as health and applied STEM associate's programs and those for certificates more generally, are consistently associated with greater likelihood of sub-BA credential attainment and higher earnings afterwards than other pathways;
- Some student choices of fields of study, and especially differences by gender and academic readiness, do not seem well-informed by these probabilities of later success;
- Student choices of programs of study change frequently, which appear to be at least somewhat costly to student outcomes (by limiting their ability to accumulate needed time within pathways); and
- Early "momentum," generated by enrolling in and attaining credits in the first year (controlling for total credits attempted and passed), has important effects on credential completion rates.

These are new findings within the rigorous empirical research literature, and provide some of the most direct evidence to date that community college students – especially those deemed not "college ready" – seem to make poorly informed choices along inefficient paths. Their completion rates and subsequent earnings could potentially be improved substantially with a number of reforms that encourage better-informed choices and with improvements in certain supports provided there.

First, though some information about pathways can only be obtained by students from direct experience, we believe the results imply a great student need for more guidance in choosing paths of study - especially those who are disadvantaged and have lower academic readiness. While access to data on student success rates in various paths of study, conditional on student achievement, are necessary to improve their choices, they are very unlikely to be sufficient. Disadvantaged students need more direct guidance, so providing more such academic and career guidance to students is necessary as well. Indeed, many community college students receive remarkably little academic or career counseling, at least partly due to institutional budget constraints (Holzer and Baum, op. cit.). Yet the costs to students in terms of lower performance and inability to accumulate important time within their chosen pathways are significant, and the returns to the provision of more guidance would likely be high as well.

But two more issues arise here that are more about community colleges as institutions. For one thing, given the unstructured nature of the institution in many places (e.g., Scott-Clayton, 2011), perhaps students need more formal institutional structure, and not just guidance along amorphous pathways, to improve their choices. This is, in fact, the point of building "guided pathways" at these institutions that Bailey, Jenkins and Jaggers call for in their recent book (2015). Though we do not yet have evidence on either the costs or student benefits of building such pathways, important experimentation with this concept is occurring around the country, and we will need to carefully consider evidence from evaluations of their cost-effectiveness.

In addition, if changes in guidance lead to major increases in student demand for occupational instruction in sub-BA credential programs like health care, there are questions about whether there will be sufficient institutional capacity in many community colleges to meet such demands. Holzer and Baum op. cit. argue that aligning the supply of instructional capacity with demand might require not only more funding for community colleges, but also changes in the incentives they face to respond to external

labor market forces and to allocate funds internally to meet student need. Broader reforms in institutional financing as well as structure might therefore be needed to meet such challenges.[24]

A second broad implication of our results involves the importance of first-year "momentum" in generating student success. Students apparently have difficulty generating momentum for at least two reasons: they have trouble taking enough classes and credits, and they have trouble passing them.

A failure to take sufficient numbers of courses and credits, especially among nontraditional (older) students, frequently reflects pressure to be employed full-time and support families (Holzer and Baum, op. cit.). Providing more stipends to students to help them meet financial needs might be helpful here; doing so within the context of more possibilities for "work-based learning," such as paid internships and apprenticeships, might be particularly helpful. Calls for more work-based learning are usually made on the basis of their impacts on subsequent student earnings, not their short-term cash needs; but providing for the latter could be important as well for many disadvantaged students and could be one more reason to expand workplace learning.

And improving the ability of students to pass their first-year classes would clearly help too. The need to reform "developmental education" has clearly been demonstrated by Bettinger et al. (2013) as well as by Long and Scott-Clayton op. cit. Promising proposals for doing so often begin with making developmental classes "co-requisite" for taking classes for full credit rather than "pre-requisite," changing the diagnostic tests used to determine need for remediation, and changing the subject matter and delivery of such remediation. Efforts to implement such reforms are being made, and the need to evaluate the impacts of such reforms is very strong.

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[24] For instance, when using outcome-based funding to allocate state subsidies to public higher education institutions, states might consider putting more weight on the subsequent earnings of their students, rather than academic measures alone. Of course, adjusting for the skills of entering students is critical when using institutional performance measures for funding, to prevent incentives for creaming in admissions. And institutions might also allow the units on campus to keep more of the revenue they generate, to create stronger institutional responsiveness to student demand for courses. On the latter topic, see Fethke and Policano (2012) as well.

Reforms along these lines, if they prove cost-effective, have the potential to improve student outcomes in important ways, and allow community colleges to live up to their potential as an important way of getting sub-BA credentials with labor market value for the many students who need them.

