Essays on the Economics of Education: Structured Transfer Programs, Enrollment Patterns, and Efficiency at Community Colleges

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ABSTRACT

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In the United States, community colleges serve nearly half of the 18 million students enrolled in postsecondary education. However, it has only been the last decade or so where these public, two-year institutions have claimed substantial attention from the research community. This dissertation consists of three essays that focus on aspects of the community college student pathway and feature analyses relevant to research, college, and state stakeholders.

The first essay evaluates the effectiveness of structured transfer pathways for Associate in Arts and Associate in Science degrees in North Carolina (called pre-major programs). It asks how these programs impact student behavior and the postsecondary outcomes of earning a community college credential, transferring to a four-year institution, and earning a baccalaureate degree compared to students enrolled in conventional, less structured associate degree programs. The paper employs an instrumental variables technique that exploits exogenous variation in student exposure to the pre-major program opportunity. Among first-time in college students, reduced-form estimates suggest that pre-major programs have a negative intent-to-treat effect on earning the intended community college credential among students enrolled in institutions that offer pre-majors. However, the program offer does not appear to have an effect on four-year credential outcomes. A plausible explanation for the findings is not that structured programs are ineffective, but rather, there likely is a failure

in the policies between two-year and four-year colleges that govern the transfer of credits. Alternatively, the programs may simply be too "light touch" to result in detectable impacts.

The second essay examines the relationship between community college enrollment patterns and two successful student outcomes – credential completion and transfer to a four-year institution. It also introduces a new way to visualize the various attendance patterns of community college students. Patterns of enrollment intensity (full- or part-time status) and continuity (enrolling in consecutive terms or skipping one or more terms) are graphed and then clustered according to their salient features. Using data on cohorts of first-time community college students at five colleges in a single state, the study finds that over an 18-semester period, ten patterns of attendance account for nearly half the students, with the two most common patterns characterized by enrolling in one semester full time or one semester part time. Among the remaining students who persisted, there is astounding variation in their patterns of enrollment. Clustering reveals two relationships: the first is a positive association between enrollment continuity and earning a community college credential and the second is a positive association between enrollment intensity and the likelihood of transfer.

The third essay discusses an economic model for community college pathways. In a departure from cost models that use cross-sectional data to relate college expenditures to student outcomes, this paper takes a longitudinal cohort approach to estimate pathway costs. It suggests a model for estimating costs, revenues, and efficiency metrics for cohorts of students progressing through a community college. The framework is then used to simulate how economic metrics change as intermediate student and institutional goals are accomplished, with a special emphasis on informing colleges engaging in reform processes. It is argued that goals with the greatest efficiency (such as increasing completion rates for students who have earned 30 credits but have not earned a credential) should be preferred when budget consciousness is prioritized.

Efficiency is a central theme running through the essays. In the first essay, structured transfer pathways are not found to be more efficient (in terms of student progression) than unstructured pathways, likely due to policy weaknesses. The second essay highlights the

scattered enrollment patterns generated by community college students, many of which are not efficient pathways for completing college. The third essay explicitly measures the expenditures and outputs to understand efficiency quantitatively and to see how college reforms may improve efficiency.

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To Mom and Dads

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Do Structured Programs of Study in Community Colleges Affect Postsecondary Outcomes?

1.1 Introduction

Despite the numerous documented social and economic benefits associated with receiving a college education, completion and transfer rates at community colleges remain too low (Belfield & Bailey, 2011; Belfield & Levin, 2007). One explanation for the low success rates found among community college students is that they become lost while "navigating a sea of choices" en route to the degree (Scott-Clayton, 2011). Students become overwhelmed by the number and types of decisions they must make, and thus the result is often failure to earn a credential or transfer.

To address the challenges students face in making decisions, researchers have suggested introducing structures - or improving existing ones - that specifically work to compensate for decision-making difficulties and lead to better outcomes (Scott-Clayton, 2011). This structure hypothesis posits that community college students are more likely to succeed in programs and environments that are tightly and consciously structured and that have little

room for deviation.

For example, one may consider students who desire to transfer to a four-year institution, as preparing students to transfer is a primary mission of community colleges. In the ideal setting, a student can complete the first two years of a baccalaureate degree at a public community college, earn an associate degree, transfer to a four-year college, and complete the last two years of the baccalaureate degree there, all in four years. In reality, this idealized version of college transfer does not occur very often - less than one percent of the degree-and-transfer-seeking students in this study follow the aforementioned four-year pathway. Instead, students rarely exit the two-year institution with an associate degree or even two-years worth of credits (Radford, Berkner, Wheeless, & Shepherd, 2010). Credits often do not transfer smoothly from one college to the next, and lower-level courses may have to be repeated at the four-year institution. The entire process rarely takes just four years, if it is completed at all (Crosta, 2013). Many colleges and states have provisions in place called articulation agreements that are designed to add more structure to the transfer process: these agreements can specify which courses will transfer from institution to institution, guarantee the transfer of a general education core, and guarantee junior standing in a major if certain associate degrees are awarded or requirements are met before transfer. They provide a structure or scaffold that should incentivize students to make better decisions.

Though articulation agreements tend to be higher-level policy structures, some structures can also be found at the program level. The focus of this study involves structured curricula called "pre-majors" that are offered at some community colleges in North Carolina. These are versions of the Associate in Arts (AA) or Associate in Science (AS) degrees that are arguably more structured and are designed to better prepare students for successful transfer to a four-year school with junior standing in a particular major. How structured pathways and programs of study affect student outcomes has become a prominent research topic in the past few years (Jenkins & Cho, 2012). Limits on choice, more precriptive program requirements, and provisions for students to receive more direction and counsel in their studies have been hailed as promising reforms by researchers and funding agencies alike

(Chaplot, Rassen, Jenkins, & Johnstone, 2013; Jenkins & Cho, 2012). Among students in this study, 13.1 percent of students in the relatively more structured pre-major programs earned a baccalaureate within six years compared to 11.6 percent of students in traditional AA/AS programs. Similarly, 33.7 percent of students who earned a pre-major diploma earned a bachelors degree compared to 29.6 percent of students in traditional, less-structured AA/AS programs.

In this study, I ask if enrollment in one of the pre-major associate degree programs offered by North Carolina community colleges affects a range of outcomes at two-year and four-year institutions. I use plausibly exogenous variation in the offer of these structured programs of study among the state's 58 colleges as an instrumental variable to identify causal parameters of interest; students who went to one of the 27 colleges where the programs were offered could enroll in them whereas students in the remaining 31 colleges could not. To preview results, I find null and negative effects of the preferred reduced-form impacts of the program offer on two-year outcomes and null effects on transfer and four-year outcomes. That is, students in colleges that offer pre-majors are one to two percentage points less likely to earn their intended associate degree within three, four, or five years. Instrumental variables estimates provide local average treatment effects of about -5 percentage points. I do not find that the pre-major offer has any detectable impact on other outcomes at the community college, transfer rates or BA earning rates over several time horizons.

The remainder of this essay is organized as follows: Section 1.2 reviews literature relevant to structure and transfer, Section 1.3 reviews the background and context of pre-majors in North Carolina, Section 1.4 explains the study design and methodology, Section 1.5 discusses the data employed for this study, Section 1.6 presents results, Section 1.7 discusses the findings, and Section 1.8 concludes.

1.2 Literature Review

What does the existing literature say about how structured programs of study affect community college student transfer outcomes? As this question has not been addressed directly, I organize the literature review into several sections that are relevant to the primary research question. The major themes that emerge are structure, programs of study, and transfer. I begin by defining structure and discussing how various structures may impact decisions made by college students. Next I review some recent hypotheses concerning how structured programs of study may affect college outcomes. Lastly, I summarize the work that has assessed the impact of a key element of structure concerning transfer: articulation agreements between two- and four-year colleges.

1.2.1 Structure in Community Colleges

Community college students make many complex choices from the moment they decide to enter postsecondary education. They engage in a decision-making process using whatever information is available, however it might be presented, and with the guidance of those who are willing to help. That is, choices are made within a structural context provided by information, policies, procedures, and agents. Scott-Clayton (2011) sets forth the structure hypothesis: community college students are more likely to succeed in programs and environments that are tightly and consciously structured and that have little room for deviation. In general, there are few examples of scholarly literature that address the structure concept directly (Deil-Amen, 2011; Rosenbaum, Deil-Amen, & Person, 2009; Scott-Clayton, 2011), and much of this work is qualitative. In this section, I provide a working definition for structure and discuss some of the conclusions drawn by studies that discuss structure in community college in general terms.[1]

[1]There is an extensive literature that studies numerous specific factors and structures that affect the thousands of choices college students make. These range from assessing how families respond to incentives for filling out financial aid applications (Bettinger, Long, Oreopoulos, & Sanbonmatsu, 2009) to how students navigate assessment and placement systems (Nodine, Venezia, & Bracco, 2011). This section, however,

The Oxford English Dictionary defines structure as, "the arrangement of and relations between the parts or elements of something complex" and, "the quality of being organized" (OED Online, 2012). The path through higher education is a fine example of something complex, with its thousands of choices to be made along with seemingly hundreds of options for each choice. Often when individuals talk about institutional structure, they are referencing the way in which the college organizes its departments and programs, its administration and financial divisions, its campuses and buildings, and its relationship to public or private governance. Here I focus on structure as the part and elements of college environments and actions that affect how students make choices.

Rosenbaum et al. (2009) consider how structure is related to student success in the context of institutional policies and procedures. They consider two competing explanations for poor student success. The first approach studies individuals, blaming student deficiencies for failure, and tries to identify which individual attributes are correlated with success. Rosenbaum et al. (2009, p. 8) criticize this approach by noting, "this implicit blame of students does not inform colleges and policy makers what actions can remedy the problems because the deficiencies arise before students enter college and may not be easily redressed." Therefore, a second strategy is required, which they call an "institutional approach". Under the institutional approach, the focus is on the "person-environment fit" and the match between student needs and institutional structures, or how organizational features provide students with varying opportunities and incentives. Comparing public community colleges to private occupational colleges on a number of procedural and structural elements, they find that private colleges redress institutional deficiencies that are part of the "poor match" between students and institutions, whereas public colleges unsuccessfully focus on repairing individual deficiencies by means of interventions such as remediation.

Scott-Clayton (2011, p. 2) draws upon Rosenbaum et al. (2009) in synthesizing the structure literature and introducing work from behavioral economics and psychology to talk more broadly about, "norms and nudges that may more subtly influence individuals' decisions

considers research that looks at structure more broadly.

at a point of action." The review argues that a general lack of structure in community colleges impedes students from making optimal decisions as they persist towards a credential. Improvements in information, advising, and bureaucratic processes - many of which could be light-touch and inexpensive reforms - could redress a lack of structure and improve outcomes.

The major theme that emerges from this limited literature on structure in community colleges is that many students get lost along the college pathway, and this is due to a lack of college know-how or social capital on part of the student combined with a lack of structures on part of the institution to compensate for this deficiency. There is a hidden curriculum of social prerequisites, and many students are not only uninformed but also have to initiate the process of seeking assistance (Deil-Amen & Rosenbaum, 2003, p. 127). Studying community college persistence and dropout qualitatively, Deil-Amen (2011) identifies structural elements related to how community college students integrate both outside and inside the classroom. Through a series of interviews, she finds that marginal students are more successful at navigating cultural, psychosocial, and intellectual college terrain when they are assisted by an institutional agent - someone to provide procedural agency. When students have an institutional agent, whether faculty or staff, to provide support for students lacking "college knowledge", the agent provides valuable social capital that helps students succeed. As students experience conflicting or incomplete information and are overwhelmed by procedure, Deil-Amen (2011) argues, it is vital to have proactive assistance of a counselor or faculty, especially for the most marginalized students. Focusing on transfer from two-year to four-year institutions, Dowd, Pak, and Bensimon (2013) also identifies an important role for institutional agents in providing a base of psychological security for students that helps them to progress through the potentially uncomfortable and intimidating transfer situation.

These types of procedural agency work to offset the passive organizational structures that limit accessibility of faculty and instructors, such as a high degree of adjunct faculty or general unavailability of faculty. Deil-Amen (2011) found that structures congruent with persistence such as cohort-based programming and enhanced opportunities for students facing similar challenges to interact are found at the small, for-profit, private and nonprofit

colleges in programs in medical and electronic technology fields. Structures such as consistency of scheduling and repetition of students gathering in similar places in a cohort-type environment provided social opportunities to interact for academic and other goals. In general, the research by Deil-Amen, Person, Rosenbaum, and Scott-Clayton suggests that structures matter for student success in community college and therefore it is important to better understand how various elements of structure correlate with student outcomes. A gap in the literature that this paper addresses specifically is the lack of empirical tests of such structures.

1.2.2 Structure and Programs of Study

Shifting from the general to the specific, there are various structures that affect the way in which students interact with their programs of study. Two strands of literature of interest here include how structure affects major or program selection and how structure affects student progression through programs.

College students choose majors based on tastes and other information. Various factors, from life experiences to prevailing cultural attitudes towards careers, may structure the information set on which students rely to make such choices. Economic theory suggests that major and occupational choices depend on earnings expectations, nonpecuniary rewards, and associated tastes and preferences. Rationally, individuals will assess the total pecuniary and nonpecuniary costs and benefits of each major and select the one that yields the greatest expected utility. Research (primarily on four-year college students) has demonstrated that students do in fact make decisions based on the presumed distribution of earnings in the population for certain majors (Betts, 1996), but students are often misinformed about these earnings or the returns to schooling in general (Jensen, 2010; Nguyen, 2008). Several studies specifically analyze college major choice under uncertainty. Arcidiacono (2004) builds a dynamic structural model of major choice to study ability sorting by major, revealing that differences in monetary returns do not explain as much variation in sorting as preferences for particular majors does. In a similar dynamic schooling model, Beffy, Fougre, and Maurel

(2012) exploit variations in the French business cycle and identify a low elasticity of major choice to expected earnings, suggesting that non-monetary factors are key drivers of schooling choice. On the contrary, Montmarquette, Cannings, and Mahseredjian (2002) find that the choice of college major is largely determined by expected earnings when incorporating an expected probability of success in a field, with heterogeneous effects for racial and sex subgroups. In a clever experiment performed by manipulating student information sets, Wiswall and Zafar (2012) find that while earnings information is important in college choice, tastes are the most important factor in choosing a program of study. Zafar (2011) is able to demonstrate that expectations are indeed revised and major switching occurs as students learn about their own abilities (GPA) and combine this with prior beliefs.

Once a program choice is made, the institutional environment may be a key component in providing the structures that get students through these programs (Jenkins & Cho, 2012; Van Noy, Weiss, Jenkins, Barnett, & Wachen, 2012). Among the numerous obstacles of confusing choices, student-initiated guidance, limited counselor availability, poor advice from staff, delayed detection of mistakes, and poor handling of conflicting demands, students face bureaucratic hurdles such as challenges in understanding courses, requirements, options, and transfer agreements (Deil-Amen & Rosenbaum, 2003). Comparing the public two-year colleges to private occupational colleges, Deil-Amen and Rosenbaum (2003) find that occupational colleges take steps to "structure out" the situations that require college specific know-how, such as course selection. Private occupational colleges found greater success by increasing structure of curriculum, choice, guidance. Fewer options decrease the need for information, helping to avoid confusion and mistaken choices. Rosenbaum et al. (2009) recommend that community colleges simplify their curricula, improve counseling, and proactively monitor student progress, and improve information systems. They find that differences in these organizational procedures explain differences in student experiences, comparing community colleges and private occupational colleges. Likewise, Scott-Clayton (2011, p. 10) concludes from the theory of bounded rationality (i.e., preferences are not complete and stable) that, "students' choices between programs of study or courses within programs

may be highly dependent upon how these choices are structured and presented." The large number of program choices and associated options are confusing (Deil-Amen & Rosenbaum, 2003). Similarly, students may experience educational setbacks if they are not well-informed about prerequisite skills needed for success in different courses of study (Bound & Turner, 2011). There is little evidence about how organization of instruction, such as small classes and residential programs, affects student outcomes and degree completion. Carefully designed experiments can improve our understanding of how program design, advising, course structure, and other resources impact degree attainment (Bound & Turner, 2011).

1.2.3 Transfer and Articulation

Over the past few decades, the policy landscape has shifted towards implementing structures that directly support the transfer function (Kisker, Wagoner, & Cohen, 2011). It is now not uncommon for state systems or pairs of institutions to have shared policies (often called articulation agreements) that facilitate transfer from two- to four-year colleges. Smith (2010) reports that about two thirds of states have some type of policy or agreement that aids students who wish to transfer, whether it is legislated in the state's administrative code, a transferable common core, or a cooperative agreement among institutions.

Though there are both institutional and individual explanations for transfer success, the policy environment also has an impact. Every state and higher education system has approached transfer policy in a unique manner, and researchers and educators have been trying to determine what combinations of policies and procedures are most effective. Here, "most effective" is not a universal concept, as some states may desire to boost transfer rates in general, while other may want to increase transfer rates after students obtain an associate degree, while still others may be content with the transfer rates but wish to increase the percentage of transfer students who actually earn a baccalaureate degree. State and institution-level policies, as well as their governance structures, the labor market, and characteristics of students all play a part in determining these outcomes.

Though upward transfer has been an important mission of the community college for

decades, there is a surprisingly small literature dedicated to studying the policies themselves. Some studies reviewed in this section serve to provide an overview of transfer policies and qualitatively evaluate their implementation and success. Others perform quantitative analysis to evaluate the impact of policies and their component parts on transfer rates and other success measures.

1.2.3.1 Status of the Policy Environment

The success of students who progress from two- to four-year schools is "increasingly dependent on the smooth transfer of credits" from institution to institution (Russell, 2005). This process is hindered by attitudes of four-year college employees who "look down" on two-year college students, uncertainty among four-year college faculty about the rigor of two-year college experiences, and the students' inability to complete necessary prerequisite coursework that allows them to carry forward credits earned at the community college (Russell, 2005). To address these challenges, states have enacted legislation or higher education coordinating boards have developed policies that specifically call for certain structures to exist as part of the articulation process in an attempt to improve or introduce a structured pathway between community college and university.

A 2010 report produced by the Education Commission of the States (ECS) surveys all 50 states and describes the status of the policy climate and specific policy elements, such as common course numbering and articulation agreements, that are thought to impact transfer rates and transfer success (Smith, 2010). The study reports that since 2001, the number of states that have a statewide policy regarding transfer has increased from 30 to 36, and the number of states that have a cooperating agreement between higher education sectors increased from 40 to 46. The ECS survey highlights seven policy levers that can affect the transfer process. They are:

- *Statewide policies*: These appear in the general statutes or administrative code of the state and either specifically legislate articulation policies or use the law to oblige the public two- and four-year sectors to develop articulation policies.

- *Cooperative agreements*: These are usually voluntary agreements between schools or sectors within a state; may be course by course or institution by institution.

- *Transfer data reporting*: Some states collect and report data on the number and success of transfers from two- to four-year schools. This is an important step in monitoring and evaluating transfer programs.

- *Incentives and rewards*: Several states offer incentives to transferring students who earn credentials or perform well academically, such as guarantees that general education courses will be satisfied at the four-year school.

- *Statewide articulation guide*: Brochures and websites exist within some systems to guide students, explain course transferability, or describe the articulation agreement.

- *Common core*: Some states have developed a common general education core that can be completed at the two-year school and then transferred en bloc to the four-year school, with full credit articulation.

- *Common course numbering*: When course numbers are the same within or across systems, it is easier for systems to streamline transfer and less likely that students will take non-transferable courses.

Though not mentioned in the ECS study, states such as North Carolina and New York also have performance funding programs that reward community college for getting students to transfer or reward four-year schools for getting transfer students to earn baccalaureate degrees (Wellman, 2002).

Transfer articulation agreements are central to the way in which two- and four-year colleges structure the transfer process. As states and systems initiate reforms, it is important for them to know where elements of these policies - such as pre-major associate degree programs that are part of articulation agreements - have succeeded of failed. The next section addresses the direct question of how these structures affect transfer outcomes.

1.2.3.2 Articulation Policies and Effectiveness

A few researchers have attempted to identify empirically whether or not articulation agreements matter. Variation in state policies provides a natural laboratory for the study of these policies. By studying the relationship between policies or specific components of these policies and transfer rates or transfer success, researchers are working towards an answer to the question of whether and how the presence of policies impacts transfer. Some examples of recent empirical work in this area discussed below are Ignash and Townsend (2000), Roksa and Keith (2008), Gross and Goldhaber (2009), and Anderson, Alfonso, and Sun (2006).

Ignash and Townsend (2000) evaluate articulation agreements that exist by the end of the 20th century. They sent a short survey to state community college agencies asking about aspects of articulation agreements including: the types or direction of transfer, the sectors involved (public/private), the component of the undergraduate degree covered, the level of involvement of faculty in developing the agreements. The researchers then classified each component of the state's policy environment on a five point scale, where 1 was strong and 5 was weak, and aggregated these measures across the state. They found that in some states, agencies came together to design policies because of legislative mandates; in other states, the agencies came together to avoid such mandates. They also document the growth of statewide articulation policies. Ignash and Townsend (2000) do not argue, however, that all states are following good practices. Only half were rated strong or fairly strong on all four measures. Most states with policies had included provisions for the transfer of a common general education core, a policy that may disincentivize the completion of an associates degree before transferring.

Performing a detailed analysis of the articulation policies codified in state statutes, Roksa and Keith (2008) conclude that these policies do not result in improved transfer rates partly because it is not their intended goal. The purpose of the policies is in fact to prevent credit loss after transfer, and this policy is more likely to impact students who already have decided to transfer. The impact on students will be felt after the transfer in terms of time to degree, baccalaureate attainment, and the number of excess or repeated credits.