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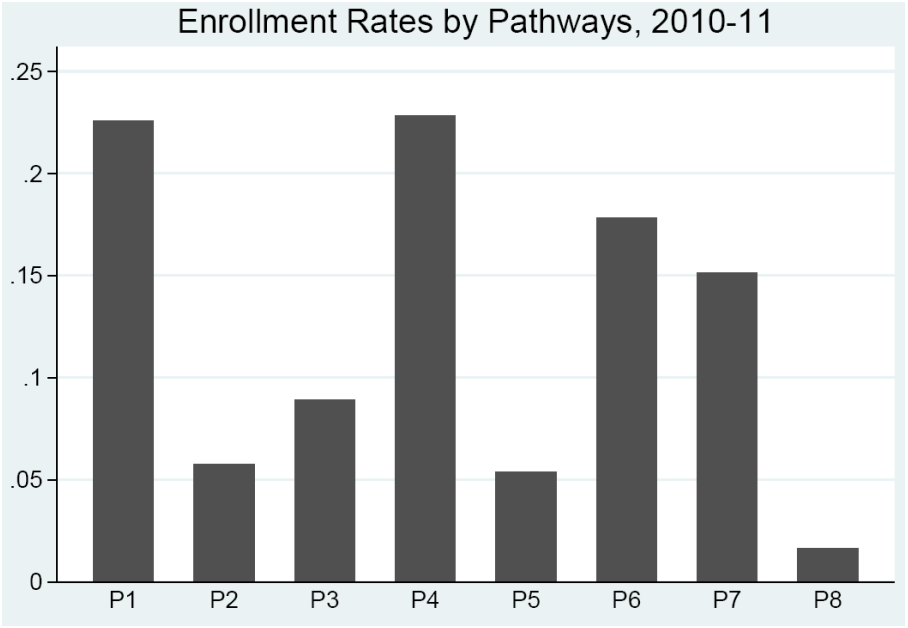
Figures

Figure 1: Pathway Distribution



Note: Pathway definitions appear in Table 2 below.