Roksa and Keith (2008) first examine policies in all states during the same time period as their National Education Longitudinal Study of 1988 (NELS:88/2000) sample to determine whether or not the state had a codified articulation policy.[2] They then isolate a sample of students who start at a community college and transfer to a public four-year school in the same state since this is the context of articulation policies. Students can then be tied to the state policies. A detailed study of student transcript information and outcomes data reveals that, "transfer students in states with articulation policies are not more likely to complete bachelor's degrees than those in states without such policies," (Roksa & Keith, 2008, p. 245). The results do not change when the authors predict the outcome using logistic regression model that controls for individual student characteristics such as sex, race, test scores, socioeconomic status, marriage and child status, student expectations, and enrollment intensity. Roksa and Keith (2008) also find that there is no difference in the time it takes to earn a bachelors degree in states with different policy environments. Students in states with articulation policies earn more credits than students in states without policies, but these findings are driven by one state (California) and disappear when it is removed.

In general, Roksa and Keith (2008) conclude that the articulation policies that were in effect during the time that this cohort of NELS students was enrolling in and moving between colleges were not effective in increasing baccalaureate attainment or reducing the time it takes to earn a bachelor's degree. One important limitation of their study, however, is the dichotomous treatment of articulation agreements. It is known from Smith (2010) and Wellman (2002) that among states that have articulation policies, the extent of these policies varies markedly. Gross and Goldhaber (2009) specifically address this weakness in their study of the effectiveness of articulation policies that uses the same NELS. They ask if different types of policies, strong versus weak policies, have different effects and how these effects might differ for students in certain racial or socioeconomic groups.

Gross and Goldhaber (2009) acknowledge the improvements in structure that articulation policies bring as they improve the quality of information and minimize uncertainty in the

[2]Most students in the NELS:88/2000 sample graduated high school in 1992.

transfer process. However, all policies are not created equal. Policies differ in their scope (what proportion of undergraduates in a state who are actually affected), how involved faculty were in creating the policy, whether or not the policy consists of a common or general transferable core curriculum, and how the states monitor or evaluate the policies. Gross and Goldhaber (2009) build on the taxonomy introduced by Ignash and Townsend (2000), who rank policies on a strength index from one to five. The authors analyze the policy components separately and aggregate them into a tripartite classification: nonexistent, weak, or strong.

The outcome of interest identified by Gross and Goldhaber (2009) is transfer itself. Since all students might not desire to transfer, the authors proceed with a selection on observables approach and control for student-level characteristics that may be correlated with students' desire or ability to transfer. Like Roksa and Keith (2008), Gross and Goldhaber (2009) do not find that articulation agreements or specific components of the agreements have a positive impact on the odds that students transfer. Analyzing the policy strength index reveals that students in states with weak policies are less likely to transfer than students in states with no policy at all. The only specific policy component that impacted transfer was the percentage of students in the state who were covered by the agreement. The racial analysis reveals that Hispanic students are sensitive to articulation policies, as they are 78 percent more likely to transfer in states with policies than states without policies. Though Roksa and Keith (2008) argue that policies are not designed to improve transfer, Gross and Goldhaber (2009) suggest that weak policy designs and poor implementation may be reasons for the lack of relationship between these policies and transfer rates.

Anderson, Alfonso, and Sun (2006) ask if the existence of statewide articulation agreements increases the probability of transfer from two- to four-year colleges. They use Beginning Postsecondary Students (BPS89) data to study whether having a statewide articulation agreement impacts the probability of transfer for all community college students and those with the intent to earn a baccalaureate. The sample only includes 680 first-time beginning postsecondary students who first enroll at a two-year school, and transfer allows for enrollment at a public, private, or for-profit four-year school within five years. The main

independent variable is whether or not the student is enrolled in a state that had a statewide articulation policy by 1991. In their logistic regression analysis, Anderson et al. (2006) conclude that students in states that have articulation policies do not experience an increase in the probability of transferring to a four-year school.

The challenges to evaluating transfer policies are numerous. Even though states have similarities across some policy elements, there are many more differences. In addition, the policies have been in a constant state of change. Nationally representative datasets provide a window at only one point in time in this changing policy landscape. Though most of the research is suggesting that these policies have limited or no impacts, it is somewhat hard to believe that these policies are not affecting student decisions nor resulting in improved outcomes for transfer students. There still, of course, may be other factors at work, not captured by models, that may be influencing individual decisions.

1.2.4 Summary of Literature

Though the existing literature does not assess directly the impact of structured programs of study on transfer outcomes, it is useful to synthesize the findings more generally. Structure at community colleges is a broadly defined concept, encompassing what information is provided, how information is provided, how agents help students make decisions, and other norms and nudges that influence choices. Structures related to programs of study may include what factors and information affect the selection of a major as well as the choice of courses within majors and other decisions such as when to take courses. If a lack of structure is leading students towards making poor decisions, it is hypothesized that policy changes that reduce choice or provide procedural agency are likely to improve a range of outcomes. The outcome of transfer to a four-year institution is in many ways structured through the use of articulation agreements between the two- and four-year institutions. However, there is not a lot of evidence that these agreements are performing their intended function, and therefore structures may require additional processes or supports in order to work.

Perhaps an underlying assumption that is implicit in the structure discussion is that

students are too often making poor decisions. Though this assertion runs counter to the tenets of rational choice models that permeate economics, much of the qualitative evidence suggests that students are indeed making mistakes, delaying decision making, and regretting decisions (Rosenbaum et al., 2009). Ultimately, their rational choices may not be optimal choices.

The pre-major programs studied in this essay are structured programs of study that are supported by articulation agreements and intended to improve course selection, increase community college completion rates, and assist the transfer process. This paper attempts to contribute to the various strands of literature discussed above by providing a quantitative analysis of how one component of structure affects outcomes. I take advantage of variation among colleges in offering the pre-major to identify a causal effect being in a relatively more structured program of study that is part of a structured transfer agreement between two- and four-year schools in a single state.

1.3 North Carolina's Pre-Major Programs

1.3.1 Background

North Carolina's Comprehensive Articulation Agreement (CAA) Between the University of North Carolina (UNC) and the North Carolina Community College System (NCCCS)[3] was first approved in 1996. Section IV of the agreement notes that, "Joint academic discipline committees developed system-wide guidelines for community college curricula that will prepare students for intended majors or professional associations at the baccalaureate level. Statewide pre-majors for AA and AS degree programs have been developed for specific major fields." The CAA Transfer Advisory Committee (TAC) web site indicates, "The pre-majors under the AA and AS serve as a blueprint for guiding community colleges in developing pro-

[3]Available at: http://www.nccommunitycolleges.edu/Programs/docs/CollegeTransfer/102.51CAA_Modified_June_2010_v4.pdf

grams for students who intend to major in specific disciplines".[4] That is, the pre-majors are Associate in Arts (AA) and Associate in Science (AS) degrees that have been tailored to (or structured around) particular major programs and have been approved by representatives from both the two- and four-year college systems. Community colleges are free to choose whether or not they will include pre-majors as part of their program and degree offerings. A summary of pre-majors available in the North Carolina system is presented in Table 1.1.[5]

In this essay, the type of structure under study relates to the way in which institutions organize their programs of study (curricular requirements) for college transfer programs. The dichotomy emphasized here is between programs that offer little choice (structured, prescribed pre-major programs) and those that offer relatively more choice (unstructured, traditional college-transfer programs). To understand the differences between the general AA program and an AA pre-major, consider a comparison between the suggested curricula for the AA and the AA pre-major in criminal justice shown in Figures 1.1 and 1.2.[6] The relatively less structured AA standard contains a 44-credit general education core where the only prescribed elements are the first and second English course. For the remaining requirements, the college invites students to choose about eighteen courses from the potentially hundreds that may meet the general education core and elective options. Although the AA program breaks the core down into broad subject units, it does not mandate the taking of any particular courses outside of English. In general, the program plan is characterized by a low degree of prescription and a high degree of choice, both within and across subject areas. The criminal justice pre-major (Figure 1.2), by contrast, deviates considerably from this template by introducing limited choices for certain requirements. For example, students

[4]Available at: `http://www.nccommunitycolleges.edu/Programs/comprehensive_a_a.htm`

[5]There are also three pre-major programs associated with the Associate in Fine Arts degree in art, music, and dance. These are not considered in this analysis as pre-major programs since they are not structured like the AA and AS pre-majors and are treated differently by the CAA (for example, courses do not transfer en bloc but are accepted on a course-by-course basis at four-year schools).

[6]These figures show the pre-major curricula as outlined by the state. Colleges may present customized versions to present to students as long as they fall within the state-defined parameters.

Table 1.1: Pre-major Offerings in NCCCS

Associate in Arts	
Anthropology	History
Art Education	Information Systems
Business Administration, Accounting, Economics, Finance & Marketing	Liberal Studies
Business & Marketing Education	Mass Communication/ Journalism
Communication/ Communication Studies	Middle Grades Education
Computer Science	Nursing
Criminal Justice	Physical Education
Elementary Education	Political Science
English	Psychology
English Education	Social Science Secondary Education
Geography	Social Work
Health Education	Sociology
Special Education	
Associate in Science	
Biology & Biology Education	Engineering
Chemistry & Chemistry Education	Mathematics
Mathematics Education	

must take three required social and behavioral science courses and a statistics course as part of the core. There are also three required courses related to criminal justice in the "Other required hours" requirement. Although the criminal justice pre-major does ask the student to choose among several humanities and natural science courses to fulfill the core requirements, the curriculum does prescribe several courses, introducing a more structured degree scaffold that could reduce some of the choice anxiety students face, direct students towards courses that are productive for both their two- and anticipated four-year degree programs, and help keep students on track. Although each pre-major contains more structure, mostly by limiting course choice by prescribing specific requirements, than the standard associate degrees, there is variation across pre-majors as to how much structure is imposed. For example, the

Figure 1.1: Associate in Arts Curriculum Guide

GENERAL EDUCATION CORE (44 SHC)*
The general education core includes study in the areas of humanities and fine arts, social and behavioral sciences, natural sciences and mathematics, and English composition.

English Composition (6 SHC) *Two English composition courses are required.*
ENG 111 Expository Writing (3 SHC) is required as the first composition course.
The second composition course must be selected from the following:

ENG 112	Argument-Based Research (3 SHC)	*or*
ENG 113	Literature-Based Research (3 SHC)	*or*
ENG 114	Professional Research and Reporting (3 SHC)	

Humanities/Fine Arts (12 SHC**)
Four courses from at least **three** of the following discipline areas are required: art, drama, dance, foreign languages, interdisciplinary humanities, literature, music, philosophy, and religion. **At least one course must be a literature course.**

Social/Behavioral Sciences (12 SHC)
Four courses from at least **three** of the following discipline areas are required: anthropology, economics, geography, history, political science, psychology, and sociology. **At least one course must be a history course.**

Natural Sciences/Mathematics (14 SHC)
Natural Sciences (8 SHC):
Two courses, including accompanying laboratory work, from the biological and physical science disciplines are required.
Mathematics (6 SHC):
At least one course in introductory mathematics is required; the other course may be selected from among other quantitative subjects, such as computer science and statistics.

A college may award a diploma under the A10100 for completion of the entire general education core as outlined with a grade of "C" or better in each course.

OTHER REQUIRED HOURS (20-21 SHC)*
One semester hour of credit may be included in a sixty-five semester hour credit associate in arts program. The transfer of the sixty-fifth hour is not guaranteed. A minimum of 20 SHC of college transfer general education, elective, and/or pre-major courses is required.

Total Semester Hours Credit (SHC) in Program: 64-65

*** Students must meet the receiving university's foreign language and/or health and physical education Requirements, if applicable, prior to or after transfer to the senior institution.**
**** 3 SHC in Speech/Communication may be substituted for 3 SHC in Humanities/Fine Arts. Speech/Communication may not substitute for the literature requirement.**

pre-major in sociology is more similar to the standard AA than the pre-major in computer science, which contains additional math requirements. But in general, the pre-majors provide an example of a pathway that is more structured than the traditional associate degree program.[7]

Twenty-seven colleges offer pre-major programs, and there are differences from college to college in terms of the proportion of college transfer students who choose these programs and in the distribution of pre-major subjects chosen. In this study, the percentage of students who

[7]There may also be differences from college to college as to how they use the State's pre-major blueprints to design suggested pre-major curricula. As a rule, though, the pre-major curricula are more prescribed than the non-pre-major programs.

Figure 1.2: Associate in Arts, Criminal Justice Pre-Major Curriculum Guide

General Education Core (44 SHC)* Forty-four semester hours of credit in general education core courses are required as outlined on the NCCCS Curriculum Standards for Associate in Arts degree programs. The general education core includes study in the areas of humanities fine arts, social and behavioral sciences, natural sciences and mathematics, and English composition.

English Composition (6 SHC) *Two English composition courses are required.*

- English 111, Expository Writing, is required as the first composition course.
- The second composition course must be selected from the following:

ENG 112	Argument-Based Research (3 SHC)
ENG 113	Literature-Based Research (3 SHC)
ENG 114	Professional Research and Reporting (3 SHC)

Humanities/Fine Arts (12 SHC**) *Four courses from three discipline areas are required.*

- One course must be a literature course.
- Three additional courses from the following discipline areas required: art, drama, dance, foreign languages, interdisciplinary humanities, literature, music, philosophy, and religion.

Social/Behavioral Sciences (12 SHC) *Four courses from three discipline areas are required.*

- One history course is required.
- The following courses are required:

POL 120	American Government (3 SHC)
PSY 150	General Psychology (3 SHC)
SOC 210	Introduction to Sociology (3 SHC)

Natural Sciences/Mathematics (14 SHC)

Natural Sciences (8 SHC):

- Two courses from the biological and physical science disciplines, including accompanying laboratory work, are required.

Mathematics (6 SHC): Two courses are required.

- One course must be in introductory mathematics (college algebra, trigonometry, calculus, etc.).
- One of the following courses is recommended to satisfy the second mathematics requirement:

choose one:

MAT 151	Statistics I (3 SHC) *or*
MAT 155	Statistical Analysis (3 SHC)

A college may award a diploma under the A1010D for completion of the entire general education core, as outlined, with a grade of "C" or better in each course.

Other Required Hours (20-21 SHC)* One semester hour of credit may be included in a sixty-five semester hour credit associate in arts program. The transfer of the 65th hour is not guaranteed.

- The following courses are required (9 SHC):

CJC 111	Introduction to Criminal Justice (3 SHC)
CJC 121	Law Enforcement Operations (3 SHC)
CJC 141	Corrections (3 SHC)

- 11 additional hours of approved college transfer

Total Semester Hours Credit (SHC) in Program: 64-65

*** Students must meet the receiving university's foreign language and/or health and physical education requirements, if applicable, prior to or after transfer to the senior institution.**

**** 3 SHC in Speech/Communication may be substituted for 3 SHC in Humanities/Fine Arts. Speech/Communication may not substitute for the literature requirement.**

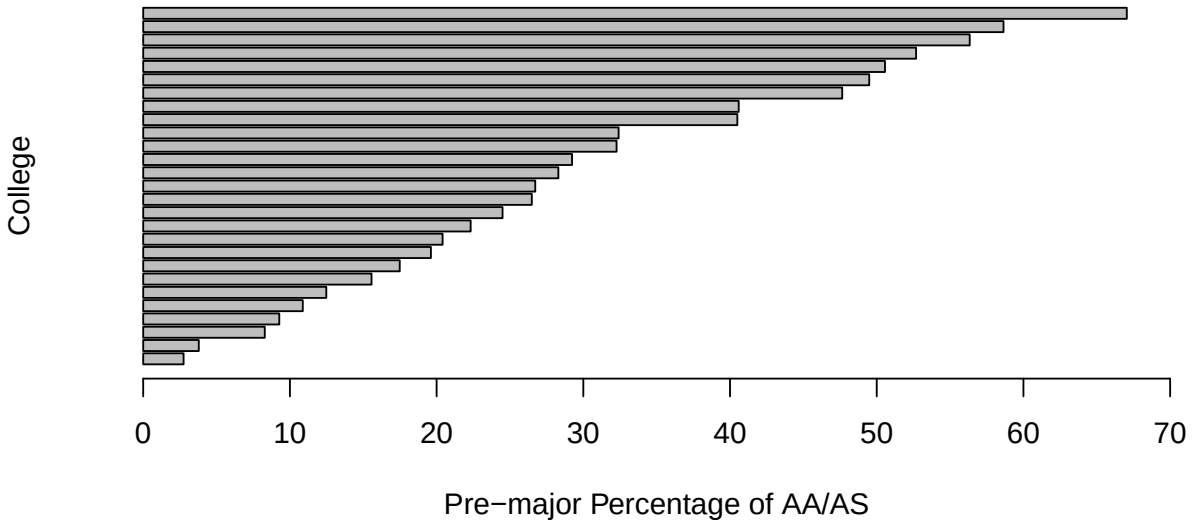

Figure 1.3: Percentage of AA/AS Degrees that are Pre-majors, by College

selected pre-major associate degree programs in eligible schools ranges from about 3 percent to 67 percent. This distribution can be seen in Figure 1.3. So even among schools that offer the programs, participation is highly variable, which could suggest differences in attitudes of counselors and advisors in program schools.[8] Similarly, the distribution of selected pre-major programs is not even. Figure 1.4 reveals that certain programs (Business Administration and Elementary, Middle Grades, and Special Education) are much more frequently chosen than most of the other pre-major subjects. However, Nursing and Psychology are also relatively popular. Some pre-major subjects have very few enrollees. Since all pre-major programs do not have the same degree of choice limitation, one might expect some differences in outcomes to be driven by particular aspects of these few, popular programs.

[8]This variation will be used as an instrumental variable in sensitivity analyses.

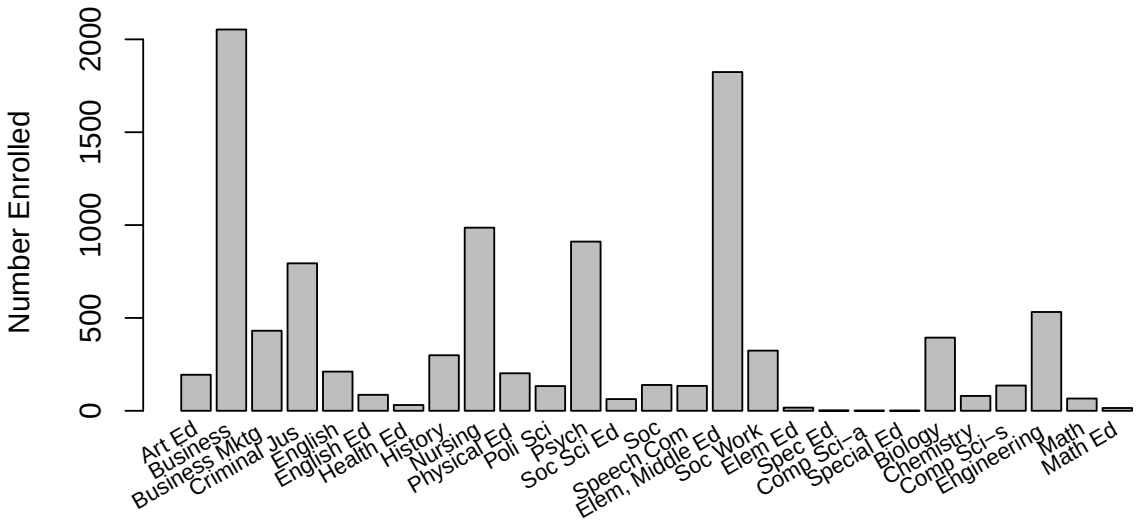

Figure 1.4: Distribution of Pre-Major Subjects

1.3.2 Theory of Action and Pre-Majors

Students who earn a pre-major diploma receive many of the same benefits under the CAA as those who earn standard AA and AS degrees: they will have fulfilled the general education core and the minimum course requirements, they will receive at least 64 hours of transfer credit, and they are guaranteed admission to at least one four-year college in the University of North Carolina system. Although the pre-majors may be considered "light touch" interventions, there are numerous ways in which enrolling in the more structured associate degree pre-major programs could, or should, impact student choices and outcomes in ways that the traditional college-transfer programs do not.

The theory of action around pre-majors includes some effects directly related to the hypotheses surrounding structure programs as well as effects that may arise simply through enrollment in a program. For example, enrollment in a pre-major program could result in an improved sense of how a student connects her two-year college experience to her

four-year college program, potentially impacting attributes of student engagement that are associated with higher persistence rates (Tinto, 1975). A structured pathway at the two-year college should help keep students on track through its limits on choice, as hypothesized by the behavioral economics literature that calls into question the benefits of too much choice (Deil-Amen & Rosenbaum, 2003; Scott-Clayton, 2011). That is, since students are instructed to follow the prescribed curriculum, they are expected to make better choices about which classes to take and, with less ambiguity of curriculum, they are expected to progress through college more quickly. Since pre-major students are specifically attempting a college-transfer credential with the pre-major subject designation, they ought to have higher associate degree completion rates than their traditional program counterparts assuming that pre-major students value the credential more. In addition, pre-major programs instruct students to fulfill requirements that are required by the four-year college's department, and this should make the transfer process smoother. By avoiding unnecessary or insufficient coursework at the two-year school, ensuring proper prerequisites are met for the four-year school, and minimizing the likelihood of having to retake or repeat coursework at the four-year institution, pre-major programs should better prepare students for success at the four-year institution. Additionally, the various pre-major curricula should provide the content knowledge that makes students more successful in a discipline. An early curricular focus in the community college potentially provides a better academic foundation for the transfer student, leading to more prepared and confident students with a higher liklihood of success at the transfer institution. Though the theory of action presented here is specific to the North Carolina context, it is reasonable to presume that prescribed associate degree programs in other states or contexts could lead to similar effects.[9]

In terms of specific hypotheses under study, it is expected that students in pre-major

[9]In general, students in pre-majors do not automatically receive additional interventions that would differentiate their pathway from students who are not in pre-majors. That is, there are no special advisors or peer communities that are implemented along with pre-majors. The programs are designed to help students make better decisions about courses.

programs will make better course-taking decisions at the community college and will have better outcomes than students who are pursuing the traditional AA and AS degrees. Specifically, if structure is beneficial for student progress, students in pre-major programs may accumulate more community college credits, have lower course withdrawal rates, take more upper level (200-level) community college courses, have greater accumulation of credits from courses on the approved college transfer list, and take fewer credits in fields that certainly do not transfer (like physical education). They may also be expected to have higher rates of earning associate degree credentials than peers in traditional AA/AS programs. Similarly, if additional structure improves transfer pathways, students in pre-major programs should be more likely to transfer to and earn baccalaureate degrees from four-year colleges and universities.