Figure 2: Credential Completion

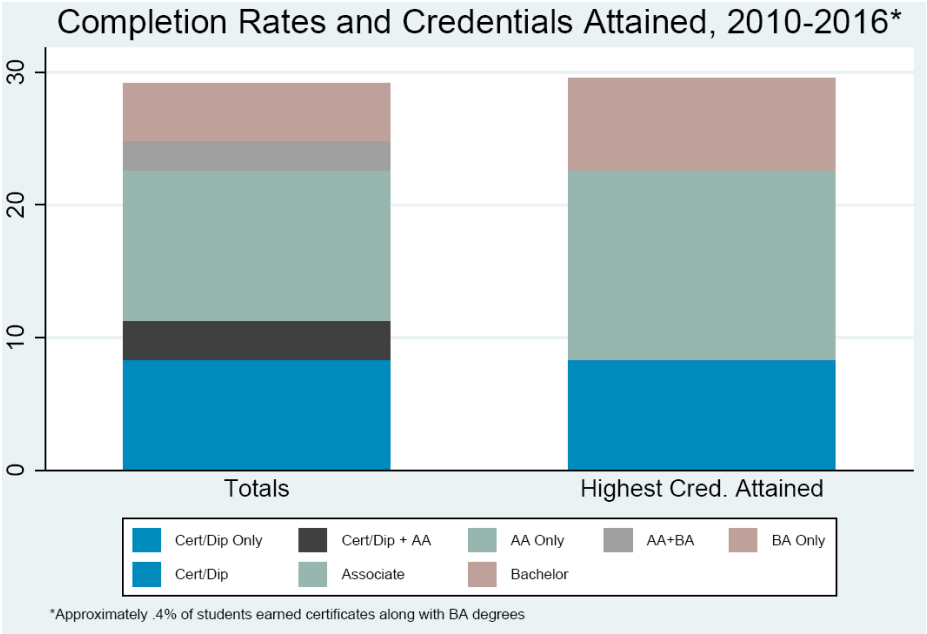


Figure 3: Credentials Completed by Starting Pathway

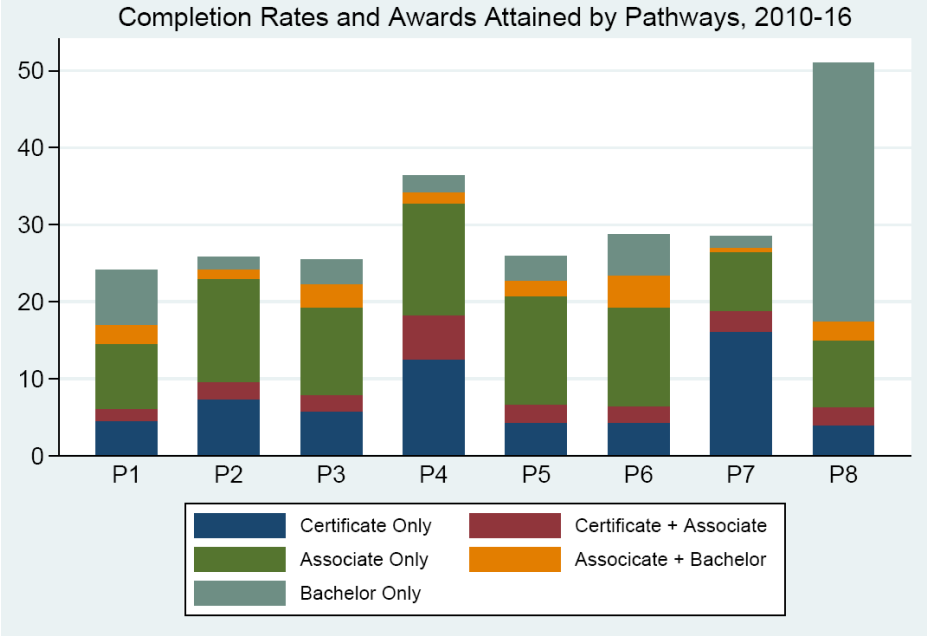


Figure 4: Progression Through College Over 6 Years

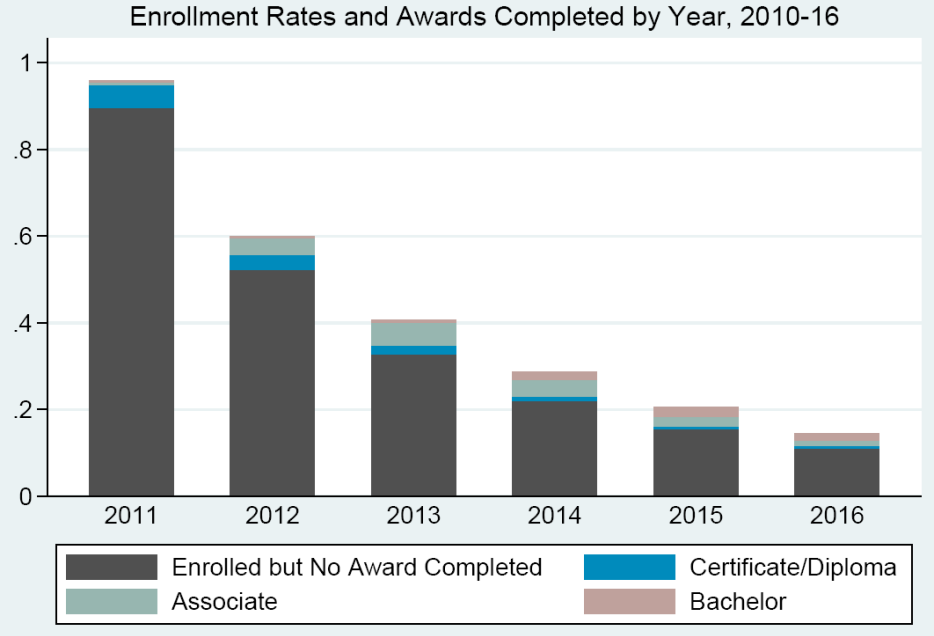


Figure 5: Pathway Transition and 4-Year Transfer

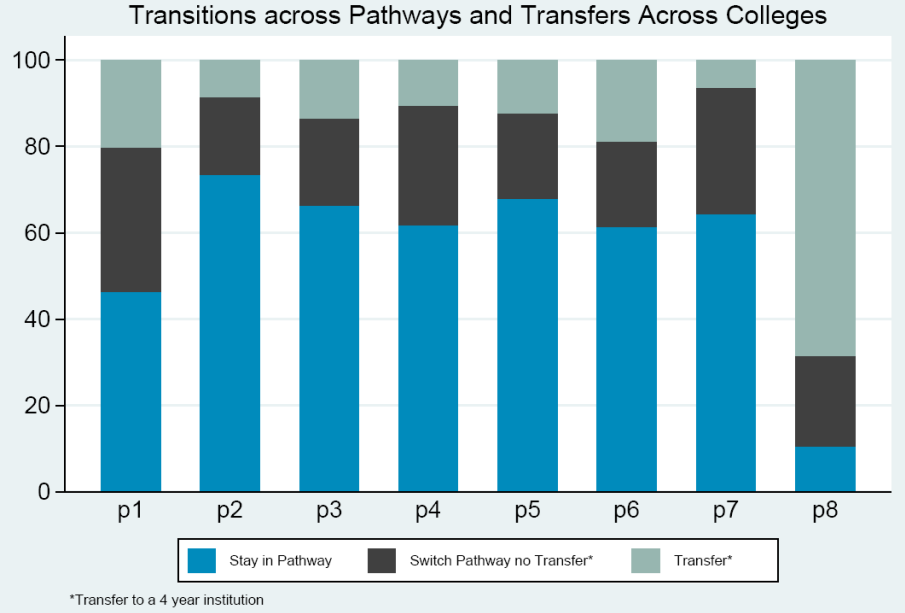


Figure 6: Types of Credentials Earned by Pathway

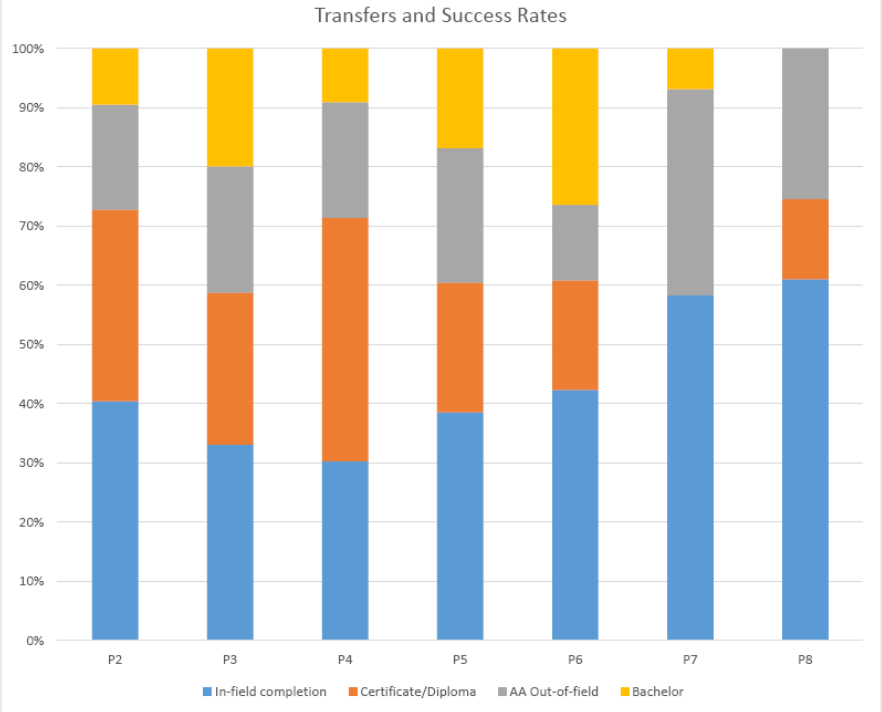
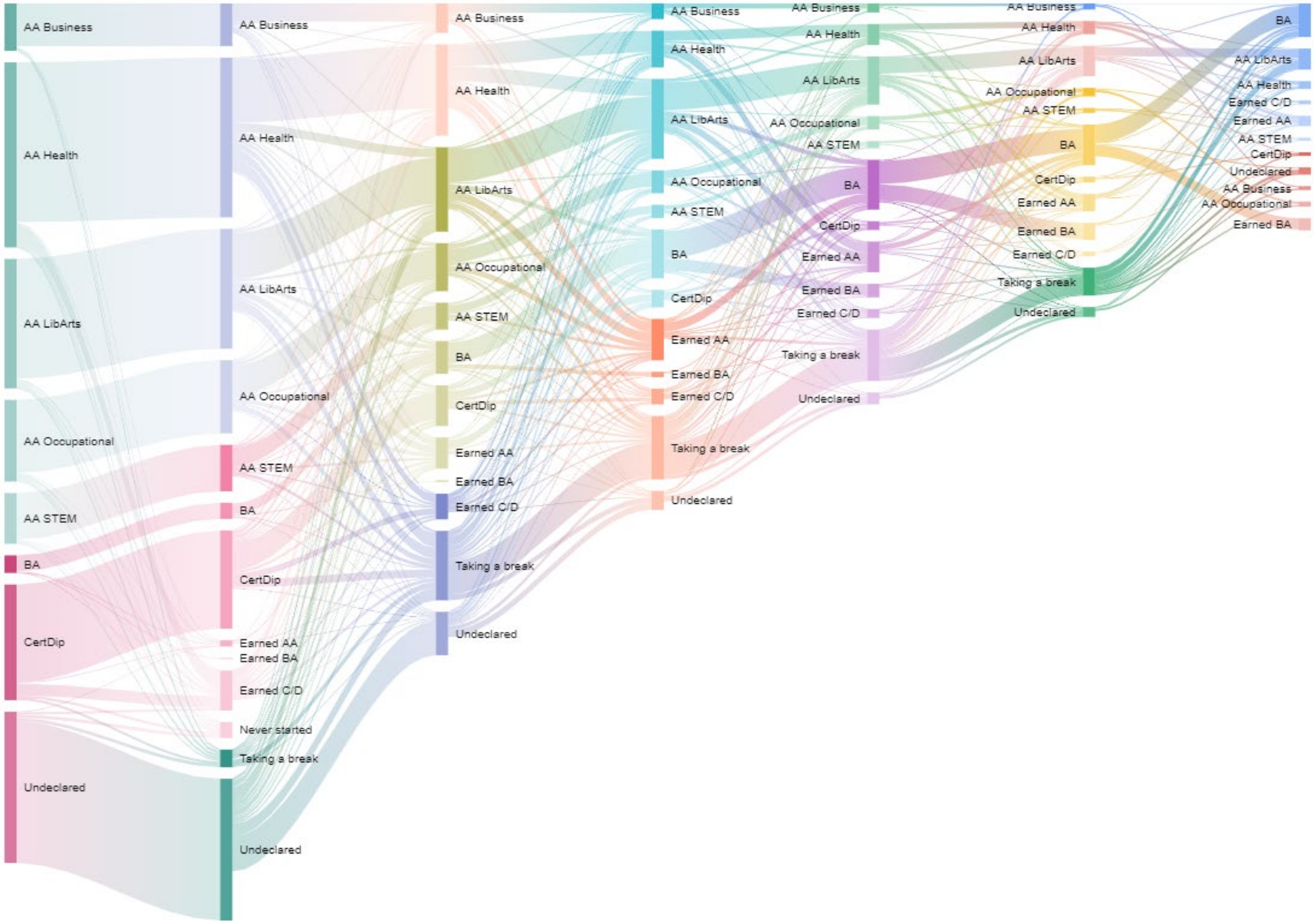


Figure 7: A Journey Through College: Pathway Choices and Switches, Persistence and Completion



Tables

Table 1: Summary Statistics

Student Characteristics	Mean	SD
Age<=24	0.56	0.50
Age>24	0.44	0.50
Male	0.41	0.49
Black	0.13	0.34
Hispanic	0.02	0.14
College Readiness		
Math	0.28	0.45
English	0.57	0.49
Reading	0.60	0.49
Overall	0.26	0.44

Table 2a: Pathway Definitions

Pathway	Pathway Description
1	No major/program declared (Reference Group)
2	Associates degree program in an applied STEM
3	Associates degree program in other occupational fields
4	Associates degree program in occupational health field
5	Associates degree program in occupational business field
6	Associates degree program in liberal arts/social sciences
7	Diploma or Certificate
8	Bachelor or Higher