1.4 Empirical Strategy

1.4.1 Ordinary Least Squares (OLS)

In this paper, I set out to examine the impact on educational outcomes of being in a pre-major program compared to being in the traditional AA/AS program. The general relationship of interest can be expressed by the following equation:

$$Y_i = \alpha + \lambda PreMajor_i + \beta X_i + \varepsilon_i \tag{1.1}$$

In Equation 1.1, Y_i is one of several outcomes of interest for student i, $PreMajor_i$ is a binary indicator where a one indicates that the student has enrolled in a pre-major program, X_i is a vector of student-level characteristics including sex, age, race, limited English proficiency status, high school diploma, citizenship, inmate status, employment status in the first term, proxies for ability, and fixed effects for the cohort year of first enrollment, and ε_i is an error term. Estimation of this equation (whether by OLS as a linear probability model or by logit/probit) will likely provide a biased estimate of the main parameter of interest, λ. Since students choose to enter a pre-major AA/AS program, unobserved characteristics - such

as motivation, drive, social capital, natural ability, or confidence in future plans - may be correlated with both the decision to pursue a pre-major and postsecondary outcomes. Therefore, the endogenous choice built into the pre-major indicator prevents one from identifying a causal effect of enrolling in a pre-major program. Or, in terms of the model presented, $E(\varepsilon_i|PreMajor_i, X_i) \neq 0$.

1.4.2 Instrumental Variables (IV)

To address potential endogeneity bias generated by student choice, I employ an instrumental variables (IV) strategy, which uses a plausibly exogenous source of variation in the pre-major diploma selection to identify the effect of pursuing a pre-major diploma, or of being on a more structured pathway rather than on a traditional AA/AS pathway. Twenty-seven of the state's 58 community colleges offered pre-major associate degree programs. Therefore, upon arriving at college, some students in the system had the option or offer of completing a pre-major, while others did not. It is arguable that the offer of the pre-major at certain institutions served as an incentive for some students to select these more structured programs. This offer or availability of the pre-major can be used as an instrument for the endogenous pre-major program indicator if certain assumptions are met. The next section provides a theoretical treatment for estimating causal impacts using the pre-major program offer as an instrumental variable.[10]

1.4.2.1 Potential Outcomes Framework

Following Angrist, Imbens, and Rubin (1996) and Imbens and Angrist (1994), I frame the IV strategy in the language of potential outcomes. Consider that there are n observations on the following: an outcome variable, Y_i, a binary treatment indicator, D_i, a binary instrument, Z_i, and an r X 1 vector of covariates, X_i. In this study, Y_i indicates an outcome such as

[10]The analytical design used in this study is essentially a randomized experiment with one-sided noncompliance, a design often found in medical trials where one group is assigned to not take a drug and a second group is assigned to take drug, but one cannot force the latter group to comply with the assignment.

transferring to a four-year school or earning a bachelor's degree, D_i indicates the student enrolled in a pre-major program upon entering college, and Z_i indicates that the student was enrolled in a college that offered associate degree pre-majors. It is the case that everyone who was offered the pre-major option did not choose to take it (so Z_i is not equal to D_i), and no one who was not offered it would have chosen it.

Omitting all of the i subscripts, potential outcomes Y are indexed against D (Y_d) and potential treatment status D is indexed against Z (D_z). So Y_1 is an individual's outcome when $D = 1$ or when the student earned the pre-major, and Y_0 is the outcome for an individual who does not earn a pre-major. Likewise D_1 is what the the individual's treatment status would be if $Z = 1$ or under the offer of the pre-major, and D_0 is the treatment status when $Z = 0$ or without the offer.

As this is not a randomized experiment, the average treatment effect of D on Y that expresses the average difference between two counterfactual states, $\mathbb{E}(Y_1 - Y_0)$, is not possible to estimate. However, under a set of assumptions, I can estimate the average causal effect in students who were induced to change their behavior due to the instrument. I can use Z as an instrumental variable to estimate the Local Average Treatment Effect (LATE): $\mathbb{E}[Y_1 - Y_0 | D_1 - D_0 = 1]$, the effect of being in a pre-major program for students who were induced to select the program due to its being offered.[11]

Under the assumptions discusse in the next section, the LATE is the ratio of two important relationships.

$$LATE = \frac{Effect\ of\ Z\ on\ Y}{Effect\ of\ Z\ on\ D} \tag{1.2}$$

The LATE in Equation 1.2 is composed of two pieces. The numerator is the reduced form or intent-to-treat (ITT) estimand and represents the effect of the instrument on the outcome. The denominator is the first stage (also an ITT estimand) and represents the effect of the

[11]Since no students who began at schools without the offer could enroll in a pre-major program, LATE may be interpreted more generally as the average treatment effect on the treated (ATET). That is, LATE is the weighted average of always takers and compliers, but in this study there are no always takers and thus the treated population consists entirely of compliers.

instrument on the endogenous pre-major indicator variable. The specific equations to be estimated are:

$$Y_i = \gamma + \delta Z_i + \beta X_i + u_i \tag{1.3}$$

$$D_i = \eta + \mu Z_i + \theta X_i + v_i \tag{1.4}$$

The reduced-form equation 1.3 and the first-stage equation 1.4 are both estimated using linear regression rather than logit or probit even though the dependent variables are binary. Angrist and Krueger (2001, p. 80) note that,"using a linear regression for the first-stage estimates generates consistent second-stage estimates even with a dummy endogenous variable." Two-stage least squares is employed later for computing the LATE ratio, but the relationship can be expressed in terms of the equations above as $LATE = \frac{\delta}{\mu}$. In all regressions reported, cluster-robust standard errors are computed using the student's entry institution as the clustering unit.

1.4.2.2 Assessment of Instrumental Variables Assumptions

For the program offer to be suitable as an instrument, it must be a plausibly exogenous source of variation related to pre-major program selection. An important assumption is that the instrument cannot be correlated with unobserved factors that caused the problem in Equation 1.1; it cannot be endogenous as well. If students were randomly assigned to schools that either offered or did not offer pre-majors, ignorable treatment assignment would be trivially satisfied. However, although not randomly assigned into schools, community college students tend to matriculate in the school nearest to their home or high school. Therefore students can be thought to receive the offer of treatment or not based on their geographic location, which is arguably ignorable. Adelman (2005) reports that of students in BPS:95/01 data, 46 percent of community college students selected their starting institution because it was close to home, compared to 32 percent of students at four-year college. "The proximity factor is more prominent in the choice behavior of students who first entered

community colleges," (Adelman, 2005, p. 38). Stange (2012a) makes a strong argument that community college students generally do not sort into institutions by ability but rather sort by location. He notes that most students attend the community college closest to where they went to high school, regardless of their ability level. By extension, I assume that students of higher or lower ability or motivation (or other factors that might be correlated with outcomes) are not sorting into colleges that offer pre-majors or not. This assumption is clearly violated if individuals choose to attend an institution based on whether or not the institution offers a pre-major.[12]

Even if it is assumed that students are not sorting into pre-major and non-pre-major institutions, there is a potential violation of the exclustion restriction if after taking the choice of pre-major into account, there is an impact of assignment (the pre-major offer) on outcomes. The institutions themselves are not randomly assigned to either offer pre-majors or not. It is ultimately an administrative decision that was made in the late 1990s when the programs were first introduced. Factors specific to each institution, such as the ability to offer a broader range of courses, positive attitudes towards structured or guided programs, or better relationships with four-year feeder institutions may influence a school's willingness to offer pre-major programs. If unobservable college characteristics that impacted the decision to offer pre-majors also correlate directly with the student outcomes under study, then the

[12]If students are strategically re-locating, the exogeneity of the offer of treatment is weakened as college choice is endogenous. Since college choice should depend on proximity to a student's home (Card, 1993; Rouse, 1995), one potential solution to endogenous college choice is to use as additional instruments the distance between student homes and the nearest community colleges that do and do not offer a pre-major. Distance should be correlated with the probability that a student attends a college that offers pre-majors but should be uncorrelated with outcomes. I address this in sensitivity analyses.

exclusion restriction is violated.[13,14]

I provide evidence supporting the validity of the instrument using quantitative and qualitative strategies. First, there should not be important observable differences between colleges that do and do not offer these programs. One way to assess this is to analyze data collected through Integrated Postsecondary Education Data Analysis System (IPEDS). Table 1.2 shows results from a series of t-tests that compare means of several institution-level characteristics between schools that do and do not offer pre-majors. I show differences for full-time equivalent (FTE) enrollment, graduation rate in 150 percent of expected time to degree, and a range of expenditures per FTE that serve as proxies for the level of resources that institutions spend on their students. Only one characteristic, instructional spending per FTE, is significantly different between the two types of institutions. The negative difference indicates that pre-major institutions spent almost $800 less per student in 2003 than non-pre-major institutions - a difference that largely fades away in the next two years. These comparisons suggest that, in general, there do not appear to be systematic observable differences in important institutional characteristics and resource expenditures between the two

[13]Other IV assumptions are satisfied trivially. The monotonicity condition ensures that the offer of a pre-major affects the decision to enroll in a pre-major in a monotone way. Since compliance and noncompliance are decisions made by students, it can be reasonably assumed that anyone who would select the program if assigned to a non-offering school would also select the pre-major if assigned to an offering school. I do not expect violations of monotonicity to bias results. The assumption of nonzero average causal effects is trivially satisfied since students who are enrolled at pre-major colleges do indeed select the pre-major program (and those who are not enrolled there do not). This assumption is also verified later when first-stage results are presented.

[14]The SUTVA assumption states that the outcomes of any student should not be affected by whether or not another student had the offer of earning a pre-major. It is a stronger form of independence among units under study, but it is reasonable to assume that one student's selection of the pre-major should not be affected by whether or not others were offered the option of the pre-major program. Satisfying the SUTVA also implies that there is no variation in treatment. However, it is not necessarily the case that all pre-major programs are the same. There are differences among the various fields of study, and this might generate variation in effects. For this study, it is assumed that the treatment is homogenous.

groups that might impact program offerings, student selection into programs, and ultimate outcomes. However, there could still be other unobservable characteristics of institutions that have important effects.

Table 1.2: Differences in Mean College Characteristics Between Colleges that Offer Pre-majors and Those That Do Not

	2003	2004	2005
FTE	786.35$^{\cdot}$	734.78$^{\cdot}$	785.42$^{\cdot}$
150 Graduation Rate	−0.04	−0.03	−0.01
Academic Support/FTE	−27.05	−92.40	−93.72
Operations and Maintenance/FTE	−104.06	−66.36	−112.40
Student Services/FTE	−49.34	22.97	−34.64
Institutional Support/FTE	−56.50	−183.16	−234.74
Instruction/FTE	−771.99*	−468.48*	−514.19$^{\cdot}$
Total Expenditures/FTE	−1089.77$^{\cdot}$	−923.11$^{\cdot}$	−1076.49$^{\cdot}$
Pell/FTE	−105.39	−59.10	−91.31
Completions/100FTE	−2.67	−2.26	−2.62

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Figures indicate pre-major college means minus non-pre-major college means. Columns represent academic years. Variables are derived from IPEDS and represent enrollment counts, graduation rates, and expenditures per FTE.

Additional support for the instrument's validity is found by regressing student background characteristics on the instrument (and other explanatory variables). The instrument should not have any predictive power in explaining these outcomes. In Table 1.3, each row represents a background student characteristic that is used as an outcome in a regression. The reported coefficients are for the pre-major offer indicator variable. Model 1 contains only the pre-major offer as an explanatory variable, Model 2 includes other demographic characteristics as controls, and Model 3 includes controls for taking developmental education courses.[15] Although the pre-major offer does seem to predict race, I do not think this reduces the credibility of the instrument. There are no other notable differences in these characteristics between the two groups of institutions.

[15]The explanatory variables are discussed in greater detail in Section 1.5.

Table 1.3: Reduced-Form Regressions of Background Characteristics on Pre-major Offer Indicator

	Model 1	Model 2	Model 3
Age	0.083	0.017	0.059
	(0.430)	(0.331)	(0.349)
Female	0.022	0.019	0.023
	(0.028)	(0.022)	(0.021)
White	−0.006	0.011*	0.011*
	(0.043)	(0.005)	(0.005)
Black	0.005	0.010*	0.010*
	(0.034)	(0.005)	(0.005)
HS Diploma	0.009	0.011	0.011
	(0.018)	(0.020)	(0.020)
Took Both Dev	0.001	−0.004	0.007
	(0.035)	(0.033)	(0.007)
Demographics		X	X
Dev Ed			X
Num. obs.	55030	55030	55030

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Another potential violation of the exclusion restriction comes from the possibility that pre-major and non-pre-major institutions differ in their relationships with four-year institutions. One way to check this is by assessing bilateral articulation agreements that community colleges and UNC colleges have developed to facilitate transfer for those students who have earned an Associate in Applied Science (AAS) degree. AAS's are considered terminal degrees that prepare students for occupations rather than for transfer. Therefore, they are not covered in the Comprehensive Articulation Agreement. Having recognized that many AAS students do desire to transfer, pairs of institutions have developed special agreements that help these students transfer more smoothly. If pre-major institutions have more of these agreements, it may indicate that they have closer ties to their students' destination institutions, which could impact transfer and baccalaureate outcomes regardless of the type of AA/AS program in which a student is enrolled. The earliest inventory available for these agreements dates from 2007, which is in the middle of the observation period. Across the state, there are 1,246 bilateral agreements between the 58 community colleges and 13 of the 16 UNC colleges. These agreements represent a range programs from nursing to business to electrical technology. Of the total, 616 agreements are held by pre-major colleges and 630 are held by non-pre-major colleges, or about 23 per pre-major college and 20 per non-premajor college. Pre-major colleges have partnered with 11 institutions and non-offering colleges have partnered with 13. Lastly, pre-major colleges have AAS articulation agreements in 74 unique programs; non-offering colleges articulate 83 AAS programs. Ultimately, there do not seem to be any important differences here that indicate stronger or weaker relationships between two- and four-year institutions by pre-major offering status.

Next, I offer anecdotal evidence that the decisions to offer these programs or not were idiosyncratic and should not be systematically related to outcomes. Variation in program offerings by college is driven by that fact that some colleges decided to offer the programs while others did not. However, what is the origin of this variation? All colleges ultimately chose to offer or not offer pre-major programs, and they did so for a number of reasons. In discussions with administrators at several colleges, many different reasons emerged for

deciding whether or not to offer these programs. A senior official at a large community college explained that academic officials decided not to offer pre-majors because they were skeptical of the ability for the state and its four-year college system (University of North Carolina) to uphold the articulation agreement that laid the groundwork for pre-major articulation. That is, the official said that the college did not want to set students up for failure or for disappointment when credits did not transfer or entrance into an academic program was denied. A senior academic official at a medium-sized college that also does not offer pre-major programs reported that the decision was philosophical. College leadership felt that pre-majors instituted too much structure during the first two-years of college, and they wanted to maintain exploration as a fundamental part of higher education.

At a medium-sized college that does offer pre-major programs, an official suggested that the programs were adopted partially since they are a good marketing tool. The administrator noted that the programs were a selling point, but were especially meaningful for students who wanted to feel like they were on more of a four-year college pathway than a two-year college pathway. In a sense, the programs help students deal with feelings of studying at "inferior" institutions. At another medium-sized institution that offers pre-majors, an administrator indicated the the pre-majors were adopted to improve advising and course selection for students in college transfer programs. The viewpoint among college leaders was the pre-majors would ultimately be beneficial to students who had a major in mind at the four-year school. From these informal discussions, there does not appear to be anything clearly systematic between colleges that do and do not offer pre-major associate degree programs. However, an in-depth qualitative analysis may be required in order to gain a better understanding of why individual colleges chose to offer pre-majors.

1.5 Data

1.5.1 Overview

The data from this study come from several first-time-in-college (FTIC) cohorts of students who begin their postsecondary studies at one of 58 community colleges in North Carolina and enroll in a college transfer AA/AS program.[16] I consider students who begin college between the Fall 2003 and the Summer of 2005. This date range was selected in order to provide enough time for students to potentially complete their community college studies, transfer, and earn a baccalaureate. I rely on several datasets provided by the NCCCS office, which collects data from all 58 colleges on student demographics, transcripts, financial aid, and credentials. Community college credential data are available through Summer 2010. Information on transfer outcomes comes from the National Student Clearinghouse (NSC) and is available through early 2012. The FTIC sample consists of 55,043 students.[17]

1.5.2 Sample and Descriptive Statistics

Before discussing analytical results, it is important to understand who is in the sample of AA/AS and transfer-seeking students under study. Descriptive statistics for all students and various subsamples are presented in Table 1.4. The first column of Table 1.4 presents means for all students. The second and third columns present means for students who are in

[16]It is, of course, possible for students to change majors or programs during their college. For this study, however, I only consider their initial program of study. It is the initial program choice that sets them on a particular pathway that is either relatively structured or unstructured. In sensitivity analyses, I restrict the sample to students who did not switch programs within one and two years.

[17]Often in studying transfer, researchers restrict the sample to students who completed some number of non-remedial credits. It is recommended that a certain threshold of credits be employed in the assessment of transfer to eliminate incidental students who would be unlikely to transfer and would bias results (Clagett & Huntington, 1992; Spicer & Armstrong, 1996). Although Adelman (2006) used 10 credits as the threshold and others have used 12 or more (Cohen, 1994), I feel that I do not have to perform this since I have a good measure of program enrollment and intent.

institutions that do not offer pre-majors and those that do, respectively. For the most part, these observable student characteristics are quite balanced. Larger differences are found in the percentage of students who are employed in the first term (64 percent vs. 59 percent) and students taking developmental education in math (56 percent vs. 51 percent), one of three proxies for prior ability. Students in non-offering institutions are somewhat more likely to enroll in math remediation but not in English remediation.[18] On the whole these differences are quite small and do not suggest any worrisome student sorting.

Table 1.4: Descriptive Statistics: Demographic Characteristics

	All Students		Control Inst.		Pre-major Inst.		AA/AS		Pre-majors	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Female	55.4	49.7	54.1	49.8	56.3	49.6	55.4	49.7	58.3	49.3
Age	24.0	7.4	23.9	7.5	24.0	7.4	24.0	7.4	24.1	7.4
White	69.5	46.1	69.8	45.9	69.3	46.1	69.6	46.0	68.5	46.5
Black	20.6	40.4	20.2	40.2	20.8	40.6	20.1	40.1	22.3	41.6
American Indian	1.4	11.8	1.1	10.4	1.6	12.7	1.8	13.4	1.2	10.9
Hispanic	3.8	19.1	3.5	18.4	4.0	19.6	4.2	20.1	3.4	18.1
Asian	2.2	14.7	2.1	14.4	2.3	14.8	2.2	14.8	2.3	14.9
Other Race	2.5	15.7	3.2	17.7	2.1	14.4	2.0	14.0	2.3	15.1
LEP	0.4	6.5	0.3	5.9	0.5	6.9	0.4	6.6	0.6	7.6
HS Diploma	94.9	22.0	94.3	23.1	95.2	21.3	95.3	21.3	95.2	21.4
US Citizen	97.7	14.8	97.3	16.1	98.0	14.0	97.9	14.5	98.4	12.6
Inmate	0.0	1.3	0.0	1.4	0.0	1.2	0.0	1.3	0.0	1.0
Employed	60.8	48.8	63.7	48.1	59.0	49.2	58.8	49.2	59.4	49.1
Took Dev Math	52.9	49.9	55.7	49.7	51.2	50.0	51.6	50.0	50.4	50.0
Took Dev Eng	30.8	46.2	30.5	46.0	31.0	46.3	31.3	46.4	30.3	46.0
Took Both Dev	25.0	43.3	24.9	43.3	25.1	43.4	25.1	43.4	25.1	43.3
2003 Cohort	34.4	47.5	34.1	47.4	34.6	47.6	35.7	47.9	32.1	46.7
2004 Cohort	33.3	47.1	34.0	47.4	32.8	46.9	33.1	47.1	32.0	46.6
2005 Cohort	32.3	46.8	31.8	46.6	32.6	46.9	31.2	46.3	35.9	48.0
N	55043		21239		33804		23745		10059	

Notes: All variables except Age are expressed as percentages.

[18]During this time period, each college in NC determined its own remediation policy, and thus the probability of a student enrolling in developmental education changes from institution to institution. The extent to which these policies correlate with the policy to offer pre-majors could be a potential concern, if, for example, the difference in developmental education rates at each college type is driving outcome differences. I control for developmental enrollment in regression models as a partial response to this issue.

The last two columns in Table 1.4 describe the students at pre-major offering institutions who selected the traditional AA/AS path or the pre-major path, respectively. Pre-major students are more heavily female and black, and less likely to be white and enrolling in developmental education. Although these differences are also small, they do provide a window into understanding who is selecting into these relatively more structure programs of study.