Table 2b: Examples of Majors in Pathways

Pathway	Most Common Majors	Number of Enrollments
2	Computer And Information Sciences	1,513
	Engineering Technology, General	372
	Automobile/Automotive Mechanics	327
	Industrial Mechanics And Maintenance	289
	Data Processing	170
3	Criminal Justice Administration	2,023
	Teacher Assistant/Aide	1,058
	Social Work	868
	Child Care Provider/Assistant	787
	Fire Science/Fire-Fighting	375
4	Registered Nursing (Rn, Asn, Bsn)	10,022
	Medical Radiologic Technology/Science	1,449
	Physical Therapy Technician/Assistant	755
	Medical Administrative/Executive Assistant	694
	Diagnostic Medical Sonography/Sonographer and Ultrasound Technician	508

Table 3: Percentage Distribution of Pathway Enrollment, by Student Group

Starting Pathway	Total	Gender		Age		College Ready	
		Male	Female	<=24	>24	Yes	No
Undeclared	22.56	25.30	20.68	27.03	16.96	30.37	24.12
Applied STEM	5.75	12.03	1.44	4.99	6.70	5.58	5.93
Occupational	8.91	9.48	8.52	8.44	9.50	6.53	9.55
Health	22.80	8.99	32.29	20.79	25.33	19.07	20.96
Business	5.39	5.22	5.50	4.09	7.01	4.45	4.93
Social sciences	17.82	20.21	16.18	19.33	15.93	20.34	16.38
Diploma/Certificate	15.12	17.14	13.73	12.79	18.03	9.40	16.55
Bachelor or Higher	1.67	1.64	1.68	2.54	0.56	4.29	1.60
Number of students	67,670	27,546	40,124	37,649	30,021	8,561	24,880

Note: The pathways are based on the majors chosen by students in the first semester of their first year (2010-11) enrolled in community college. Columns sum to one. The sample size for College Ready (Overall) and College Ready (English) are smaller due to missing values. See Table 1.

Table 4: Six-Year Completion Rate, by Student Group and Credential Type: 2011–2016

Awards	All	Gender		Age		College Ready	
		Male	Female	<=24	>24	Yes	No
Totals							
Certificate & Diploma Only	8.33	6.45	9.62	7.10	9.88	6.21	8.68
Certificate + AA	2.93	1.75	3.74	2.51	3.45	3.99	2.38
Associate Only	11.36	9.71	12.49	10.26	12.73	14.66	8.58
Associate + Bachelor	2.20	2.01	2.34	2.64	1.66	5.21	1.36
Bachelor Only	4.33	4.29	4.36	6.15	2.05	11.17	2.97
Complete							
Any Credential	29.54	24.42	33.06	29.12	30.07	42.20	24.15
Certificate/Dip.	11.65	8.40	13.88	10.07	13.63	11.17	11.24
Associate	16.66	13.55	18.79	15.60	17.99	24.28	12.40
Bachelor	6.93	6.50	7.22	9.25	4.01	17.33	4.51
Highest Credential Attained							
Certificate & Diploma	8.33	6.45	9.62	7.10	9.88	6.21	8.68
Associate	14.29	11.46	16.22	12.77	16.19	18.65	10.96
Bachelor	6.93	6.50	7.22	9.25	4.01	17.33	4.51

Note: In addition to the combinations list, approximately .4% of students earned certificates along with BA degrees; these individuals are included in the total counts.

Table 5: Mean Quarterly Earnings by Education, Ages 25-34 in 2017

	Total		Male		Female	
Education Attainment	Quarterly Earnings ($)	Return to Credential	Quarterly Earnings ($)	Return to Credential	Quarterly Earnings ($)	Return to Credential
BA/BS	11,724	1.96	12,753	1.89	10,992	2.32
AA/AS	9,724	1.62	11,167	1.65	8,917	1.88
Diploma	9,545	1.59	11,293	1.67	8,145	1.72
Certificate	7,456	1.24	9,946	1.47	5,814	1.23
Some college	7,706	1.29	8,917	1.32	6,276	1.32
High school only	5,995	–	6,752	–	4,738	–
AA/AS by pathway						
STEM	12,332	2.06	12,838	1.90	7,809	1.65
Business	8,430	1.41	10,653	1.58	7,659	1.62
Health care	11,399	1.90	13,177	1.95	11,168	2.36
Other occupations	9,608	1.60	12,310	1.82	6,147	1.30
Liberal Arts	8,286	1.38	9,732	1.44	7,352	1.55

Note: Quarterly earnings are the average earnings of the 2nd and 3rd quarters. Return to credential is calculated as the ratio of earnings to those of a high school graduate.

Table 6: Regression Results: Effects of Pathways and Intermediate Outcomes on Credential Attainment