Table 1.5 summarizes information on program participation (rows one and two) and outcomes. Though only 47 percent of colleges off pre-major programs, about 61 percent of students in the cohort were eligible to enroll in them. About 18 percent of students across the state and 30 percent of students at offering colleges select into the programs.

Table 1.5: Descriptive Statistics: Program Availability, Participation, Outcomes

	All Students		Control Inst.		Pre-major Inst.		AA/AS		Pre-majors	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-major College	61.4	48.7	0.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
In Pre-major	18.3	38.6	0.0	0.0	29.8	45.7	0.0	0.0	100.0	0.0
CC Credits	32.2	29.7	32.5	30.1	32.0	29.5	31.5	29.4	33.0	29.5
Withdrawal Rate	17.8	25.1	20.3	25.8	16.2	24.5	15.8	24.3	17.4	24.9
200 Course	7.8	9.4	8.1	9.8	7.6	9.1	7.3	9.0	8.3	9.4
Coll Tran Rate	68.2	29.3	67.2	29.2	68.9	29.4	68.2	29.8	70.5	28.3
Coll Tran Creds	26.7	24.5	26.3	24.6	27.0	24.5	26.3	24.3	28.5	24.8
PE Credits	0.5	1.0	0.5	1.0	0.5	1.0	0.4	1.0	0.5	1.0
Intend CC 3yrs	5.5	22.8	6.1	24.0	5.2	22.1	5.9	23.6	3.3	17.8
Intend CC 4yrs	6.9	25.4	7.7	26.7	6.4	24.5	7.5	26.3	3.8	19.2
Intend CC 5yrs	7.6	26.5	8.5	27.9	7.0	25.6	8.3	27.6	4.0	19.7
Any CC 3yrs	8.9	28.4	8.6	28.0	9.0	28.7	9.0	28.7	9.0	28.7
Any CC 4yrs	12.2	32.7	11.8	32.3	12.4	32.9	12.3	32.9	12.4	33.0
Any CC 5yrs	14.3	35.0	13.9	34.6	14.5	35.3	14.5	35.2	14.7	35.4
Xfer 3yrs	21.1	40.8	21.8	41.3	20.6	40.5	20.3	40.2	21.5	41.1
Xfer 4yrs	27.1	44.5	27.8	44.8	26.7	44.3	26.4	44.1	27.6	44.7
Xfer 5yrs	31.0	46.2	31.6	46.5	30.6	46.1	30.2	45.9	31.4	46.4
Xfer 6yrs	34.0	47.4	34.5	47.5	33.8	47.3	33.3	47.1	34.9	47.7
BA 4yrs	3.4	18.1	3.3	18.0	3.4	18.2	3.3	17.9	3.7	19.0
BA 5yrs	8.1	27.2	7.8	26.9	8.2	27.4	7.9	27.0	8.9	28.4
BA 6yrs	12.0	32.5	11.8	32.3	12.1	32.6	11.6	32.1	13.1	33.8

Notes: All variables are expressed as percentages.

I consider several outcomes in this study, described in rows 3 through 21 in Table 1.5. First, I focus on community college course-taking outcomes: non-developmental college cred-

its earned, course withdrawal rates, number of upper-level (200-level) credits earned, the percentage of courses attempted that are on the approved list of college transfer courses, the number of credits earned in college transfer courses, and the number of credits earned in physical education courses. There are also six outcomes that focus on degree-earning rates at the community college: earning the intended degree within three, four, or five years from first community college enrollment and earning any community college credential within three, four, or five years. Next I focus on outcomes related to four-year colleges: transferring to a four-year school within three, four, or five years and earning a bachelor's degree from a four-year school, within four, five, or six years. Although achieving two-year credentials, transferring, and earning a baccalaureate degree are all stated goals of the pre-major programs and thus are relevant outcomes to study, it may be the case that pre-major programs have a greater impact on community college course-taking patterns than on distant outcomes such as graduation and transfer.[19]

Although the structure hypothesis predicts that students in pre-major programs should be more likely to earn community college credits, to transfer to a four-year institution, and to earn a bachelors degree than those who are not in these structured programs, these simple comparisons suggests that the relationship is more nuanced. Comparing the last two columns of Table 1.5, it appears that students in pre-major programs are much less likely to earn a community college credential but slightly more likely to transfer and earn a baccalaureate degree. However, columns two and three, which compare students in offering and non-offering institutions (the reduced-form comparisons), tell a similar story with regard to two-year outcomes but the opposite story with regard to four-year outcomes. In fact, there

[19]Students are considered as successfully transferred or earned a four-year credential if they have done so at any four-year college. That is, I do not restrict outcomes to those that occur at colleges in the UNC system. Although the pre-majors are designed with transfer from NCCCS to UNC in mind, students may also transfer to one of several independent or private colleges that have agreed to the CAA. In this sample, about 70 percent of students who transfer remain in the state of North Carolina and 58 percent transfer to a UNC institution. Restricting the sample by transfer destination would essentially be controlling for a post-treatment event, which would further bias results (Gelman & Hill, 2006).

appear to be no differences in baccalaureate completion rates between students at offering and non-offering colleges.

1.6 Results

1.6.1 OLS Results

I begin by presenting OLS results based on Equation 1.1. Table 1.6 reports OLS coefficients on the indicator variable denoting that the student has enrolled in a pre-major. Each row is a community college or transfer outcome, and each column is a separate model specification. The first column (Model 1) only contains the explanatory variable of interest. The second model adds demographic characteristics (from Table 1.4), and the third and preferred model adds indictors for enrolling in developmental education to proxy prior ability. Adding explanatory variables to the models generally does not produce large changes in the coefficients of interest, regardless of the outcome. The OLS results suggest that students in pre-major programs may earn about 1.3 more college credits and about 0.7 upper level course credits than those in traditional AA/AS programs. Pre-major students also earn about 2.5 more credits approved for college transfer compared to their traditional AA/AS counterparts. Though I find no effects for earning any associate degree, there is a negative and significant relationship, however, between earning the intended credential and enrollment in a pre-major program - from 3 to 5 percentage points depending on the time frame allowed. That is, students in pre-major programs are less likely to earn their pre-major credential within three, four, or five years than students in traditional AA/AS programs. I find no significant relationship between enrollment in a pre-major program and transferring to a four-year college or baccalaureate recipience.

Table 1.7 restricts the sample so that the comparisons are only among students who are in pre-major colleges. The pattern of significance is the same as found in Table 1.6. Students in pre-major programs still earn more meaningful and higher levels credits, but they are less likely to earn their intended credential. There remains no detectable impact on other two-

year outcomes. There are some small positive impacts on the baccalaureate outcomes, but they disappear after controlling for ability.

1.6.2 First-Stage Results

Acknowledging that there is likely bias in these OLS coefficients, I next present coefficients from instrumental variables models, beginning with the first-stage results. The first-stage results computed from estimating Equation 1.4 are shown in Table 1.8. Across the three models, there is a positive and significant relationship between being in a school that offers pre-majors and selecting a pre-major program (coefficient of 0.297 with a standard error of 0.037). This is not unexpected, as students who are not enrolled at one of the 27 pre-major colleges are not able to select the program. These first-stage results chiefly support the key assumption required for identification with instrumental variables that the instrument has a non-zero causal effect on treatment.[20] Perhaps trivially, the program offer does indeed incentivize students to select into pre-major programs.

1.6.3 Reduced-Form Results

The reduced-form, intent-to-treat results (ITT) from estimating Equation 1.3 are shown in Table 1.9 for community college and transfer outcomes. The tables report coefficients on the instrument, which can arguably be interpreted as causal parameters that reflect the impact of the availability or offer of pre-major programs on outcomes. Estimates for the two-year outcomes in Table 1.9 tell a different qualitative story as the OLS results reported in Section 1.6.1. The impacts of pre-major enrollment on credit and course-taking outcomes fall to zero, and there is no detectable reduced-form impact on earning any community college credential. However, I do find a negative coefficient on earning the intended credential: students at offering schools are about 1.5 percentage points less likely to earn the intended credential within each time frame. These results are relatively robust across model specifications. Null

[20] In addition, the F-statistic on the excluded instrument is sufficiently large, 8,024.

impacts of the program offer on transfer and four-year outcomes remain.

Significant intent-to-treat (ITT) effects can be scaled by the first-stage result to arrive at a local average treatment effect (LATE) of being in a pre-major program. Null effects, however, are likely to remain zero. Since significant effects were detected for earning the intended credential, I will report coefficients from two-staged least squares (2SLS) procedures that estimate the LATE in the next section.

1.6.4 Instrumental Variables Results

Instrumental variables coefficients are presented for all outcomes in Table 1.10 (I present all outcomes for completeness even though many will remain zero as they were in the reduced-form models). The IV estimates are the reduced-form effects scaled up by the percentage of students who comply with assignment (who enroll in a pre-major program). Under the assumptions discussed in Section 1.4.2.1, these coefficients represent the LATE, the effect of the treatment on the treated, or the effect of being on a relatively structured pathway on outcomes for those incentivized to select the program due to the offer of treatment.

The effect of being in the pre-major program on earning the intended two-year credential ranges from about -3.7 to -5.4 percentage points when measuring the outcome from three to five years (see Table 1.10). These impacts are remarkably similar to the OLS results of -3 to -5 percentage points. The general interpretation is the same, though the IV results may be interpreted as causal effects for the students in pre-major programs.

Taken together, instrumental variables estimates suggest that on average, pre-major programs do not have meaningful impacts on two-year and four-year outcomes. The results thus far seem to contradict hypotheses surrounding structured programs of study. The next section consists of a series of subgroup and sensitivity analyses that test the robustness of these general findings. A discussion follows.

1.6.5 Extensions and Sensitivity Tests

1.6.5.1 Reduced-Form Models with Different Subsets

Often in North Carolina, statewide analyses are at risk of being driven by the two largest colleges in the state. Table 1.11 reports results for a sample of students at 56 colleges; Wake Technical Community College and Central Piedmont Community College have been omitted. Wake Tech does not offer pre-majors, but Central Piedmont does. The reduced-form results for two-year outcomes are similar, and the coefficients on the instrument for the earning the intended credential outcomes are just slightly larger than in models that include these two colleges. It does not seem that these instutions were driving any of the earlier results.

As mentioned earlier, I identify students in pre-major programs by looking at the program in which a student is enrolled in her first term. Students, of course, change programs of study at various points in time along their higher education pathway. It is possible that the main effects include several students in both the pre-major and non-premajor groups who may not be considered committed to their particular program of study that was determined upon first entering college. Therefore, I consider estimates from two additional models that consider students who remain in their programs for at least one year and at least two years. Table 1.12 presents reduced-form results for this first group of "serious" students who did not change their program of study within the first year. The results mirror earlier findings of negative program effects on earning the intended credential and transferring within three years. Results using a sample of students who did not change programs within two years are presented in Table 1.13. The direction and magnitude of the reduced-form effects are the same, as the sample restriction does not markedly affect the intepretation of results.

Structured programs such as pre-majors may be more effective for students in different age groups. Given the differences in pathways between younger and older students (Calcagno, Crosta, Bailey, & Jenkins, 2007), it is possible that younger students respond more favorably to prescribed programs of study that limit choice. To test this, Table 1.14 reports reduced-from coefficients for a subsample of students who are 22 years old or less upon entry to

community college (N=34,833). Surprisingly, effects that were significant when using the entire sample do not persist for this subset of younger students, suggesting that results are driven by older students. All previously significant coefficients are attenuated to zero when using this sample of younger students. In addition, for younger students, the only effect I detect is that students in pre-major institutions earn about 2.2 more credits from courses on the approved college transfer list.[21]

1.6.6 Reduced-Form Models with Alternate Instruments

The primary instrument used thus far is simply a dummy variable that indicates a student is enrolled at an institution that offers pre-major programs. It has been assumed that the offer of the pre-major provides an incentive for students to earn the degree and that this instrument works the same at each pre-major college. As mentioned and shown in Figure 1.3, there is substantial variation in the percentage of students in offering colleges who actually select the pre-major programs. To use this variation in the analysis, I create an alternative real-valued instrument where in lieu of a binary indicator, the instrument is the proportion of pre-major students at each institution. Such an instrument could, in a sense, represent the strength of the incentive to earn a pre-major at each institution and could be considered a stronger instrument. Reduced-form coefficients using the percentage of pre-majors instrument are presented in Table 1.15. Effects for earning the intended two-year credential remain negative and significant for pre-major students, though the magnitudes of the effect are much larger compared to Table 1.9.

An alternative instrumental variables strategy is to combine distance to college types and program selection in designing an instrument, similar what Bettinger and Long (2005) do in their study of the effects of developmental education in Ohio. Though most students attend the nearest community college, some students have options. Figure 1.5 shows the placement of colleges throughout North Carolina by pre-major offer status. The manner

[21] Though not shown here, reduced-form coefficients using a sample of those older than age 22 upon starting college reveal significant coefficients seen in previous tables.

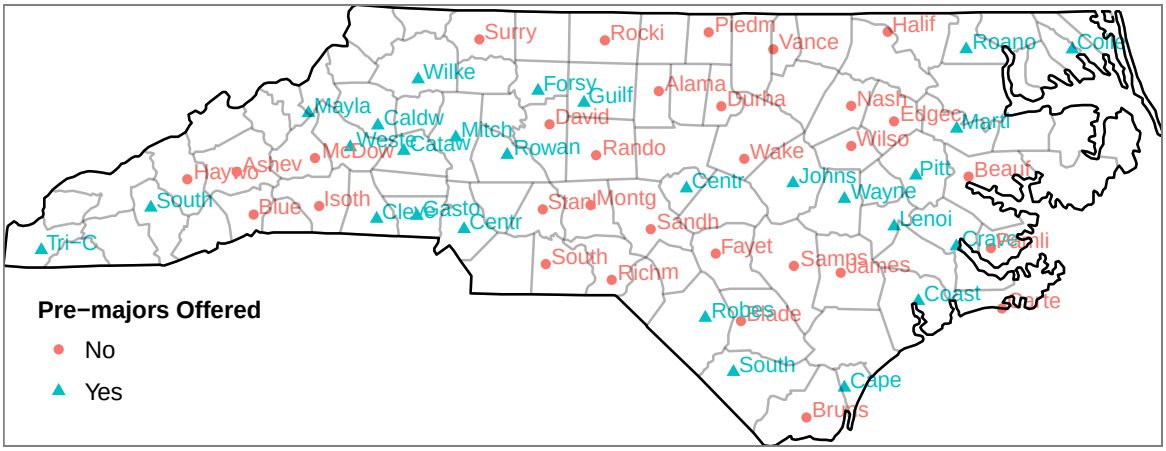

Figure 1.5: NC Community Colleges by Pre-Major Offer

in which colleges are placed throughout the state allows some students to choose between colleges that do and do-not offer pre-majors even though the nearest college may generally be the chosen one. Though many students live within a cluster of colleges that are either offering or non-offering, some students could travel to an offering college that might not be the closest. If distance to college is related to the school chosen and therefore the pre-major offer policy and distance is not related to any of the outcomes under study, then distance is a valid instrument for the type of college attended and for selection into a pre-major program. The instrument presented here combines the likelihood of a students' choosing a particular institution (based on distance) with the likelihood of selecting a pre-major program at a college (based on student characteristics).[22] The interaction of these variables should exogenously predict selection into pre-major program if distance exogenously predicts college attendance and colleges have variation in their pre-major policies. To predict the likelihood

[22]Partial address information (street address, county, and state) was available for about 45,000 students in the sample. These addresses were geocoded to ascertain longitude and latitude, and these were used to compute great-circle distances between students and each college.

of attending a particular college, I estimate a conditional logit model with j equations for each individual i where each equation describes college alternatives as shown in Equation 1.5.

$$Pr(Y_i = j) = \frac{e^{B'X_{ij}}}{\sum_j e^{B'X_{ij}}} \tag{1.5}$$
$$B'X_{ij} = \alpha + \beta S_j + \gamma_1 D_{ij} + \gamma_2 D_{ij}^2 + \varepsilon_{ij}$$

In Equation 1.5, S_j are fixed effects for each college, D_{ij} is the distance that student i lives from college j, and D_{ij}^2 is distance squared. Though not shown here, results from this first model indicate that students are less likely to attend colleges that are increasingly farther away. The second part of the instrument is a probit model that predicts the likelihood of a student choosing a pre-major at each college. This value is zero at the 31 non-offering colleges and between zero and one at the 27 offering colleges. The probit model predicts pre-major selection controlling for student characteristics in Table 1.4. I combine the probabilities of attendance and of selecting pre-major programs to construct the instrument by computing a weighted sum:

$$Z = \sum_{j \in J} Pr(PreMajor_i | College_j) Pr(Collegej | Anycollegej \in J) \tag{1.6}$$

The important variation in the instrument comes from differences across campus in the likelihood that a student would choose a pre-major program and the geographic proximity that determines how much weight each college's probability should be considered.

Reduced-form results using the instrument in Equation 1.6 are presented in Table 1.16. The reduced-form impact on earning the intended credential is negative like in all models presented thus far, though coefficients are only significant for earning the credential within four or five years. I also see a negative impact of pre-major programs on transferring to a four-year school within the four time periods - with magnitudes as high as negative ten percentage points. Additionally, there is a significant effect of earning credits on the approved college transfer list, indicating better decision-making among probable pre-major students.

Finally, I present a simple reduced-form specification that uses the distance in miles to the closest pre-major college (divided by 100) as an instrument. Coefficients are reported in Table 1.17 (they are generally opposite in sign as the other tables since greater distance means less likely to be a pre-major student).[23] In general, the distance instrument yields the same pattern of effects as have been seen thus far, though magnitudes are most similar to the OLS/IV estimates. The interpretation is that the probability of earning the intended credential within five years increases by 4 percentage points for every 100 miles in distance a student resides from a pre-major college. Taken together, the sensitivity analyses do not suggest any major changes in interpretation of results from the main models.

1.7 Discussion

1.7.1 General Findings

The research question in this study asks if enrolling in pre-major associate degree programs has a causal impact on community college and university outcomes. The first-stage results suggest that the offer of pre-majors does indeed induce some students to select into these programs. The reduced-form and instrumental variables estimates suggest that these programs are having a null or negative effect on measured outcomes, and any effect sizes are small in magnitude.

There are two findings that warrant specific attention. First, I find a negative effect of pre-major programs on earning the intended community college credential, but no effect on earning any associate degree. It is likely that these findings together are detecting that students who are enrolled in pre-major programs are indeed earning a community college credential, but they are earning the traditional AA/AS rather than the pre-major AA or AS.[24] Students may have difficulty finding certain courses or scheduling required courses that

[23]The first-stage coefficient on the distance instrument is -0.9, $p < 0.001$.

[24]Of the 10,059 students initially enrolled in pre-major programs, 407 earned the intended pre-major diploma within five years and 1,478 earned the traditional AA/AS within five years. Therefore, at very high

are needed to complete the pre-major program of study, and so many may just opt to earn the traditional credential. Still others might receive various other certificates in a range of different programs instead.

Second, in some models, I find a weak, negative impact for transferring to four-year schools but no impacts for baccalaureate earning rates. The estimates suggest that students in the pre-major programs may not be transferring up to four-year schools at higher rates than those in AA/AS programs, but this in some ways is an intention of the programs. Pre-majors are partially designed to incentivize completing the AA/AS degree before transferring, and so I expect pre-major students to transfer later than traditional AA/AS students. However, there is no detectable difference in credits accumulated at community colleges, which I would also expect if pre-major students were staying longer at community colleges attempting to finish programs. Further, though pre-major students transfer at lower rates, this does not seem to have an impact on baccalaureate completion rates. Thus it seems that whatever the path taken from two- to four-year schools, whether pre-major or traditional route, early or later transfer, students in both programs are just as likely to earn or not earn bachelors degrees within four, five, or six years after starting college.

Though the findings of this analysis may not support the notion that additional structure in community college programs can benefit students, I pause before indicting structure as harmful to students. There are a few potential ways to interpret my findings. One explanation is that the pre-major programs did not really lead to differences in behavior compared to traditional students. Alternatively, they may have led to some differences, but the differences were not large enough to have an impact. Since I do not detect effects on course-taking patterns in any model, one might argue that there essentially is no treatment. Similarly, longer term outcomes like transfer and bachelor's degree completion maybe not be impacted if there is no treatment or, if there is a treatment, the impact it has on student behavior at the community college does not extend to impacts at four-year colleges.

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rates, students who intend to earn pre-major diplomas (and maintain enrollment in these programs) are switching to the traditional degree program.

An alternative explanation for null findings is that even though the comparison colleges do not offer pre-major programs explicitly, the colleges may have been informally offering similarly structured pathways. This could occur in two ways. First, it is possible that non-pre-major colleges use the pre-major curriculum templates to advise students who desire to transfer and who have a transfer degree program in mind. These students would fundamentally be following a similar program of study, though perhaps not as strict, as students in pre-major programs at offering colleges. Second, non-offering colleges could simply create their own curriculum templates that are prescriptive like pre-major programs. Therefore, the results in this paper may not be null because of the lack of structure's efffectiveness, but rather it could be that the comparison students also have access to similarly structured programs or non-offering colleges are finding equally effective ways to advise students.

That all said, it is likely that the empirical results are detecting a failure in process, policies, and procedures that are required to support structured programs rather than the failure of the structured programs themselves. The negative results for pre-majors, which are a provision supported by the Comprehensive Articulation Agreement, are in concordance with much of the existing research on transfer articulation agreements. Gross and Goldhaber (2009) suggest that weak policy designs and poor implementation may be reasons for the lack of relationship between these policies and transfer rates. Wellman (2002) warns that transfer policies are often written with the associate degree in mind, but proper incentives are not there to encourage students to actually complete the degree before transferring.