	First Pathway				Last Pathway			
	Any credential	Bachelor	Associate	Cert/dip	Any credential	Bachelor	Associate	Cert/dip
Pathway								
STEM	1.367***	1.012	1.291**	1.498***	1.472***	0.005***	1.970***	1.965***
Occupational	1.352***	2.528***	1.314**	1.227	1.338*	0.028***	2.035***	1.544*
Health	1.765***	1.484**	1.540***	2.027***	2.364***	0.029***	3.424***	2.734***
Business	1.288***	2.456***	1.462***	0.897	1.278*	0.036***	2.329***	1.103
SS/lib arts	1.075	1.897***	1.098	0.867	1.173	0.037***	1.677**	1.475*
Cert/dip	1.689***	0.761	0.939	2.715***	2.119***	0.047***	1.140	4.194***
BA	1.301	4.981***	0.862	1.261	1.366**	1.722***	0.902	0.369***
College ready (Eng)	0.898*	1.504***	1.181*	0.702***	0.885**	1.369**	1.148*	0.706***
Not college ready, passed Dev Ed	0.798***	0.776*	0.957	0.749***	0.829***	0.784	0.995	0.793***
Cum. # credits taken	1.034***	1.073***	1.039***	1.016***	1.034***	1.044***	1.043***	1.024***
Pct. credits passed	1.020***	1.006	1.039***	1.013***	1.020***	1.016**	1.040***	1.012***
Year 1 # credits taken	1.025***	1.055***	1.032***	1.017***	1.028***	1.059***	1.035***	1.017***
Year 1 pct. credits passed	1.000	1.002	0.998***	1.002***	1.000	0.999	0.998**	1.003***
2.0-3.0 GPA	2.214***	19.264***	4.443***	1.675***	2.220***	12.587***	4.403***	1.706***
3.0 GPA and higher	4.927***	141.117***	10.730***	2.132***	4.840***	83.128***	10.349***	2.135***
Semesters in pathway	1.054***	0.872***	1.114***	1.062**	1.036***	1.300***	1.022	0.983
pseudo R-sq	0.42		0.38		0.42		0.42	
N			67,670				67,670	

* p<0.05, ** p<0.01, *** p<0.001

Note: Standard errors are adjusted for clustering in community college; coefficients are presented as odds ratios. The first column represents results from a binomial logit regressions for the attainment of any credential, while the next three represent results from a multinomial regression with three possible credentials attained: bachelor's degree, associate's degree, and certificate/diploma. The reference group for pathways is "undeclared." These regressions are cross-sectional, with just one observation per student reflecting the 6-year period.

Table 7: Regression Results with Random and Fixed Effects

Any credential	**Overall Sample: RE**	**FE sample: RE**	**FE**
Cum. # credits taken	1.026***	1.017	1.048***
	(0.002)	(0.063)	(0.002)
Pct. credits passed	1.025***	1.010	1.034***
	(0.002)	(0.022)	(0.003)
Year 1	1.433**	1.258	4.063***
	(0.182)	(3.094)	(0.557)
Year 2	1.435***	1.218	3.062***
	(0.126)	(1.042)	(0.309)
Year 3	1.528***	1.240	2.426***
	(0.094)	(0.522)	(0.152)
Year 4	1.355***	1.141	1.731***
	(0.043)	(0.280)	(0.065)
Cum. # semesters in pathway	1.125***	1.188	1.355***
	(0.016)	(1.173)	(0.024)
First Path 2) AA STEM	0.989	0.902	0.873
	(0.082)	(0.960)	(0.100)
First Path 3) AA Occupational	1.060	0.958	0.834
	(0.061)	(0.752)	(0.093)
First Path 4) AA Occupational Health	1.330***	1.162	1.082
	(0.079)	(0.096)	(0.108)
First Path 5) AA Occupational Business	1.008	0.931	0.607***
	(0.052)	(1.079)	(0.080)
First Path 6) AA Social Sciences	1.033	0.957	1.137
	(0.058)	(0.447)	(0.093)
First Path 7) Diploma or Certificate	1.469***	1.425	1.240*
	(0.132)	(0.308)	(0.112)
First Path 8) BA or higher	0.939	0.781	1.330
	(0.208)	(0.199)	(0.250)
Last Path 2) AA STEM	1.249*	1.552	1.517**
	(0.109)	(1.146)	(0.231)
Last Path 3) AA Occupational	1.186***	1.565	1.417**
	(0.059)	(1.737)	(0.167)
Last Path 4) AA Occupational Health	1.209**	1.099	0.573***
	(0.071)	(0.359)	(0.040)
Last Path 5) AA Occupational Business	1.162	1.461	1.102
	(0.092)	(1.091)	(0.186)
Last Path 6) AA Social Sciences	0.968	1.426	1.280**
	(0.040)	(1.129)	(0.100)
Last Path 7) Diploma or Certificate	1.661***	1.842	1.133
	(0.068)	(1.797)	(0.180)
Last Path 8) BA or higher	0.301***	0.359	0.131***
	(0.029)	(1.269)	(0.017)
Cum. GPA	1.448***	1.153	2.133***
	(0.037)	(0.228)	(0.141)
N (Student-Semesters)	279,014	129,728	129,728

N (Students)	67,670	18,589	18,859

* p<0.05 ** p<0.01 *** p<.001

Note: Standard errors are adjusted for clustering within community college; coefficients are presented as odds ratios. The first column represents results from a binomial logit regression for the attainment of any credential for the overall sample and is estimated using a random effects model. The second column presents random effects estimates for the same sample used in the fixed effects regression; in this case, the sample includes only those students who attained a credential and changed pathways during the 6-year period. The third column represents results from the same binomial logit regression, but includes fixed effects. The reference group for pathways is "undeclared."

Appendix

Appendix Table 1: Regression Results: Effects of Pathways and Intermediate Outcomes on Credential Attainment (Males)

Pathway	First Pathway				Last Pathway			
	Any credential	Bachelor	Associate	Cert/dip	Any credential	Bachelor	Associate	Cert/dip
Pathway								
STEM	1.125	0.671	1.242*	1.091	0.996	0.000***	1.491*	1.134
Occupational	1.280**	3.103***	1.245*	1.120	1.162	0.018***	1.789***	1.345
Health	1.830***	1.682**	1.557***	2.102***	2.246***	0.020***	3.137***	2.647***
Business	1.422***	2.750***	1.668***	0.997	1.328**	0.020***	2.333***	1.229
SS/lib arts	1.108	2.309***	1.150	0.880	1.138	0.026***	1.564*	1.505**
Cert/dip	1.837***	0.927	1.064	2.700***	2.138***	0.029***	1.185	3.889***
BA	1.374	5.380***	0.879	1.422	1.469***	1.487*	1.042	0.470***
College ready (Eng)	0.917	1.350**	1.119	0.800*	0.900	1.311	1.096	0.793**
Not college ready, passed Dev Ed	0.703***	0.498***	0.770*	0.735***	0.731***	0.507***	0.813	0.770***
Cum. # credits taken	1.035***	1.078***	1.041***	1.018***	1.034***	1.048***	1.044***	1.024***
Pct. credits passed	1.019***	1.001	1.041***	1.012***	1.019***	1.014*	1.043***	1.011***
Year 1 # credits taken	1.018***	1.056***	1.029***	1.005	1.020***	1.059***	1.033***	1.005
Year 1 pct. credits passed	1.000	1.004	0.998**	1.003***	1.001	1.000	0.998*	1.003***
2.0-3.0 GPA	1.997***	28.401***	4.645***	1.532***	1.992***	19.197***	4.539***	1.552***
3.0 GPA and higher	4.383***	247.665***	11.055***	1.881***	4.223***	137.913***	10.391***	1.887***
Semesters in pathway	1.049***	0.861***	1.114***	1.042*	1.041**	1.367***	1.039*	0.977
pseudo R-sq	0.4		0.38		0.4		0.42	
N	40,124							

* p<0.05, ** p<0.01, *** p<0.001

Note: In Appendix Tables 1-4, standard errors are adjusted for clustering within community college; Coefficients are presented as odds ratios. The first column represents results from a binomial logit regressions for the attainment of any credential, while the next three represent results from a multinomial regression with three possible credentials attained: bachelor's degree, associate's degree, and certificate/diploma. The reference group for pathways is "undeclared." These regressions are cross-sectional, with just one observation per student reflecting the 6-year period.

Appendix Table 2: Regression Results: Effects of Pathways and Intermediate Outcomes on Credential Attainment (Females)

Pathway	First Pathway				Last Pathway			
	Any credential	Bachelor	Associate	Cert/dip	Any credential	Bachelor	Associate	Cert/dip
Pathway								
STEM	1.339*	0.981	1.225	1.537*	1.588***	0.009***	2.181***	2.117**
Occupational	1.456**	1.818**	1.416*	1.436	1.666**	0.053***	2.490***	1.917*
Health	1.660***	1.256	1.573**	1.897***	2.733***	0.061***	4.201***	2.950***
Business	1.099	2.126***	1.161	0.738	1.139	0.100***	2.240***	0.729
SS/lib arts	1.014	1.450*	1.025	0.843	1.200	0.061***	1.852***	1.311
Cert/dip	1.431*	0.568**	0.777	2.591***	2.054***	0.084***	1.085	4.494***
BA	1.165	4.302***	0.813	0.899	1.238	2.263***	0.762	0.219***
College ready (Eng)	0.882**	1.708***	1.251*	0.587***	0.887*	1.449**	1.234*	0.616***
Not college ready, passed Dev Ed	0.967	1.323	1.285*	0.782**	1.016	1.346	1.319**	0.858
Cum. # credits taken	1.033***	1.067***	1.035***	1.015***	1.034***	1.039***	1.041***	1.025***
Pct. credits passed	1.022***	1.016	1.034***	1.015***	1.022***	1.021**	1.036***	1.014***
Year 1 # credits taken	1.036***	1.053***	1.035***	1.036***	1.038***	1.056***	1.037***	1.035***
Year 1 pct. credits passed	0.999	0.999	0.998	1.001	0.999	0.996**	0.998*	1.002
2.0-3.0 GPA	2.741***	12.399***	4.077***	2.087***	2.747***	8.394***	4.065***	2.123***
3.0 GPA and higher	6.239***	70.089***	10.162***	2.823***	6.192***	48.695***	9.925***	2.749***
Semesters in pathway	1.060***	0.887***	1.112***	1.093***	1.028*	1.211***	0.995	0.996
pseudo R-sq	0.44		0.4		0.45		0.43	
N				27,546				

* p<0.05, ** p<0.01, *** p<0.001

Appendix Table 3: Regression Results: Effects of Pathways and Intermediate Outcomes on Credential Attainment (College Ready)