Prevailing attitudes of personnel in North Carolina involved with the transfer and articulation process confirm this interpretation, and pre-major programs are losing support even at schools where they are currently offered. Personal communications with administrators at three colleges have revealed that there is a general lack of faith in the programs, and many schools are considering to phase them out as they redesign their program offerings as part of new reforms. "If we could get rid of all of them, I would. The pre-majors were great in concept, but didn't quite live up to their potential," wrote one administrator via e-mail.

Another administrator elaborated:

> When they were adopted, the pre-majors were created with a host of rules that do not always apply to the AA and AS degrees. Students had to take the courses as prescribed and could not make substitutions, and they were limited in the number of courses they could take at other institutions. Students began complaining that universities were not receiving the pre-majors as they were intended. If students did not work with the university from the start of their time at the community college, they still risked having to repeat their courses again after transferring. The rules led to few students being able to get through the pre-major degree programs, and they often dropped the pre-major to only earn the AA or AS degrees at the point of graduation.

A college administrator noted, "I personally have consoled many a crying a student, while trying to convince them that AA degree is really the same thing and that the only difference is that it won't say 'Pre-Major in Psychology' on it."

The quantitative results presented here and the anecdotal evidence from college administrators suggest that there is a concern that the processes that support pre-majors for transfer and baccalaureate outcomes are not strong. However, it is also suprising that reduced-form estimates were unable to detect impacts on course-taking. At minimum, students in pre-major programs should be making better decisions about which courses to take than their traditional AA/AS counterparts who are theoretically more likely to become "lost".

This present study stops short of pursuing the full qualitative analysis that could yield insights into the underlying mechanisms and institutional dynamics that contribute to the successes and failures of pre-major programs at both the two- and four-year institutions. This may be a ripe area for further research to aid our understanding of how various structures impact student success.

1.7.2 Validity

Internal validity considerations were discussed along with the empirical strategy in Section 1.4. Ultimately, the interpretation of results as causal depends on the arguments made

in support of the instrumental varible. Of additional concern is external validity, or the degree to which the findings here can be generalized to other students in other systems. The largest threats to external validity come from the situational aspects of this current study. The structured associate degree pre-major programs have been studied in a policy environment that is unique to North Carolina. That is, even in states with relatively similar community college systems, it may be difficult to predict how the introduction of structured programs would impact outcomes. Other states have different articulation policies and relationships with four-year institutions, contextual factors that could influence how structured programs work in practice. The ability to generalize across individuals is less worrisome, as first-time-in-college community college students are not markedly different from state to state. It is mostly the specific features of students' college environments that threaten external validity.

1.7.3 Policy Implications

The lack of significant findings does not preclude some potentially important policy insights. At the time of this writing, the two- and four-year sectors in North Carolina are revamping the statewide articulation agreement. Central to the revised policy are a set of college transfer pathways that are built upon the idea of pre-majors. That is, colleges will no longer offer traditional AA/AS programs, and students will have to select a program focus or concentration early on. One explanation for our null results is that the mechanisms in place that are supposed to support the transfer pathway are not functioning as effectively as they could. It is likely that the existing articulation agreement, which includes the pre-major programs as well the list of courses that should transfer smoothly between sectors, is failing to do its job. Therefore, it is recommended that the two systems consider all aspects of the revised articulation agreement so that it is strengthened substantially. For example, community colleges should be sure to offer the courses that are specified in the transfer degree curricula. Four-year institutions should commit to accepting college credits that students earn in the community college system. Importantly, the newly designed pathways

must be clear - not only to students, but also to faculty in both sectors so that there is an understanding of how the two-year programs are aligned with destination programs in the four-year institutions.

1.8 Conclusions

Pre-major associate degree programs were created in North Carolina to help students align their community college coursework with courses that would be taken by native university students pursuing the same major during their first two years. By design, they offer a more structured pathway through the associate degree and potentially offer a smoother transition to four-year institutions. This paper presents arguably causal evidence on the impact of enrolling in pre-major programs on a range of outcomes such as course-taking decisions, earning community college credits, earning community college credentials, transferring to a four-year school, and earning a bachelor's degree.

I find that pre-major programs have negative or null effects on outcomes, reducing the probability of students earning their intended community college credential and possibly reducing transfer rates to four-year schools. These results were upheld in a range of sample manipulations and sensitivity tests with different instruments. Overall, I do not believe that the findings are an indication that structured programs of study fail to improve outcomes. But rather, there is likely a failure of supports that are required for students to succeed in these programs of study. Efforts should be undertaken by the two- and four-year systems in North Carolina to revisit the current articulation agreement and improve the underlying processes affiliated with these pathways.

Table 1.6: OLS - CC and Transfer Outcomes

	Model 1	Model 2	Model 3
CC Credits	0.992	1.156$^{\cdot}$	1.323*
	(0.831)	(0.670)	(0.666)
Withdrawal Rate	−0.005	−0.006	−0.004
	(0.021)	(0.021)	(0.019)
200 Course	0.660*	0.693**	0.713**
	(0.267)	(0.243)	(0.242)
Coll Tran Rate	0.028	0.031$^{\cdot}$	0.023**
	(0.019)	(0.018)	(0.007)
Coll Tran Creds	2.179***	2.321***	2.431***
	(0.629)	(0.524)	(0.539)
PE Credits	0.057	0.059	0.062
	(0.050)	(0.048)	(0.049)
Intend CC 3yrs	−0.027***	−0.028***	−0.028***
	(0.004)	(0.004)	(0.005)
Intend CC 4yrs	−0.037***	−0.038***	−0.038***
	(0.005)	(0.004)	(0.005)
Intend CC 5yrs	−0.044***	−0.044***	−0.045***
	(0.005)	(0.005)	(0.005)
Any CC 3yrs	0.002	0.002	0.001
	(0.007)	(0.006)	(0.008)
Any CC 4yrs	0.004	0.003	0.003
	(0.009)	(0.008)	(0.009)
Any CC 5yrs	0.005	0.004	0.004
	(0.010)	(0.008)	(0.009)
Xfer 3yrs	0.005	0.006	0.000
	(0.012)	(0.011)	(0.012)
Xfer 4yrs	0.006	0.008	0.002
	(0.015)	(0.014)	(0.014)
Xfer 5yrs	0.006	0.007	0.001
	(0.017)	(0.015)	(0.016)
Xfer 6yrs	0.011	0.012	0.006
	(0.017)	(0.015)	(0.015)
BA 4yrs	0.004	0.004	0.002
	(0.004)	(0.004)	(0.005)
BA 5yrs	0.010	0.010	0.007
	(0.008)	(0.008)	(0.010)
BA 6yrs	0.014	0.015	0.012
	(0.011)	(0.010)	(0.011)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	55043	55030	55030

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.7: OLS - CC and Transfer Outcomes, Pre-major Colleges

	Model 1	Model 2	Model 3
CC Credits	1.431	1.624*	1.686*
	(0.969)	(0.764)	(0.726)
Withdrawal Rate	0.016	0.016	0.017
	(0.021)	(0.021)	(0.019)
200 Course	1.070***	1.111***	1.113***
	(0.236)	(0.201)	(0.207)
Coll Tran Rate	0.023	0.025	0.020**
	(0.016)	(0.016)	(0.006)
Coll Tran Creds	2.177***	2.328***	2.360***
	(0.649)	(0.570)	(0.584)
PE Credits	0.065	0.067	0.068
	(0.048)	(0.045)	(0.045)
Intend CC 3yrs	−0.027***	−0.027***	−0.027***
	(0.005)	(0.005)	(0.005)
Intend CC 4yrs	−0.036***	−0.036***	−0.036***
	(0.006)	(0.006)	(0.006)
Intend CC 5yrs	−0.043***	−0.043***	−0.043***
	(0.006)	(0.006)	(0.006)
Any CC 3yrs	0.000	0.000	−0.001
	(0.007)	(0.006)	(0.007)
Any CC 4yrs	0.001	0.001	0.001
	(0.010)	(0.008)	(0.009)
Any CC 5yrs	0.002	0.002	0.002
	(0.010)	(0.008)	(0.009)
Xfer 3yrs	0.012	0.013	0.010
	(0.011)	(0.011)	(0.011)
Xfer 4yrs	0.013	0.014	0.011
	(0.014)	(0.012)	(0.012)
Xfer 5yrs	0.012	0.013	0.010
	(0.015)	(0.014)	(0.013)
Xfer 6yrs	0.016	0.016	0.013
	(0.016)	(0.014)	(0.013)
BA 4yrs	0.004	0.004	0.003
	(0.003)	(0.003)	(0.005)
BA 5yrs	0.009	0.010	0.008
	(0.007)	(0.007)	(0.008)
BA 6yrs	0.015·	0.016*	0.014
	(0.008)	(0.008)	(0.009)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	33804	33794	33794

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.8: First-Stage Regression

	Model 1	Model 2	Model 3
Intercept	0.000***	−0.040	−0.031
	(0.000)	(0.055)	(0.061)
Pre-major College	0.298***	0.298***	0.297***
	(0.038)	(0.038)	(0.037)
2004 Cohort		0.009	0.009
		(0.011)	(0.011)
2005 Cohort		0.033·	0.033·
		(0.017)	(0.017)
Female		0.015	0.015
		(0.011)	(0.011)
Age		0.000	0.000
		(0.000)	(0.000)
White		−0.022	−0.021
		(0.014)	(0.014)
Black		−0.005	−0.004
		(0.018)	(0.020)
American Indian		−0.077	−0.075
		(0.071)	(0.070)
Hispanic		−0.047*	−0.046*
		(0.021)	(0.021)
Asian		−0.012	−0.010
		(0.026)	(0.025)
LEP		0.055	0.055
		(0.044)	(0.044)
HS Diploma		−0.003	−0.002
		(0.023)	(0.023)
US Citizen		0.032	0.030
		(0.056)	(0.054)
Employed		0.005	0.005
		(0.013)	(0.012)
Took Dev Math			−0.013
			(0.022)
Took Dev Eng			−0.027
			(0.029)
Took Both Dev			0.030
			(0.025)
R^2	0.140	0.143	0.144
Num. obs.	55043	55030	55030

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Dependent variable for all models is a binary indicator for earning a pre-major. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.9: Reduced-Form - CC and Transfer Outcomes

	Model 1	Model 2	Model 3
CC Credits	−0.504	−0.520	−0.242
	(1.212)	(1.069)	(1.087)
Withdrawal Rate	−0.041	−0.041	−0.040
	(0.029)	(0.029)	(0.029)
200 Course	−0.552	−0.556	−0.510
	(0.367)	(0.353)	(0.335)
Coll Tran Rate	0.017	0.020	0.013
	(0.025)	(0.022)	(0.012)
Coll Tran Creds	0.653	0.710	0.928
	(1.088)	(0.971)	(0.985)
PE Credits	0.004	0.000	0.004
	(0.099)	(0.096)	(0.096)
Intend CC 3yrs	−0.010	−0.010*	−0.011·
	(0.006)	(0.005)	(0.006)
Intend CC 4yrs	−0.013*	−0.014*	−0.015*
	(0.007)	(0.006)	(0.006)
Intend CC 5yrs	−0.015*	−0.016**	−0.016*
	(0.007)	(0.006)	(0.006)
Any CC 3yrs	0.004	0.003	0.002
	(0.009)	(0.008)	(0.008)
Any CC 4yrs	0.005	0.004	0.003
	(0.011)	(0.009)	(0.009)
Any CC 5yrs	0.006	0.005	0.005
	(0.011)	(0.009)	(0.009)
Xfer 3yrs	−0.012	−0.010	−0.017·
	(0.014)	(0.012)	(0.010)
Xfer 4yrs	−0.010	−0.008	−0.014
	(0.018)	(0.014)	(0.012)
Xfer 5yrs	−0.010	−0.008	−0.014
	(0.020)	(0.016)	(0.014)
Xfer 6yrs	−0.007	−0.004	−0.010
	(0.021)	(0.017)	(0.015)
BA 4yrs	0.001	0.001	−0.001
	(0.005)	(0.005)	(0.005)
BA 5yrs	0.004	0.005	0.001
	(0.011)	(0.010)	(0.009)
BA 6yrs	0.003	0.004	0.001
	(0.015)	(0.013)	(0.013)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	55043	55030	55030

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.10: IV - CC and Transfer Outcomes

	Model 1	Model 2	Model 3
CC Credits	−1.693	−1.748	−0.814
	(4.140)	(3.655)	(3.688)
Withdrawal Rate	−0.138	−0.139	−0.134
	(0.104)	(0.104)	(0.105)
200 Course	−1.854	−1.868	−1.715
	(1.322)	(1.274)	(1.202)
Coll Tran Rate	0.057	0.069	0.044
	(0.084)	(0.073)	(0.042)
Coll Tran Creds	2.194	2.385	3.122
	(3.629)	(3.241)	(3.304)
PE Credits	0.012	0.000	0.013
	(0.332)	(0.324)	(0.323)
Intend CC 3yrs	−0.032$^{\cdot}$	−0.035*	−0.037*
	(0.019)	(0.016)	(0.018)
Intend CC 4yrs	−0.045*	−0.048**	−0.049*
	(0.020)	(0.018)	(0.019)
Intend CC 5yrs	−0.050*	−0.053**	−0.054**
	(0.021)	(0.019)	(0.020)
Any CC 3yrs	0.015	0.010	0.007
	(0.031)	(0.025)	(0.029)
Any CC 4yrs	0.017	0.012	0.012
	(0.036)	(0.030)	(0.032)
Any CC 5yrs	0.021	0.015	0.016
	(0.037)	(0.030)	(0.032)
Xfer 3yrs	−0.040	−0.035	−0.058$^{\cdot}$
	(0.048)	(0.040)	(0.033)
Xfer 4yrs	−0.034	−0.027	−0.048
	(0.059)	(0.049)	(0.040)
Xfer 5yrs	−0.034	−0.027	−0.046
	(0.067)	(0.055)	(0.045)
Xfer 6yrs	−0.022	−0.014	−0.033
	(0.070)	(0.058)	(0.048)
BA 4yrs	0.004	0.004	−0.004
	(0.017)	(0.017)	(0.016)
BA 5yrs	0.013	0.015	0.004
	(0.037)	(0.034)	(0.032)
BA 6yrs	0.009	0.014	0.002
	(0.051)	(0.046)	(0.043)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	55043	55030	55030

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using two-staged least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.11: Reduced-Form, No Wake or CPCC

	Model 1	Model 2	Model 3
CC Credits	−0.172	−0.428	−0.265
	(1.444)	(1.253)	(1.263)
Withdrawal Rate	−0.004	−0.002	0.002
	(0.023)	(0.023)	(0.022)
200 Course	−0.236	−0.272	−0.281
	(0.400)	(0.392)	(0.382)
Coll Tran Rate	0.044*	0.041*	0.021
	(0.021)	(0.021)	(0.013)
Coll Tran Creds	0.880	0.661	0.684
	(1.270)	(1.114)	(1.113)
PE Credits	−0.021	−0.020	−0.012
	(0.083)	(0.082)	(0.083)
Intend CC 3yrs	−0.012·	−0.012·	−0.014*
	(0.007)	(0.006)	(0.007)
Intend CC 4yrs	−0.015·	−0.014·	−0.016*
	(0.008)	(0.007)	(0.008)
Intend CC 5yrs	−0.016*	−0.016*	−0.018*
	(0.008)	(0.007)	(0.008)
Any CC 3yrs	0.003	0.004	0.001
	(0.010)	(0.008)	(0.009)
Any CC 4yrs	0.005	0.006	0.004
	(0.011)	(0.010)	(0.010)
Any CC 5yrs	0.005	0.006	0.004
	(0.012)	(0.010)	(0.011)
Xfer 3yrs	0.002	0.001	−0.012
	(0.010)	(0.010)	(0.011)
Xfer 4yrs	0.008	0.007	−0.006
	(0.011)	(0.011)	(0.012)
Xfer 5yrs	0.011	0.008	−0.005
	(0.013)	(0.013)	(0.013)
Xfer 6yrs	0.015	0.013	0.000
	(0.014)	(0.014)	(0.014)
BA 4yrs	0.004	0.005	0.001
	(0.006)	(0.006)	(0.006)
BA 5yrs	0.013	0.013	0.006
	(0.010)	(0.010)	(0.010)
BA 6yrs	0.016	0.015	0.008
	(0.013)	(0.012)	(0.012)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	45211	45199	45199

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.12: Reduced-Form, No program changers within 1 year

	Model 1	Model 2	Model 3
CC Credits	−1.091	−1.069	−0.737
	(1.178)	(1.018)	(1.020)
Withdrawal Rate	−0.043	−0.043	−0.042
	(0.031)	(0.031)	(0.031)
200 Course	−0.707$^{\cdot}$	−0.703$^{\cdot}$	−0.639$^{\cdot}$
	(0.400)	(0.376)	(0.353)
Coll Tran Rate	0.016	0.019	0.013
	(0.026)	(0.023)	(0.013)
Coll Tran Creds	0.259	0.305	0.582
	(1.186)	(1.036)	(1.039)
PE Credits	0.002	−0.003	0.001
	(0.106)	(0.103)	(0.102)
Intend CC 3yrs	−0.010	−0.011*	−0.012$^{\cdot}$
	(0.007)	(0.006)	(0.006)
Intend CC 4yrs	−0.015*	−0.016*	−0.016*
	(0.007)	(0.006)	(0.007)
Intend CC 5yrs	−0.017*	−0.018**	−0.018*
	(0.007)	(0.007)	(0.007)
Any CC 3yrs	0.002	0.001	0.001
	(0.009)	(0.008)	(0.008)
Any CC 4yrs	0.002	0.001	0.001
	(0.010)	(0.009)	(0.009)
Any CC 5yrs	0.003	0.001	0.002
	(0.011)	(0.009)	(0.009)
Xfer 3yrs	−0.012	−0.011	−0.017$^{\cdot}$
	(0.015)	(0.012)	(0.010)
Xfer 4yrs	−0.011	−0.009	−0.015
	(0.018)	(0.015)	(0.013)
Xfer 5yrs	−0.011	−0.009	−0.014
	(0.020)	(0.017)	(0.014)
Xfer 6yrs	−0.007	−0.005	−0.010
	(0.021)	(0.018)	(0.015)
BA 4yrs	0.001	0.002	−0.001
	(0.006)	(0.005)	(0.005)
BA 5yrs	0.004	0.005	0.001
	(0.012)	(0.011)	(0.010)
BA 6yrs	0.003	0.004	0.001
	(0.017)	(0.015)	(0.014)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	47895	47885	47885

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.13: Reduced-Form, No program changers within 2 years

	Model 1	Model 2	Model 3
CC Credits	−0.966	−0.903	−0.567
	(1.195)	(1.007)	(0.995)
Withdrawal Rate	−0.045	−0.046	−0.045
	(0.033)	(0.032)	(0.033)
200 Course	−0.657	−0.641	−0.578
	(0.449)	(0.412)	(0.385)
Coll Tran Rate	0.016	0.020	0.013
	(0.028)	(0.024)	(0.013)
Coll Tran Creds	0.325	0.388	0.688
	(1.286)	(1.111)	(1.099)
PE Credits	0.008	0.004	0.008
	(0.105)	(0.102)	(0.101)
Intend CC 3yrs	−0.009	−0.010$^{\cdot}$	−0.010
	(0.007)	(0.006)	(0.006)
Intend CC 4yrs	−0.013$^{\cdot}$	−0.014*	−0.014*
	(0.007)	(0.007)	(0.007)
Intend CC 5yrs	−0.015*	−0.016*	−0.016*
	(0.008)	(0.007)	(0.007)
Any CC 3yrs	0.003	0.002	0.002
	(0.009)	(0.008)	(0.008)
Any CC 4yrs	0.003	0.002	0.003
	(0.010)	(0.009)	(0.009)
Any CC 5yrs	0.003	0.002	0.003
	(0.010)	(0.009)	(0.009)
Xfer 3yrs	−0.013	−0.012	−0.018$^{\cdot}$
	(0.016)	(0.013)	(0.011)
Xfer 4yrs	−0.010	−0.009	−0.014
	(0.020)	(0.016)	(0.013)
Xfer 5yrs	−0.010	−0.008	−0.013
	(0.022)	(0.018)	(0.015)
Xfer 6yrs	−0.005	−0.004	−0.009
	(0.023)	(0.019)	(0.015)
BA 4yrs	0.000	0.001	−0.002
	(0.006)	(0.006)	(0.006)
BA 5yrs	0.003	0.004	0.001
	(0.013)	(0.012)	(0.011)
BA 6yrs	0.002	0.003	0.000
	(0.018)	(0.016)	(0.015)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	43418	43408	43408

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.14: Reduced-Form, Students age ≤ 22

	Model 1	Model 2	Model 3
CC Credits	−0.006	0.261	0.362
	(1.314)	(1.097)	(1.127)
Withdrawal Rate	−0.041	−0.041	−0.041
	(0.030)	(0.030)	(0.030)
200 Course	−0.455	−0.407	−0.386
	(0.432)	(0.407)	(0.386)
Coll Tran Rate	0.022	0.024	0.023*
	(0.025)	(0.021)	(0.012)
Coll Tran Creds	1.820	2.105*	2.209*
	(1.194)	(1.064)	(1.057)
PE Credits	0.023	0.024	0.024
	(0.121)	(0.116)	(0.115)
Intend CC 3yrs	−0.006	−0.007	−0.008
	(0.007)	(0.006)	(0.007)
Intend CC 4yrs	−0.009	−0.010	−0.010
	(0.007)	(0.006)	(0.007)
Intend CC 5yrs	−0.009	−0.010	−0.010
	(0.007)	(0.006)	(0.007)
Any CC 3yrs	0.005	0.004	0.004
	(0.011)	(0.009)	(0.010)
Any CC 4yrs	0.005	0.005	0.004
	(0.012)	(0.010)	(0.011)
Any CC 5yrs	0.010	0.009	0.008
	(0.012)	(0.010)	(0.011)
Xfer 3yrs	−0.012	−0.013	−0.016
	(0.013)	(0.013)	(0.012)
Xfer 4yrs	−0.009	−0.009	−0.011
	(0.017)	(0.016)	(0.015)
Xfer 5yrs	−0.007	−0.007	−0.010
	(0.020)	(0.018)	(0.017)
Xfer 6yrs	−0.003	−0.003	−0.005
	(0.021)	(0.019)	(0.017)
BA 4yrs	0.004	0.002	0.001
	(0.005)	(0.005)	(0.005)
BA 5yrs	0.011	0.010	0.009
	(0.012)	(0.011)	(0.010)
BA 6yrs	0.012	0.012	0.010
	(0.017)	(0.015)	(0.015)
Demographics		*X*	*X*
Dev Ed			*X*
Num. obs.	34833	34833	34833

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.15: Reduced-Form, Percent Pre-Major Instrument

	Model 1	Model 2	Model 3
CC Credits	1.958	1.574	2.366
	(2.972)	(2.504)	(2.479)
Withdrawal Rate	−0.047	−0.048	−0.039
	(0.081)	(0.082)	(0.075)
200 Course	0.203	0.125	0.196
	(0.948)	(0.877)	(0.857)
Coll Tran Rate	0.070	0.065	0.017
	(0.073)	(0.072)	(0.024)
Coll Tran Creds	3.503	3.213	3.692$^{\cdot}$
	(2.401)	(1.990)	(1.969)
PE Credits	0.222	0.210	0.230
	(0.213)	(0.212)	(0.214)
Intend CC 3yrs	−0.040*	−0.042**	−0.047*
	(0.017)	(0.014)	(0.020)
Intend CC 4yrs	−0.056**	−0.057***	−0.061**
	(0.019)	(0.016)	(0.021)
Intend CC 5yrs	−0.061**	−0.063***	−0.066**
	(0.020)	(0.016)	(0.020)
Any CC 3yrs	−0.001	−0.004	−0.011
	(0.028)	(0.022)	(0.030)
Any CC 4yrs	0.003	0.000	−0.004
	(0.033)	(0.026)	(0.032)
Any CC 5yrs	0.007	0.003	0.001
	(0.034)	(0.026)	(0.031)
Xfer 3yrs	−0.026	−0.027	−0.062$^{\cdot}$
	(0.034)	(0.029)	(0.035)
Xfer 4yrs	−0.026	−0.028	−0.061
	(0.040)	(0.034)	(0.040)
Xfer 5yrs	−0.035	−0.036	−0.068
	(0.044)	(0.037)	(0.043)
Xfer 6yrs	−0.027	−0.027	−0.060
	(0.047)	(0.040)	(0.043)
BA 4yrs	−0.002	−0.001	−0.013
	(0.011)	(0.011)	(0.016)
BA 5yrs	0.004	0.004	−0.014
	(0.024)	(0.022)	(0.028)
BA 6yrs	0.001	0.000	−0.018
	(0.035)	(0.031)	(0.037)
Demographics		X	X
Dev Ed			X
Num. obs.	55043	55030	55030

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Percent Pre-major shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.16: Reduced-Form, Bettinger and Long instrument

	Model 1	Model 2	Model 3
CC Credits	2.622	3.880	4.596$^{\cdot}$
	(3.021)	(2.392)	(2.463)
Withdrawal Rate	−0.076	−0.077	−0.076
	(0.083)	(0.085)	(0.079)
200 Course	−0.001	0.244	0.399
	(1.104)	(0.984)	(0.962)
Coll Tran Rate	−0.011	0.016	0.014
	(0.084)	(0.084)	(0.025)
Coll Tran Creds	3.583	4.890**	5.565**
	(2.580)	(1.848)	(1.839)
PE Credits	0.246	0.271	0.274
	(0.215)	(0.221)	(0.223)
Intend CC 3yrs	−0.035$^{\cdot}$	−0.037*	−0.037
	(0.020)	(0.016)	(0.024)
Intend CC 4yrs	−0.053*	−0.055**	−0.054*
	(0.022)	(0.018)	(0.025)
Intend CC 5yrs	−0.058**	−0.061**	−0.059*
	(0.022)	(0.018)	(0.024)
Any CC 3yrs	0.012	0.008	0.009
	(0.031)	(0.025)	(0.035)
Any CC 4yrs	0.014	0.009	0.011
	(0.036)	(0.029)	(0.037)
Any CC 5yrs	0.022	0.016	0.018
	(0.037)	(0.028)	(0.035)
Xfer 3yrs	−0.076$^{\cdot}$	−0.063$^{\cdot}$	−0.071$^{\cdot}$
	(0.040)	(0.033)	(0.039)
Xfer 4yrs	−0.099*	−0.083*	−0.088*
	(0.049)	(0.041)	(0.043)
Xfer 5yrs	−0.114*	−0.100*	−0.104*
	(0.055)	(0.046)	(0.046)
Xfer 6yrs	−0.111$^{\cdot}$	−0.099*	−0.102*
	(0.059)	(0.048)	(0.044)
BA 4yrs	−0.008	−0.008	−0.012
	(0.010)	(0.010)	(0.016)
BA 5yrs	−0.019	−0.014	−0.018
	(0.026)	(0.023)	(0.029)
BA 6yrs	−0.029	−0.018	−0.022
	(0.039)	(0.033)	(0.038)
Demographics		X	X
Dev Ed			X
Num. obs.	44863	44863	44863

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on instrument shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

Table 1.17: Reduced-Form, Distance/100 to closest Pre-major college

	Model 1	Model 2	Model 3
CC Credits	2.045	−0.183	−0.863
	(4.129)	(3.193)	(3.266)
Withdrawal Rate	0.155	0.159$^{\cdot}$	0.158$^{\cdot}$
	(0.096)	(0.094)	(0.093)
200 Course	1.657	1.189	1.035
	(1.388)	(1.256)	(1.187)
Coll Tran Rate	0.026	−0.015	−0.015
	(0.081)	(0.073)	(0.039)
Coll Tran Creds	−1.080	−3.251	−3.882
	(3.151)	(2.625)	(2.600)
PE Credits	0.016	−0.006	−0.009
	(0.303)	(0.294)	(0.292)
Intend CC 3yrs	0.025	0.022	0.022
	(0.017)	(0.016)	(0.019)
Intend CC 4yrs	0.045*	0.040*	0.039$^{\cdot}$
	(0.021)	(0.020)	(0.021)
Intend CC 5yrs	0.050*	0.045*	0.044*
	(0.022)	(0.021)	(0.022)
Any CC 3yrs	−0.020	−0.025	−0.025
	(0.028)	(0.023)	(0.027)
Any CC 4yrs	−0.014	−0.021	−0.023
	(0.035)	(0.028)	(0.030)
Any CC 5yrs	−0.013	−0.021	−0.023
	(0.037)	(0.029)	(0.031)
Xfer 3yrs	0.081$^{\cdot}$	0.064	0.071$^{\cdot}$
	(0.049)	(0.041)	(0.037)
Xfer 4yrs	0.107$^{\cdot}$	0.086$^{\cdot}$	0.091*
	(0.059)	(0.049)	(0.044)
Xfer 5yrs	0.110$^{\cdot}$	0.091$^{\cdot}$	0.094$^{\cdot}$
	(0.066)	(0.055)	(0.049)
Xfer 6yrs	0.105	0.088	0.091$^{\cdot}$
	(0.069)	(0.057)	(0.049)
BA 4yrs	0.002	−0.001	0.002
	(0.013)	(0.013)	(0.015)
BA 5yrs	0.018	0.006	0.009
	(0.030)	(0.028)	(0.028)
BA 6yrs	0.040	0.021	0.025
	(0.041)	(0.036)	(0.036)
Demographics		X	X
Dev Ed			X
Num. obs.	44863	44863	44863

Notes: Significance denoted by: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$. Only coefficient on Distance/100 to closest Pre-major College shown. Dependent variables are listed in first column. Models were estimated using ordinary least squares. Robust standard errors in parentheses, clustered at the college level.

2

Intensity and Attachment: How the Chaotic Enrollment Patterns of Community College Students Relate to Educational Outcomes

2.1 Introduction

The study of student pathways through community college has become an important part of understanding the whole student experience. Student pathways are the time-ordered series of courses that students complete as they advance toward their education goals, typically program completion with a credential or transfer to a bachelor's degree program. Centrally related to student pathways are students' enrollment patterns–both the intensity of enrollment as measured by full-time and part-time status and the continuity or attachment of enrollment as measured by the consecutiveness of attendance. It is well known that few students who enroll in public two-year colleges go on to complete an award within two years of study (Radford, Berkner, Wheeless, & Shepherd, 2010). A key reason for this is that community college student pathways and enrollment patterns are anything but traditional;

students routinely switch into and out of full-time and part-time status, and they frequently skip terms.[1]

Precisely how diverse student enrollment patterns are among students and the extent to which they are correlated with postsecondary outcomes have yet to be documented thoroughly. Although previous research has considered the relationship between starting as a full- or part-time student and educational outcomes (O'Toole, Stratton, & Wetzel, 2003) or has described the circumstance of mixed enrollment intensity (McCormick, Geis, Vergun, & Carroll, 1995), investigators have not typically considered the full extent of diversity in enrollment patterns. It is important for institutions to track students and understand when they are at risk of abandoning their studies, but colleges have not yet developed the ability to distinguish between normal variations in students' education pathways and danger signs of potential dropout.

This study addresses two research questions:

1. What are the enrollment patterns generated by community college students?

2. How are characteristics of these patterns related to postsecondary outcomes, such as earning a credential and transferring to a four-year institution?

Using data on two cohorts of students at five colleges in a single state, the investigation presented here reveals the diversity of enrollment patterns in terms of intensity and continuity that are generated by community college students along their educational pathways. The study employs a novel graphical technique to illustrate these patterns. In addition, the study aggregates thousands of enrollment patterns into six distinct types using a cluster analysis that combines patterns based on their main features. These clusters are found to be correlated with the probabilities that students will earn credentials and transfer to a bachelor's degree-granting institution.

[1]Although four-year student pathways are becoming more varied over time as students attend multiple educational institutions and swirl between different types of institutions (Adelman, 2006), this study considers enrollment pathways of only those students who begin in the public two-year sector.

Four key insights result from this analysis, some of which contradict the conventional view of how community college students progress. First, there are many unique patterns of enrollment generated by students over a five-year period. Second, categorizations of students as either part- or full-time based on first-term enrollment are largely inaccurate as they ignore the high degree of switching between these two attendance states. Third, it is particularly challenging to get students into and through programs of study when attendance is so varied. Finally, clustering enrollment patterns reveals that students in groups characterized by high levels of enrollment continuity are more likely to earn a credential (than students in groups with low levels of continuity) and students in groups characterized by high levels of intensity and consecutive full-time enrollment are more likely to transfer to a four-year school (than students in groups with low levels of enrollment intensity). Ultimately, continuity of enrollment and some full-time study are critical for success.

The remainder of this paper is organized as follows. Section 2.2 briefly reviews relevant literature related to postsecondary enrollment intensity. Section 2.3 describes the data set used for this investigation. Section 2.4 describes the empirical framework and findings, Section 2.5 presents a discussion of the findings, and Section 2.5 offers a conclusion.

2.2 Review of the Literature

Organizing, describing, and analyzing community college students by their patterns of enrollment and course-taking behavior has proved to be a useful exercise for better understanding the diverse educational pathways experienced by these students (Adelman, 2005; Bahr, 2010; Hagedorn, Cabrera, & Prather, 2010).[2] In *Moving Into Town*, Adelman (2005) used rich data from the nationally representative National Education Longitudinal Study of 1988 (NELS:88) to provide an organizing framework for traditional-age community college stu-

[2]Though closely related, this study does not cover the more general literature on theories of student persistence and attrition. For a historical overview that traces these theoretical models from Tinto (1975) to Bean (1980) to Metzner and Bean (1987) to Pascarella and Terenzini (1991), see Metz (2004).

dents. The report considered students as "residents" who move into and out of the "town" of community college, focusing on their pathways in a series of portraits: the link between high school and college (the event portrait), what happens at the college (the residence history portrait), and patterns of exit (the graduates portrait). In the residence history portrait, for example, Adelman (2005) used course-taking behavior to classify students as "homeowners", "visitors", or "tenants" based on the number of credits they earn from community colleges. Combining all three portraits ultimately led to a list of six distinct traditional-age populations served by the community college.

Incorporating enrollment intensity into a broad classification of student types, Bahr (2010) developed a typology of community college students using a cluster analytic technique. He built on earlier classification work (Ammon, Bowman, & Mourad, 2008; Hagedorn & Prather, 2005; VanDerLinden, 2002) that sought to identify broad types of community college students by combining behavioral data on course-taking and enrollment. Bahr used a very large sample of credit and non-credit students and focused on 13 enrollment and behavioral characteristics, such as units attempted in several subjects of study, enrollment intensity (mean units attempted per semester), course success ratios, and persistence (number of terms and years enrolled). Taxonomies such as this serve to illustrate the main types of students who are enrolling in these multiple-mission-oriented institutions and for what purpose. As Bahr noted, such an understanding will, "assist policymakers, administrators, practitioners, and other stakeholders in directing and optimizing the use of limited resources to maximize the benefits received by students ... [and] the increasing attention of institutional accountability has drawn attention to the need to distinguish students who enroll for differing objectives or desired benefits" (2010, p. 726).

Much of the existing literature related to enrollment patterns and enrollment intensity, however, does not take a broad descriptive tack but rather focuses on the relationship between students' first-semester experiences (their intensity in the first term) and educational outcomes. Additional national work by Adelman (1999, 2006) studied correlations between course-taking patterns and outcomes, finding that students who attended full-time less fre-

quently, did not enroll continuously, or were unable to earn at least 20 credits by the end of the first calendar year were much less likely to earn a bachelor's degree. Studying community college students in California, Driscoll (2007) analyzed course-taking patterns over six years, finding strong correlations between high levels of first-term (fall) enrollment intensity and the likelihood of returning for the spring semester as well as transfer and bachelor's degree earning rates. This descriptive analysis, however, relies on simple correlations and is not able to account for other confounding factors that may explain the observed relationships.

Stratton, O'Toole, and Wetzel (2004, 2007) and O'Toole, Stratton, and Wetzel (2003) have performed various analyses of the 1990/94 Beginning Postsecondary Students Longitudinal Survey (BPS) to explore the reasons behind enrollment intensity differences and the relationship between intensity and dropping out of college among students in two-year and four-year colleges. In an effort to understand why students enroll full-time or part-time, Stratton et al. (2004) concluded that older individuals and those in states with lower unemployment rates are less likely to enroll full-time. Studying the relationships between initial enrollment intensity to intensity over time, O'Toole et al. (2003) revealed that using initial (first-term) full-time/part-time status underestimates the incidence of part-time enrollment intensity, as about one quarter of their sample stopped out or attended part-time for at least one term but still managed to graduate or continue to enroll at the end of five years.

Stratton et al. (2007) focused on differences in attrition rates among students who begin postsecondary education on a part-time or full-time basis. Their analysis recognized that factors correlated with initial enrollment intensity may be correlated with the decision to drop out, leading to bias in simply estimating the effect of initial enrollment intensity on the probability of attrition. Modeling both the choice to enroll as a full- or part-time student and the decision to drop out as separate but related processes revealed that observable factors associated with dropout behavior differ by initial enrollment intensity. That is, there are different observable factors associated with attrition depending on whether a student begins as a full-time or part-time student. The authors found that parental education, timing of enrollment, college GPA, and local economic conditions are associated with attrition for full-

time students but not for part-time students. Therefore, it is not initial part-time status per se that is correlated with attrition, but the underlying differences in observable factors that determine the correlation between full- or part-time status and attrition.

More recently, Attewell, Heil, and Reisel (2012) used NELS:88 data to conduct a study from the academic momentum perspective, which posits that students who accumulate credits more quickly improve their chances of completing a college degree, independent of academic readiness or socioeconomic status. Credit accumulation is intimately related to enrollment intensity, as full-time students more often accumulate credits more quickly. Attewell et al. (2012) examined four categorical indicators of momentum (no delay between high school and college, attending part-time in the first semester, taking 18 or more credits in the first semester, and enrolling in the first summer after freshman year) and used propensity score matching to identify average treatment effects of momentum on attaining a college credential. They found that graduation rates are lower for students who delay college entry and who take part-time course loads but found somewhat weaker positive effects on graduation for taking a large course load or enrolling in the first summer after freshman year.

2.2.1 Contributions of this Study

The research reported here contributes to the literature on enrollment patterns in multiple ways. First, it focuses on a relatively recent cohort of students solely from community colleges, rather than using an aging, nationally representative dataset that combines college sectors or focuses on four-year colleges. A better understanding of students in two-year colleges can be obtained by studying them in isolation. Because they are more likely to have family responsibilities, to work full time, to have greater financial constraints, and to be more academically underprepared than their counterparts in four-year institutions (Horn, Nevill, & Griffith, 2006), community college students attend college erratically and vary greatly in the rate at which they earn college credits.

Second, this study uses a longitudinal approach in identifying enrollment patterns. Most studies consider enrollment intensity in the student's first term as the most important aspect

of intensity, and none have described the subsequent variation in intensity revealed as students progress along their pathways. Third, a new method for describing enrollment patterns is introduced that provides a visual representation of the entire diversity of enrollment patterns. To aid interpretation, the resulting patterns are clustered by intensity and continuity features, which in turn link enrollment decisions (such as switches from full- to part-time attendance) to postsecondary outcomes. This kind of representation could be useful in facilitating communication among faculty and other stakeholders about how community college students attend college, and it could help illustrate the link between aspects of enrollment patterns and postsecondary outcomes.

2.3 Data Overview

This study uses student-level data from five community colleges located in a single state in the United States. Since they are part of a centralized state system, the colleges participate in a common course numbering system and offer a similar set of degrees and certificates. Each college uses a semester system in which an academic year is defined as the fall and spring terms followed by a shorter summer term. The analysis sample comprises first-time-in-college (FTIC) students who began at one of the five institutions in the 2005-06 or 2006-07 school year. The students are followed through the 2010-11 school year (18 terms or six academic years for the 2005 entering cohort, and 15 terms or five years for the 2006 entering cohort).

The sample consists of 14,429 degree- or transfer-seeking students. These students generally intended to earn a certificate, diploma, or associate degree as determined by their first enrolled program upon entering college. This designation distinguishes them from the block of community college students who enroll in shorter, non-credit vocational or adult basic skills programs. Students in the sample are considered degree- or transfer-seeking if they took placement exams or, when placement exam results were unavailable, they enrolled in credit-bearing courses and did not meet any of the following criteria: enrolled in non-credit

vocational courses; enrolled in English as a Second Language (ESL), Adult Basic Education, and Graduate Equivalency Degree (ABE/GED) programs; or enrolled dually in high school and college. For this analysis, student data across the five colleges has been aggregated.[3]

The data collected are extensive, including both student demographic information and full community college transcripts. Credential attainment data were provided by the colleges, and data on transfer to other colleges came from the National Student Clearinghouse. Given that the data came from each college's administrative records, it is important to point out some potential limitations as administrative data are often inconsistent and prone to errors. Students are considered first-time-in-college by searching for historical enrollments in the National Student Clearinghouse database ten years prior to first community college enrollment. There are, however, some institutions that do not participate in this service; students who attended these colleges would be missed and counted as FTIC incorrectly. A similar disclaimer applies to the analysis of transfer students. Finally, the definition of degree-seeking used in this study may differ from definitions used elsewhere in the literature. Although it is generally in line with the definition used by the Integrated Postsecondary Education Data System (IPEDS), authors sometimes restrict analysis samples to students who have earned a minimum number of students in order to filter out students who may not actually be credential-seeking (e.g. Adelman, 2006). Since this study is interested in characterizing the full range of credential-seeking, first-time community college entrants, no such restriction is placed on the sample.

2.4 Empirical Analysis

2.4.1 Patterns of Enrollment

This section begins by introducing a framework for analyzing patterns of enrollment, focusing on the characteristics of continuity and intensity. Intensity distinguishes between full-time

[3]Appendix Tables 2.5 to 2.7 present sample descriptive statistics.

and part-time enrollment, where full-time is defined as attempting 12 or more credit hours in the fall and spring terms and six or more credit hours in the summer term.[4] In general, a full-time course load means four courses in a 16-week fall or spring semester. Including summer terms forces a few nontrivial decisions. Taking at least one course in the summer is not uncommon, and it represents an important continuity in enrollment.[5] So as to not ignore summer enrollment or downplay its contribution to credit accumulation, this study treats it as a term like fall and spring.[6]

To aid exposition, all terms have been numbered so that each individual's first term of enrollment is term one, regardless of whether it is fall, spring, or summer. Of the three potential first terms of enrollment during the academic year, 68 percent of the sample started in fall, 24 percent in spring, and 8 percent in summer. Each subsequent term is numbered incrementally from the student's first term. This approach does result in some blurring of enrollment, as one student's term three will be fall and another student's will be summer. However, since community college students attend so haphazardly, this left-shifted numbering should not distort conclusions about the diversity of patterns or the clusters generated from

[4]For full-time students, this is a standard division in the literature, as most financial aid and institutions require 12 credits for a student to be considered full time. However, some researchers have considered nine credits as full time. Colleges in the sample differ on the number of summer credits required to be considered full time; some set the floor at six and others at nine. Students take, on average, between 13 and 14 credits in a term when they are designated as full time and between five and seven credits when designated as part time.