	First Pathway				Last Pathway			
	Any credential	Bachelor	Associate	Cert/dip	Any credential	Bachelor	Associate	Cert/dip
Pathway								
STEM	1.468***	1.044	1.381**	1.558	2.158***	0.024***	3.243***	2.838***
Occupational	1.252*	2.258***	1.265	0.941	1.721***	0.107***	2.949***	1.756**
Health	1.877***	1.256	1.491**	2.348***	3.129***	0.049***	4.782***	3.751***
Business	1.328*	2.937***	1.410*	0.806	1.556**	0.000***	3.139***	1.247
SS/lib arts	1.058	1.814***	1.035	0.788	1.455*	0.050***	2.367***	1.738*
Cert/dip	1.682***	0.845	0.973	2.844***	2.577***	0.092***	1.761*	5.192***
BA	0.906	2.753***	0.487	1.059	1.489*	1.548*	0.937	0.400**
Cum. # credits taken	1.033***	1.074***	1.034***	1.015***	1.034***	1.049***	1.040***	1.023***
Pct. credits passed	1.022***	1.010	1.040***	1.013***	1.021***	1.015	1.042***	1.012***
Year 1 # credits taken	1.025***	1.057***	1.029***	1.014**	1.026***	1.056***	1.030***	1.014**
Year 1 pct. credits passed	0.998*	1.006**	0.996***	1.001	0.999	1.003	0.996***	1.001
2.0-3.0 GPA	2.296***	23.984***	4.338***	1.577***	2.314***	18.219***	4.257***	1.618***
3.0 GPA and higher	6.047***	182.307***	12.224***	2.038***	6.008***	135.171***	11.386***	2.059***
Semesters in pathway	1.049***	0.888***	1.117***	1.073**	1.007	1.225**	0.972	0.968
pseudo R-sq	0.45		0.41		0.45		0.45	
N				19,157				

* p<0.05, ** p<0.01, *** p<0.001

Appendix Table 4: Regression Results: Effects of Pathways and Intermediate Outcomes on Credential Attainment (Not College Ready)

	First Pathway				Last Pathway			
	Any credential	Bachelor	Associate	Cert/dip	Any credential	Bachelor	Associate	Cert/dip
Pathway								
STEM	1.613***	0.761	1.470*	1.757***	1.491**	0.000***	1.435	1.877***
Occupational	1.357	2.143	1.590*	1.165	1.350*	0.000***	1.831**	1.384
Health	1.865***	1.316	1.512*	2.087***	2.493***	0.000***	2.602***	2.757***
Business	1.260	3.720***	1.748**	0.903	1.274	0.128**	2.294***	1.012
SS/lib arts	1.082	1.404	1.138	0.976	1.211	0.038**	1.451	1.379
Cert/dip	1.781***	0.685	0.862	2.438***	2.158***	0.032**	0.756	3.366***
BA	1.275	4.079**	1.083	1.259	0.822	0.955	0.558	0.242***
Cum. # credits taken	1.033***	1.098***	1.050***	1.017***	1.037***	1.067***	1.055***	1.026***
Pct. credits passed	1.021***	1.022	1.054***	1.016***	1.021***	1.025*	1.055***	1.015***
Year 1 # credits taken	1.029***	1.061***	1.031***	1.032***	1.030***	1.061***	1.035***	1.032***
Year 1 pct. credits passed	1.000	1.008*	1.000	1.001	1.001	1.002	1.000	1.002
2.0-3.0 GPA	1.993***	27.560***	4.607***	1.676***	1.992***	25.114***	4.528***	1.615***
3.0 GPA and higher	3.827***	171.809***	9.571***	2.379***	3.762***	152.725***	9.478***	2.220***
Semesters in pathway	1.042**	0.887**	1.072**	1.066**	0.991	1.292**	0.990	0.979
pseudo R-sq	0.42		0.4		0.42		0.43	
N	14,284							

* p<0.05, ** p<0.01, *** p<0.001

Appendix Table 5: Regression Discontinuity Tests of Causal Effects

Running Variable	Running Variable Year	Treatment	Outcome	RD Estimate			First Stage	
				Coefficient	Standard Error	P>|z|	Coefficient	P>|z|
Overall GPA	2012	Credits taken 2013	Any AA	0.0013	0.0007	0.063	-15.7090	0.0000
Overall GPA	2012	Pct. Credits passed 2013	Any AA	0.0017	0.0009	0.069	-11.6470	0.0000
Overall GPA	2012	Credits taken 2013	Any Cert.	0.0009	0.0005	0.088	-18.2320	0.0000
Overall GPA	2012	Pct. Credits passed 2013	Any Cert.	0.0011	0.0007	0.088	-14.0960	0.0000
STEM GPA	2012	Pct. Credits passed 2012	AA in 2012	0.0012	0.0011	0.288	-14.5270	0.0000
STEM GPA	2012	Credits taken 2013	Any AA	0.0018	0.0011	0.110	-22.5450	0.0000
STEM GPA	2012	Pct. Credits passed 2013	Any AA	0.0022	0.0019	0.232	-20.0510	0.0000
STEM GPA	2012	STEM in 2013	Cert. in 2013	0.2880	0.2283	0.207	-0.0477	0.0040
STEM GPA	2012	Health in 2013	Cert. in 2013	0.3531	0.2886	0.221	-0.0470	0.0740
STEM GPA	2012	Cert. in 2013	Cert. in 2013	0.4933	0.4919	0.316	-0.0399	0.1260
STEM GPA	2012	STEM in 2013	Any Cert.	0.3531	0.3165	0.265	-0.0403	0.3000
STEM GPA	2012	STEM in 2013	Any AA	0.5197	0.5367	0.333	0.0113	0.0060
STEM GPA	2012	Health in 2013	Any AA	0.6960	0.5512	0.207	-0.0375	0.0360
STEM GPA	2012	Cert. in 2013	Any AA	1.3395	1.3463	0.320	-0.0332	0.1260