[5]In an essay on a nationally representative cohort of students from NELS:88/2000, Adelman (2006) found that, "More than 60 percent of the students in the sample under investigation enrolled during summer terms. Undergraduates ... have shattered observance of the traditional academic calendar. Summer term credits are more than metaphors for high octane persistence: Earning more than 4 credits during those terms held a consistently positive relationship to degree completion, and gave African-American students, in particular, a significant boost in hypothetical graduation rates" (p. xx).

[6]About 8.2 percent of courses and 8 percent of credits are attempted during summer terms. In addition, 37 percent of students take at least one summer course. These numbers are sufficient to justify considering the summer term as an important data point in a study of enrollment attachment and intensity.

the patterns. Nevertheless, there are some differences among students who started in different terms. Spring entrants were more likely than fall or summer entrants to skip their immediate second term, and summer entrants were more likely to enroll consecutively in the first three terms. That said, subsequent patterns for each group are still greatly diverse, and the qualitative story would be the same if each group were studied individually.

To describe enrollment patterns, I have created a vector of length 18 for each student that consists of a series of zeroes, ones, and periods.[7] The i^{th} location of the vector is a 1 if the student enrolled in term i full time, 0 if enrolled part time, and a period if not enrolled. For example, a traditional student who begins in the fall and follows an idealized two-year degree track may enroll full time in the first two terms and skip the summer term for two consecutive years. That student's vector would appear as:

```
"11.11............."
```

A student who enrolls intermittently with different degrees of intensity may have a pattern that appears as:

```
"01010..0..0..1...."
```

Over the 18 observed terms and 14,429 students in the sample, there are 4,594 distinct patterns of full-time, part-time, and non-enrollment. Though it is impractical to tabulate all of them, the ten most common types are shown on the top panel of Table 2.1 and ten of the least common patterns are presented on the bottom panel.[8] Of over 4,500 distinct patterns, the ten most frequent types account for 44 percent of students. The two most common

[7]This analysis combined data from the 2005 and 2006 cohorts. The maximum vector length is 18 for the 2005 cohort and 15 for the 2006 cohort, reflecting the amount of data provided for each cohort. Therefore the last three slots are necessarily non-enrollment periods for the 2005 cohort. Combining the cohorts may inflate the total number of patterns, but it does not change the substantive interpretation.

[8]When broken out by fall, spring, and summer starters, the first two rows in Table 2.1 remain in the top position. The remaining top patterns differ in that the spring entrants are more likely to take an early term off and summer entrants are more likely to have early continuous enrollment.

patterns are for students who enroll either part time only or full time only in the first term (28 percent of students). These 4,000 students are the earliest leavers potentially for a number of reasons - and their frequency is striking. Though most are no longer enrolled in higher education after the first term, some of them do earn short-term certificates (19 students) or transfer to a four-year institution sometime after that first term (595 students).[9]

Table 2.1: Enrollment Intensity Patterns

Pattern	Frequency	Cumulative Percent
0.....	2810	19%
1.....	1190	28%
00.....	744	33%
11.....	561	37%
10.....	291	39%
11.11.....	175	40%
01.....	145	41%
0.0.....	140	42%
11.1.....	125	43%
00.0.....	115	44%
100.....0..0.....	1	99%
00.00.11.11.1.....	1	99%
11111.1100.....	1	99%
00.01.00.00.....	1	99%
10.1..11.11.1.....	1	99%
00.....0..0..	1	99%
10.00.10001.100...	1	99%
00..0.0.00.....0..	1	99%
10.11111111.....	1	99%
11.1..11011.1.....	1	100%

Note: In intensity patterns, 1 indicates enrolled full-time, 0 indicates enrolled part-time, and a period (.) indicates not-enrolled. The position of the number in the vector indicates the term, from 1 to 18.

[9]These figures are consistent with national data on freshmen fall-to-fall retention rates at two-year public colleges, which are about 50 per cent for full-time entrants and 40 per cent for part-time entrants. (Source: NCES, IPEDS Fall 2005 Enrollment Retention Rate File, Fall 2004 Enrollment File.)

Although many of the students in the sample enroll sparsely, as suggested by the top panel, there are thousands of students who generate unique enrollment intensity patterns over a long period of time, as illustrated by those in the bottom panel. These students are characterized by several matriculation periods, gaps in enrollment, longer persistent states of attendance or non-attendance, and frequent switching among full-time, part-time, and non-enrollment status. In general, common patterns are short and unique patterns are long. The longer a student stays, the more likely the student's pattern will be unique. Few students who stay relatively longer do so in identical ways.

It is important to note that students usually stop enrolling after they graduate or transfer, yet the pattern representation used here does not provide any provision for formal exit. Among students captured in the top panel, 65 (about 1 percent) earned a certificate or associate degree. Certificate awards are concentrated in the second pattern and associate awards in the sixth pattern. The purpose of this paper thus far has been to introduce this method and draw attention to the impressive number of enrollment intensity patterns generated. The next sections show how one can visualize these patterns and draw conclusions from them.

2.4.2 Visualization of Enrollment Intensity

To better understand the entire range of enrollment patterns without tabulating every distinct type requires a graphical approach. A well-organized image can be constructed from the pattern vectors, providing a broad overview of the patterns and how they relate to graduation and transfer. The study considers each student's vector as shown in Table 2.1 and stacks them all on top of each other to create a matrix of 14,429 students by 18 terms. It then sorts the patterns consecutively, such that similar patterns are grouped together and full-time enrollment is above part-time, which is above non-enrollment. The intuition is that in term one some students attend full time and others attend part time. In term two, the full-time students in term one attend full time, attend part time, or do not enroll, as do first-term part-time students. Students continue to be divided in this manner, term by term,

and the resultant graphic representation uses three different colors for full-time, part-time, and non-enrollment status to illustrate the patterns.

Figure 2.1 presents an image of the enrollment intensity patterns for all 14,429 students. White space indicates non-enrollment (no attempted credits), blue is part-time enrollment, and orange is full-time enrollment.[10] Columns indicate terms; rows are students. It is useful to think about the construction of the image from left to right. The left-most side of the image shows the distribution of enrollment intensity in the first terms. For example, the top portion of the first column shows students who initially enrolled full time, while the bottom portion shows those who enrolled part time. Scanning across the image allows one to see the wide variability after the first few terms as students change their levels of intensity and attachment.

One can compare Figure 2.1 to what might be expected from a conventional view of student progression. Figure 2.2 shows what an enrollment graphic might look like if students followed standard pathways that begin with fall enrollment. The graphic is organized from the top down to express the following three enrollment intensity patterns, separated by black horizontal lines:

```
"110110............"

"11011............."

"11.11............."
```

Figure 2.2 thus shows what Figure 2.1 would look like in a world where all students follow some version of the conventional two-year pathway through community college. These patterns are in reality particularly rare (even after including summer- and spring-entrant students). However, it is useful to contrast the homogeneity of Figure 2.2 with the heterogeneity of Figure 2.1.

An immediate concern when looking at patterns like those of Figure 2.1 is that some students graduate or transfer out of the community colleges, and their doing so results in

[10] In greyscale, full-time enrollment is light; part-time is dark.

later periods of non-enrollment. It is possible to show the relationship between completion outcomes and enrollment intensity on these figures by overlaying indicator marks where and when completion outcomes occur. Figure 2.3 updates Figure 2.1 by adding points to show when students have earned a degree or certificate, and Figure 2.4 shows when students transfer by adding indicator marks (purple dots) that represent students' first enrollment term in a four-year school.[11] Perhaps not surprisingly, credentials are most heavily clustered along the top of Figure 2.3, where students have more consecutive terms of full-time enrollment.[12] However, there are several examples of persistent students who manage to earn a credential after 12 or even 15 terms of part-time or intermittent enrollment.

The indicator marks in Figure 2.4 that represent transfer show a few clusters where one would expect them to be. Some students transfer after one term of community college study, perhaps due to deferral from a four-year institution, spring admission to a four-year institution, or perhaps even co-enrollment at a four-year institution. Of the 148 students who attended in term one and transferred by term two, 4 percent began community college in the spring and 32 percent began in the summer. Others arrive at the four-year college during term four, which would likely be the first fall term after a full year of community college study. Terms seven and ten have clusters of transfers, a pattern expected of fall entrants who transfer to a four-year institution in a following fall term. Remarkably, the transfer patterns suggest a high degree of non-continuous postsecondary enrollment. Though most transferees leave after one or two community college terms, many students depart community college and then wait years before enrolling in a bachelor's degree-granting institution. Still others engage in concurrent enrollment (as seen by transfer indicator marks inside of the blue or orange bars).

[11]Students are determined to have transferred if they have spent at least two semesters in a four-year institution.

[12]Completion outcome and transfer indicator marks in Figures 2.3 and 2.4 have been jittered slightly to avoid excessive overlapping.

2.4.3 Summary of Vector and Graphical Analysis

The method presented here provides a readily available tool for describing student progress both quantitatively and qualitatively.[13] Some key insights emerge from the vector and graphical analyses taken together. First, they reveal that students generate a lot of patterns due to intermittent enrollment and frequent switching between full- and part-time status. Some students still enroll alternately full time and part time well into their sixth year of study (17 percent). About 1 percent of students follow the traditional fall-spring, fall-spring pattern (with a break for summer) during the first six terms, followed by no additional enrollment in subsequent terms. Some 28 percent of students have only one term of community college enrollment, and over one quarter of them never return after that first term. Almost 40 percent of students enroll in one term or in two consecutive terms and never return to either a two-year or four-year institution within the study's tracking period. Except for those who leave the institution early into their postsecondary careers, few remaining students have the same enrollment patterns in college.

Second, and related to the first, there is a lot of switching between full- and part-time status. In general, those who begin as full-time students are more likely to attend full-time subsequently, suggesting a much quicker rate of credit accumulation than for those who start part time. However, students frequently switch between full- and part-time attendance (43 percent of students do so at least once.) About 69 percent of full-time starters who returned at least once had at least one part-time term. Half of part-time starters who returned at least once had at least one full-time term. This finding challenges the notion that starting intensity is indicative of future enrollment intensity (and it reinforces the findings of O'Toole et al. (2003) discussed earlier). Similarly, among students who enrolled in more than one term, 17 percent attended only full time, 22 percent attended only part time, and 61 percent attended a mix of part and full time. About one quarter of students had two or more switches between full- and part-time status, and 32 percent of students had consecutive

[13]Numbers and percentages in this section were obtained from a simple analysis of the pattern vectors demonstrated in Table 2.1.

part-time enrollment. The high degree of switching challenges the common assumption that students can be identified as full or part time based on their status upon entering college.

Third, the patterns help explain why colleges have difficulty getting students into and through programs of study (Jenkins & Cho, 2012). The enrollment intensity figures reveal that students who persist are quite likely to experience a range of enrollment intensities over their college careers. Very few community college students follow a traditional fall-spring-fall-spring pattern with full-time enrollment in all terms (1.2 percent), the pathway that is often advertised by colleges as standard and that can be seen in suggested curriculum guides on college websites. Few students earn an associate degree in expected two years (3.5 percent). Over a six-year/18-term horizon, many students leave after their first contact with the college (28 percent). Only a handful of them complete short-term certificates or transfer to a four-year institution (15 percent of the 28 percent). In the cohorts under study, the typical student attended full time in about 44 percent of the terms attended. Finishing a two-year degree within two years is bound to be uncommon when full-time enrollment is this low.

The enrollment patterns identified by the current study are remarkably varied and can be even described as chaotic; they raise several questions about the nature of the patterns. Why do full-time students switch to part time and vice versa? Are there any differences in academic achievement between students who attend full time consecutively compared with those who switch to part time? What about differences in demographics or financial aid awards in the second term? Perhaps students simply cannot get into desired courses. Of course, a range of other factors (as well as the eventual attainment of postsecondary outcomes) will have an impact on whether, when, and how intensely students enroll.

2.4.4 Clusters and their Relationship to Postsecondary Outcomes

Although there are thousands of distinct patterns of enrollment intensity, they are all generated from the same basic components: students attempt different course loads at different points in time. This section describes the pattern clusters based on the features of the

patterns that indicate degrees of intensity and continuity, enabling the production of a typology of enrollments, a more parsimonious way of thinking about the student behavior observed. Variation in postsecondary outcomes among clusters provides a way to correlate the features of patterns with outcomes. The study employs a k-means clustering algorithm that generates six clusters of enrollment patterns. The clusters are created solely from the information gleaned from enrollment intensity patterns and do not include other academic or demographic characteristics (See Appendix for a summary of the clustering algorithm.)

Importantly, the analysis presented here is related to, but different, from that of Bahr (2010) and his predecessors in that the emphasis is on aggregating the longitudinal patterns created only by variation in intensity and continuity of enrollment. The goal, however, remains to identify student types and provide a more parsimonious way of describing the enrollment patterns presented previously. Table 2.2 provides a summary of the clusters and their characteristic; Table 2.3 presents examples of patterns found in each cluster using the vector description discussed in Section 2.4.1 above. Students are unevenly spread across clusters, as Cluster 5 has 5 percent of students and Cluster 2 has 35 percent. This spread of students into clusters is not unexpected as 44 percent of students generate the top ten patterns of enrollment. Below I describe the clusters and provide descriptive names.[14] Appendix Figures 2.8 and 2.9 present visualizations of the clusters in the style presented in Section 2.4.2.

Cluster 1: *Full-Time Persisters* (N=2,858; 20 percent). These students enroll primarily full time and for an average of 4.5 terms. They begin full time and remain full time, or begin

[14]It is important to note that there is a level of subjectivity required in naming and describing the clusters as well as in choosing which variables to include in their creation. Though I tried to be as fair and objective as possible, I chose to focus on particular attributes in developing labels; other researchers might interpret the clusters somewhat differently. The clusters, of course, are a result of the particular measures that I considered for the algorithm. Since the focus here is on enrollment intensity and continuity, I omitted many factors that could be used in a more general clustering of students. It is thus possible and probable that I have omitted some important factors related to enrollment intensity that would have resulted in different clusters.

part time and change to full time, where they remain. They have relatively few changes in attendance statuses compared with students in other clusters with a similar number of enrolled terms. For many of these students, their first part-time enrollment was followed by a long spell of non-enrollment.

Cluster 2: *Early Leavers* (N=4,998; 35 percent). This largest cluster captures the students who enroll for the fewest number of terms (usually only one). Later enrollments usually occur well after the first enrollment term if at all, and there is virtually no consecutive enrollment. These students are thus characterized by very sparse enrollment.

Cluster 3: *Early Persistent Switchers* (N=1,958; 14 percent). These students attend for four terms on average, about 50 percent of which are full time. Almost all change intensities between the first two terms. They are likely to switch from full- to part-time attendance and then remain part time, though they occasionally revert back to full time. They have a relatively high number of switches between full- and part-time attendance. These students consecutively enroll in the first two terms but then have sporadic enrollment over the remainder of the time frame.

Cluster 4: *Mostly Part-Timers* (N=2,376; 16 percent). These primarily part-time students have very few intensity changes. Much of this group might be described as first-year experimenters, enrolling only for two part-time consecutive terms, although some do persist into later terms. A few *Mostly Part-Timers* start full time, but quickly lower their intensity and maintain a lengthy trail of part-time enrollment.

Cluster 5: *Early Attachers* (N=728; 5 percent). This smallest cluster is characterized by almost nine terms of enrollment on average along with frequent switching between full- and part-time intensity. These students do not interrupt enrollment until the eighth term on average, into the third year of study, and most of the enrollment is full time. Their enrollment is front-loaded in the earliest terms and highly consecutive. These students consistently attempt to earn credits term after term at any intensity possible.

Cluster 6: *Later Attachers* (N=1,511; 10 percent). Students in this group also enroll for a long period of timeover nine terms, on averagebut attend full time less often than the *Early*

Attachers. The students have a similar number of full- to part-time switches, but experience their first enrollment interruption earlier on, generally in their third term. That is, *Later Attachers* follow a more traditional approach of "two terms on, one term off," and they also have a high degree of persistence. This group is more likely to switch from part- to full-time attendance than the opposite, but has a lower level of consecutive full-time enrollment due to more interruptions.

The six clusters identify some student types that appear elsewhere in the community college literature. For example, the *Early Leavers* cluster is similar to the *drop-in* cluster of Bahr (2010), but perhaps *Early Leavers* have less favorable success rates. Like Bahr's clusters, those presented here also stratify along some demographic lines (though no demographic or environmental characteristics were considered in their creation). Table 2.4 presents demographic characteristics by cluster that show how some enrollment intensity and continuity clusters are correlated with individual characteristics (and how many are not). *Full-Time Persisters*, *Early Persistent Switchers*, and *Later Attachers* tend to be the youngest at about age 21 (upon entry into community college), whereas *Early Leavers* and *Mostly Part-Timers* are age 25-26 on average. These findings are consistent with evidence that older students have different enrollment trajectories from younger students (Calcagno, Crosta, Bailey, & Jenkins, 2007). All of the clusters hover around 60 percent white, ranging from 55 percent for Mostly Full-Time Switchers to 64 percent for *Later Attachers*. *Early Full-Time Persisters* and *Later Attachers* have the smallest black student representation, at about 18 percent. Secondary education attainment is somewhat stratified across clusters, as *Full-Time Persisters*, *Early Attachers*, and *Later Attachers* are more likely to have traditional high school diplomas compared with GEDs or no diploma. Large differences in first-term financial aid are found as well, as only 21 percent of students in the *Mostly Part-Timers* and *Early Leavers* clusters received aid compared with 45 percent of the *Full-Time Persisters* cluster. If data were available on dependency or working status, these would most certainly stratify clusters as well.

There are no strong differences across clusters on a socioeconomic status index created

from the variables shown on Appendix Table 2.6. Focusing on college readiness as measured by developmental placement, this investigation found that students in the *Early Attachers* and *Full-Time Persisters* clusters had higher overall college-readiness rates. Students in the *Early Leavers* and *Mostly Part-Timers* clusters had the lowest college-readiness rates overall and in each individual subject. These findings are congruent with the notion that better prepared students are more likely to persist and rapidly accumulate credits than their less prepared counterparts who enroll with hesitation (part-time) and become discouraged quickly.

Of more interest for this study is how postsecondary outcomes such as earning a credential or upward transfer correspond to clusters of enrollment patterns. (Variation in outcomes across clusters also validates the clusters themselves, showing that they produce meaningful groups of students). Figure 2.5 shows the community college credential earning rates (within five years for the 2006 cohort and six years for the 2005 cohort) for each of the six clusters. Credentials earned include short-term and long-term certificates and associate of arts, associate of science, and associate of applied science degrees. The lowest rates, perhaps not surprisingly, are found among the cluster of *Early Leavers* (1 percent), the *Mostly Part-Timers* (5 percent), and the *Early Persistent Switchers* (6 percent). *Early Attachers* have the highest graduation rate (43 percent) and the *Later Attachers* are not far behind (37 percent). The group of *Full-Time Persisters* has a credential earning rate that is somewhat lower than what one might expect for students who have so much full-time attendance (18 percent), mostly because they are transferring before earning a two-year credential.

Differences in transfer behavior in relation to enrollment pattern clusters help explain some of the variation in credential earning rates as well. As Figure 2.6 shows, transfer rates are higher than credential rates for all clusters except *Early Attachers* and *Later Attachers*. Notably, the first cluster of *Full-Time Persisters* has the second highest transfer rate (29 percent), suggesting that students in this group, who have more intense enrollment, seek to transfer without first obtaining a credential. Students in the *Early Attachers* cluster have the highest transfer rates and graduation rates (33 percent and 43 percent, respectively).

Students in this highly attached group are earning a lot of credits early on, earning a two-year degree, and then transferring upward. Contrast their outcomes with those of the *Later Attachers*, who are earning a two-year credential at a slower pace and are less inclined to transfer to a four-year school within the observed time frame (14 percent transfer). The *Early Leavers*, *Early Persistent Switchers*, and *Mostly Part-Timers* have about the same transfer rates as the *Later Attachers* (14-15 percent) cluster but *Later Attachers* have a much higher graduation rate of 37 percent.

Figure 2.7 shows how the clusters vary for any of the two outcomes: earning a credential or transferring to a four-year institution. As expected, it is a blend of Figures 2.5 and 2.6, with *Early Attachers*, *Later Attachers*, and *Full-time Persisters* having the highest likelihood of one of these outcomes. The implication again is that a combination of attached, intense enrollment with few breaks is associated with the greatest probability of transfer or earning a credential.

Taken together, the six clusters support the fourth main finding of this paper: students in groups characterized by high levels of enrollment continuity (*Early Attachers* and *Later Attachers*) are more likely to earn a credential than students in groups with low levels of continuity, and students in groups characterized by high levels of intensity and consecutive full-time enrollment (*Full-time Persisters* and *Early Attachers*) are more likely to transfer to a four-year college than students in groups with low levels of enrollment intensity. Though not causal, these relationships suggest that taking breaks in enrollment (discontinuous enrollment) may be particularly harmful for students who desire to earn a credential and that part-time enrollment may be particularly harmful for students who desire to transfer. For credential seekers, it is important to maintain consecutive enrollment; for transfer seekers, it is important to earn credits early. Although it does not appear that the frequency of switching between full-time and part-time states is detrimental, it is clear that groups identified by mostly part-time or discontinuous enrollment have lower credential-earning and transfer rates. Continuity of enrollment and full-time study are critical for student success.

2.5 Discussion and Implications

In this study I have introduced a method for assessing community college students' enrollment patterns and describing their variation. I have also created a typology of enrollment comprised of six clusters of enrollment types based on the information gleaned from enrollment intensity and continuity patterns. This section first discusses why there is so much variation in students' enrollment patterns. It then addresses the ways that the method employed in the study, along with the research findings, may prove useful for stakeholders such as college administrators, policymakers, and researchers. The section concludes with some directions for further research.

2.5.1 Possible Reasons for Students' Enrollment Pattern Variations

According to human capital theory, individuals make enrollment and schooling decisions by weighing the costs and benefits of college education (now and in the future) against the costs and benefits of alternatives (see Becker, 2009; Clotfelter, Ehrenberg, Getz, & Siegfried, 2008; Mincer, 1974; Schultz, 1961). That is, students will change enrollment intensity and attendance towards or away from schooling when they believe they will be better off by doing so. Several factors that affect the cost/benefit calculation may impact enrollment decisions, and factors may change continuously throughout an individual's life. Perhaps the most commonly studied tradeoff is between schooling and work: generally these are seen as temporal substitutes, and as the value of work (expected earnings) increases, less school is consumed.[15] Individuals will also respond to direct costs of attending college (choosing less school as these costs increase relative to costs of other goods), and they wil react to other family and financial demands. Less straightforward in the human capital context is how students react to early academic feedback. However, poor grades in early terms

[15]Dadgar (2012) discusses how working while in community college affects credit attainment and GPA. She finds small negative effects of working on academic outcomes.

could depress a student's valuation of the benefits to education if completion of courses or credentials seems unlikely. Human capital considerations likely form the backdrop for variations in enrollment patterns, but it is not always clear whether the enrollment patterns that result from such decisions are optimal for students.[16]

Intensity changes and interruptions in general may reduce positive peer effects and interfere with momentum for students.[17] Reducing from full-time to part-time attendance (as *Early Persistent Switchers* and *Early Attachers* do) may improve educational outcomes for some students by providing more time to focus on fewer courses and academic obligations. However, it is also possible that employment and other extracurricular activities may consume newly freed time. Reducing their course load may also be a response by students to poor academic performance. Students who do poorly in one term may respond by decreasing their intensity in future semesters (or by becoming discouraged and dropping out altogether). If the lighter intensity persists, students' rate of progress may be slowed significantly. It is, of course, possible that students may reduce intensity temporarily, perhaps due to short-term financial constraints or course availability, and then resume full-time attendance.

Similarly, students might change from part-time to full-time attendance if they feel more confident academically, see an improvement in their personal or financial situation, or experience an increase in motivation or desire to complete a program of study. It is also the case that such a change could occur if a student lost employment but could still finance a full-time load. Increasing enrollment intensity should speed up degree completion since it speeds up credit accumulation, and this effect should be magnified if switching to full-time persists and students do not revert back to low intensity enrollment.

It may also be the case that the structure of community college programs of study is

[16]The decisions may be rational but not optimal from the student perspective, given the incomplete information set the student has about the future and imperfect ability to make intertemporal tradeoffs.

[17]There has been substantial research on summer learning losses for K-12 students, finding that skills and knowledge often deteriorate during the summer months, with low-income students facing the largest losses. Summer instruction is advocated as having potential to stop these losses and propel students toward higher achievement. See McCombs et al. (2012) for a thorough review.

related to enrollment variation. The highly flexible structure of many community college programs, in which students can drop in and out at will at the very least allows, but may also encourage, great variation in enrollment patterns. Community colleges are in many cases offering access to courses but not adequately facilitating program completion (Jenkins, 2011). Students who are in more coherent programs (such as nursing, for example) may be much more constrained in their ability to drop in and out and even to attend full or part time, but this may indeed promote stronger program completion. As Rosenbaum, Deil-Amen, and Person (2009) have noted in their comparison of private occupational colleges and public community colleges, the lack of structure in community college offerings can lead students to make bad, or at least suboptimal, decisions.

The patterns of enrollment intensity and continuity identified in this study are the result of choices made at different points in time under different constraints. Students do not randomly switch between full- and part-time enrollment, but rather act rationally (though not always optimally) in accordance with particular circumstances. The clusters provide a way of looking at groups of students who made similar decisions and asking important questions about their behavior. For example, the *Full-Time Persisters* cluster contains many students who did not return to college after their first part-time enrollment. Does this behavior lead to a diagnosis of part-time status as a harbinger of dropout? The largest cluster of *Early Leavers* consists of students who make a similar decision to stop enrolling after very little time at the community college. What cost-benefit analysis are these students making that leads them to leave college so quickly? What factors contribute to this decision, and are the factors different for different groups of students?

2.5.2 Policy and Program Implications

Gaining a better understanding of the student experience is invaluable for various stakeholders. Informing college personnel about the types of enrollment patterns and their relative sizes illuminates the fact that too many students do not persist past the first term (e.g., *Early Leavers*) and few students choose the most efficient or recommended path toward earning a

credential. Although it may be challenging for an institution to identify which students are likely to be in which clusters at the outset of college, performing this type of analysis on historical data would provide faculty, advisors, and student services professionals with a picture of student pathways. Faculty and administrators may not realize the wide variation in enrollment that their students experience, and they should be aware of the high likelihood that many of their students have significant interruptions in their enrollment and have departed from any type of traditional college pathway. For faculty, understanding interruptions may encourage them to provide more review during the first few lectures of a course. In addition, a focus on key subgroups, such as students who require various levels of developmental education and students in particular curricular programs, can lead to more effective interventions when they are most needed. For example, if students in certain programs are likely to have interruptions in enrollment at certain points in time, college personnel may look to the program of study design to make changes or try different advising strategies. Similarly, if students in other subgroups are found to be systematically skipping the important fall or spring terms, student services and advising professionals may investigate causes and develop strategies to encourage more continuous enrollment. Chaotic and varied enrollment patterns provide challenges for college administrators tasked with scheduling classes and determining staffing and resource requirements and advisors charged with making recommendations to students. Making a college-wide effort to acknowledge this is a first step in improving student pathways.

Acknowledging the range of patterns is important for policymakers as well. They should realize that credential completion or transfer for community college students may take longer than two or three years, and that there may be policies and incentives related to financial aid, tuition, and placement testing that reinforce the suboptimal pathways taken by students. For example, policies surrounding the number of terms that Pell grant awards are available may make sense for most four-year college students but little sense for persisting community college students. The total number of terms for Pell eligibility was recently reduced to 12 from 18, a policy change that might hinder completion for many community college

students. When designing metrics for evaluating college performance, policymakers should consider that college enrollment patterns range from those characterized by *Early Leavers* to *Early Attachers*, these different types of students make very different choices after their first contact with the college and may have different goals.

Generally speaking, recommendations for what stakeholders ought to do with findings about student enrollment patterns are not immediately clear: should institutions adjust their behaviors or should students modify their behaviors? For example, if attachment is critical for completion of a two-year credential, do stakeholders force students to continuously enroll? It is typically unfeasible to oblige students to enroll or change intensity, but institutions and policymakers can certainly consider interventions and policies that provide incentives for students to change behavior.

2.5.3 Implications for Future Research

The analysis presented here should give pause to researchers studying community college student behavior who are analyzing panels of short time periods. They face significant limitations in capturing the student experience. Similarly, researchers working in longitudinal frameworks should understand how the diversity of enrollment patterns impacts studies of educational timing. Many studies often use initial enrollment intensity when examining postsecondary student behavior and outcomes. First-term intensity may be a useful proxy for unobservable characteristics such as self-esteem and perceived academic ability as much as it is a function of financial and time constraints. However, it does not always indicate future enrollment intensity. Researchers studying transfer should be aware that the transition from two- to four-year college is often not immediate, requiring a close look at the timing of transfer.

One potential area for further research is the development of a model that can generate the observed enrollment patterns. Similar to Stange (2012b) and Keane and Wolpin (1997), the strategy - though computationally complex - could model the dynamic decision-making process (enroll part time, enroll full time, work full time, stop out, etc.) of these students over

the life cycle. Researchers could then carry out policy simulations to study how enrollment decisions and postsecondary outcomes would change in response to changes in: opportunity costs of going to college, tuition, self-assessment of academic ability (based on experiences at college), institutional structures, and remediation placement policies, etc.

A second area of research could explore changes in enrollment intensity more closely. Does switching between full- and part-time enrollment help or harm students? That is, is it better for students to have consistent enrollment of one type or to just accumulate credits in any way possible? Is a switch from full- to part-time attendance undesirable? Does such a switch imply greater part-time attendance in subsequent terms? Related to these questions is the issue of modeling changes in enrollment intensity. Can one predict when students are likely to have a gap in enrollment, change intensities, or simply enroll in the next semester full or part time? What characteristics are associated with these transitions?

A third important area of study concerns transfer. Many students enter the community college with the desire to transfer to a four-year institution. However, as Figure 2.4 reveals, transfer pathways vary considerably across individuals. Students transfer at many different points in time with varying numbers of transferable credits. There has been some research exploring the nature of upward transfer (see Long & Kurlaender, 2009), but there still remain several outstanding questions concerning enrollment patterns, transfer, and baccalaureate completion. For example, are the patterns associated with successful upward transfer related to completion of a bachelor's degree as well? And how do disruptions between community college enrollment and four-year college enrollment affect degree completion?

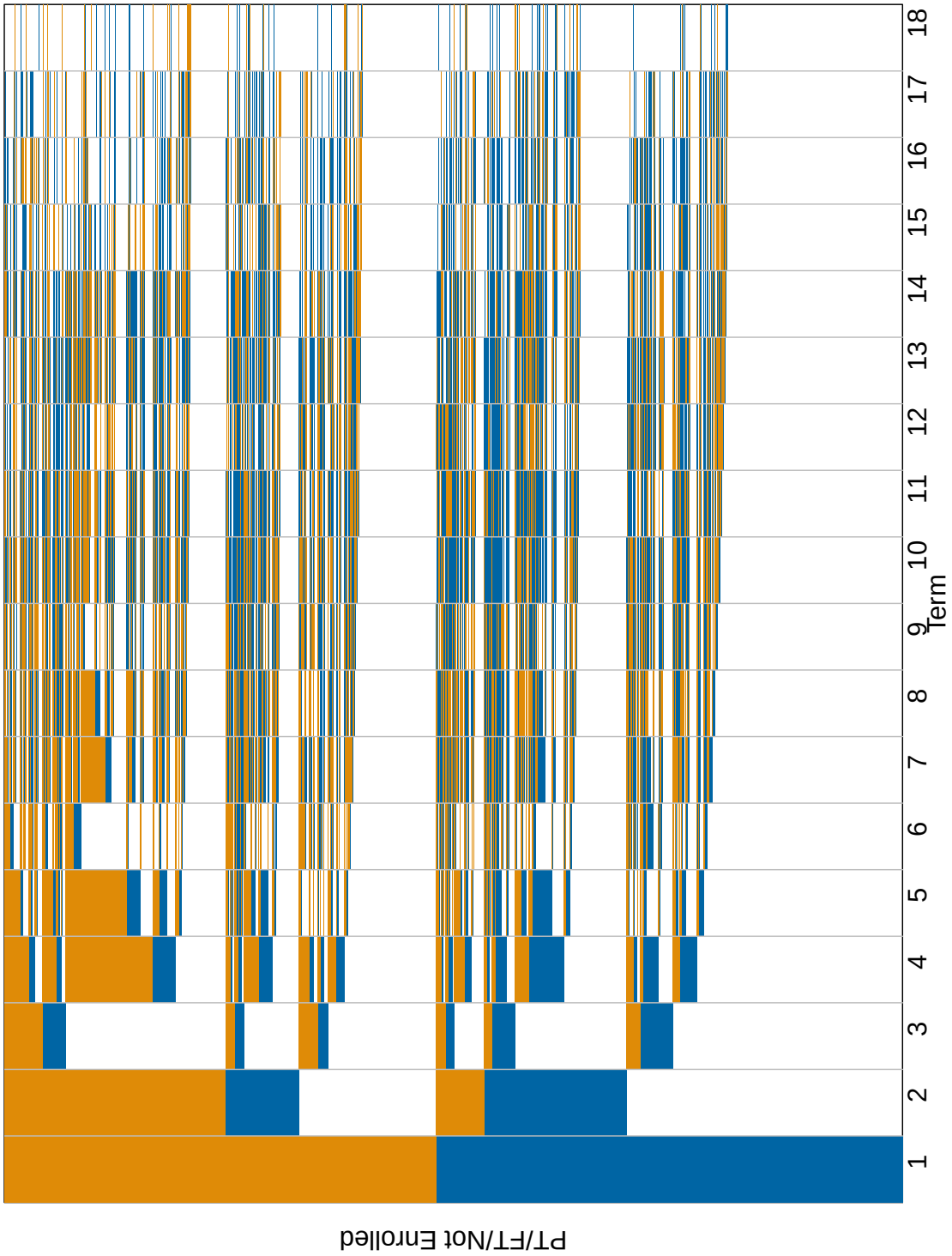
2.6 Conclusion

This paper presents a way to conceptualize and visualize community college enrollment patterns and to cluster them by their characteristics. It uses student-level data from a sample of 14,429 degree- or transfer-seeking FTIC students from five community colleges located in a single state who began in the 2005-06 or 2006-07 school year. After five to six

years, most of these students forged paths that are not highly productive or efficient. The diversity in individual patterns cannot be overstatedalthough nearly half of the students followed about ten patterns (most of them associated with early attrition from college), the remaining students took thousands of distinct pathways involving full-time, part-time, and interrupted enrollment. Characterizations of students as either part or full time are thus largely inaccurate as they ignore the high degree of switching between these two enrollment statuses. The chaotic enrollment patterns of students illustrated in this study pose challenges for colleges and other stakeholders in helping students to enter and complete programs of study.

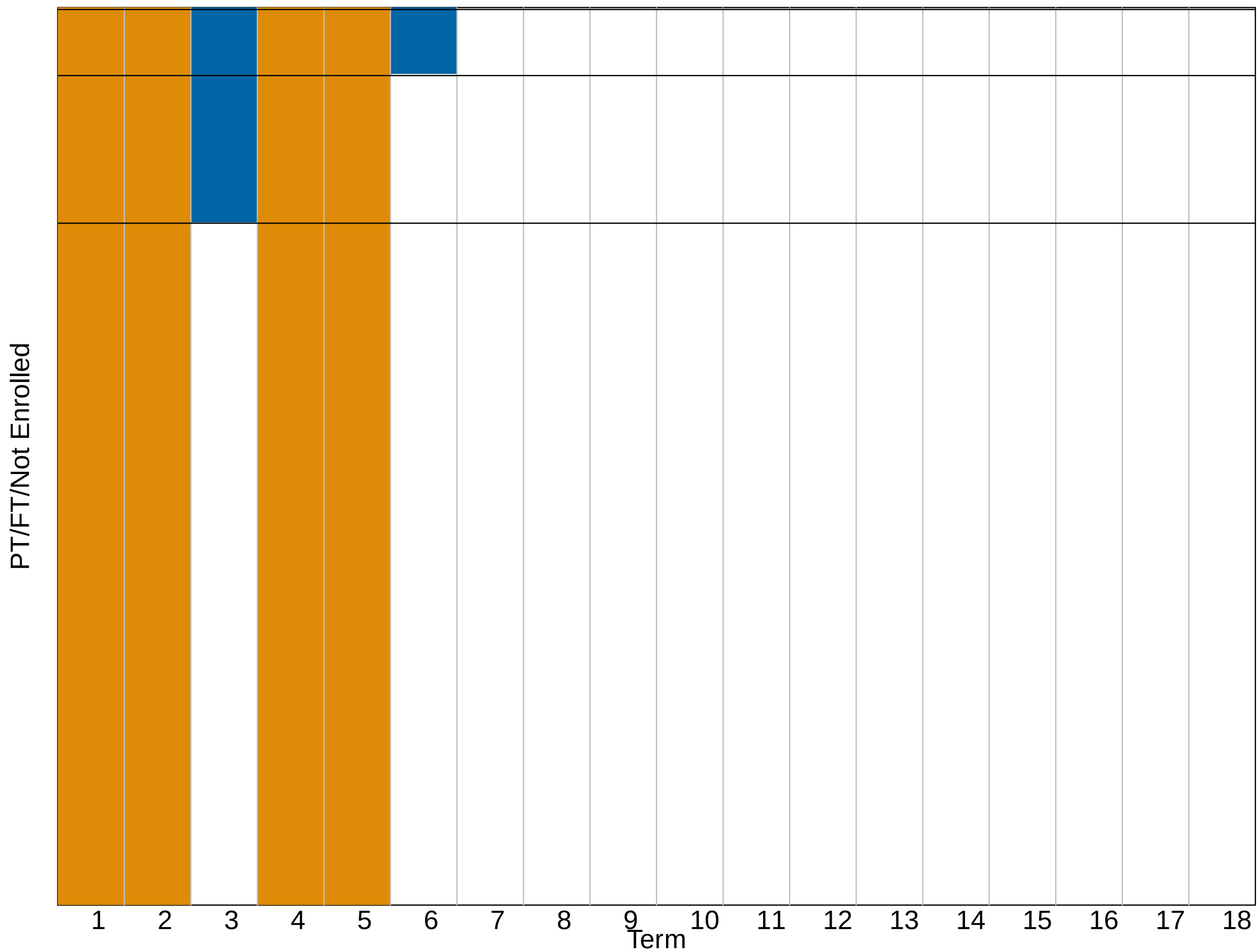
Clustering these enrollment patterns based on intensity, persistence, interruption, and frequency reveals six major pattern types. The most favorable graduation outcomes are associated with students who tend to enroll term after term with few breaks. The most favorable upward transfer outcomes are associated with students who tend to enroll full time rather than part time. Continuity of enrollment and full-time enrollment whenever possible are keys to community college success.

Figure 2.1: Image of All Enrollment Intensity Patterns



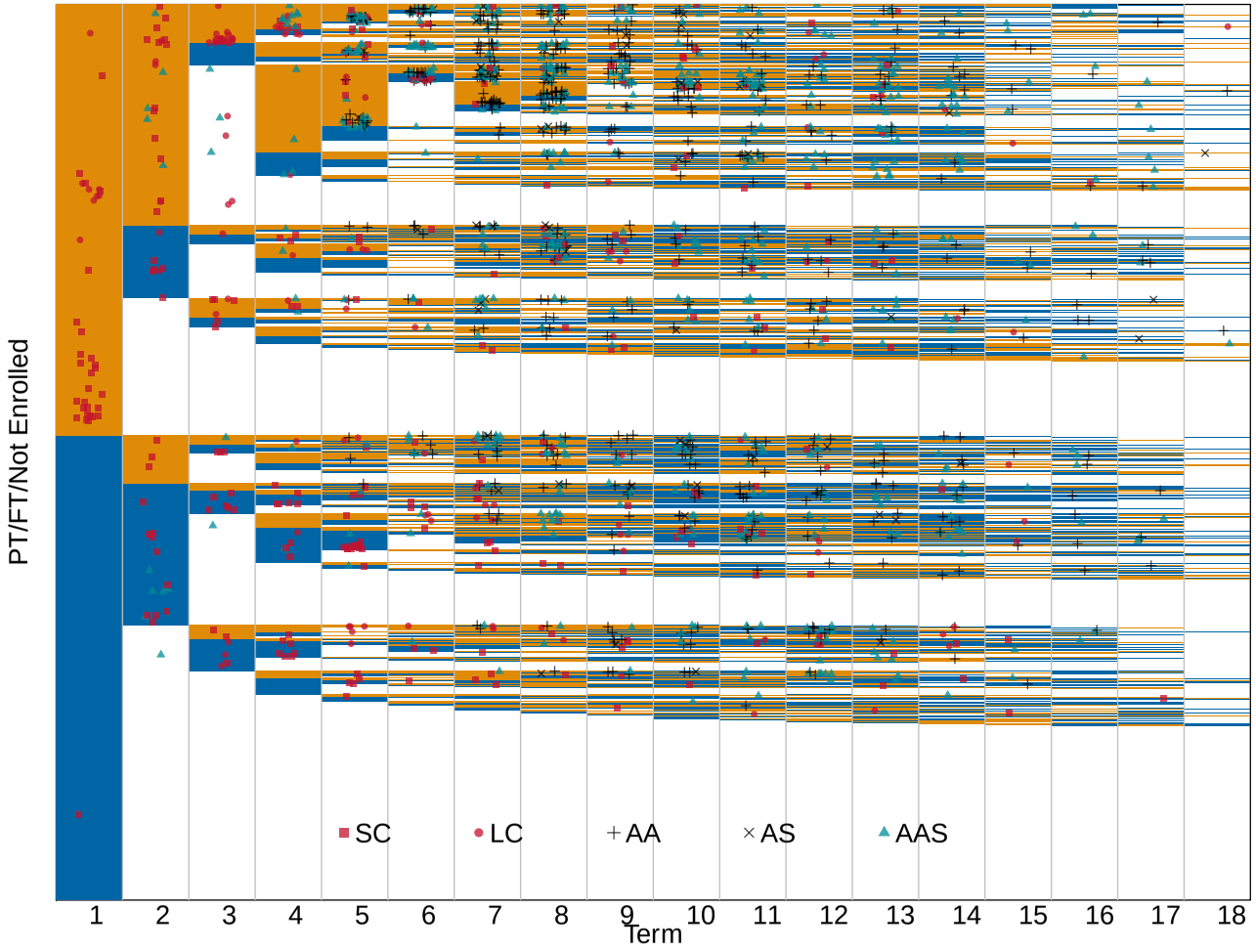
Note: Each thin row represents a student, each column a term. Combining thin rows of students with the same enrollment intensity status in each column results in bars of color. Blue bars indicate part-time enrollment; orange bars, full-time enrollment; white space, non-enrollment.

Figure 2.2: Image of Traditional Enrollment Intensity Patterns



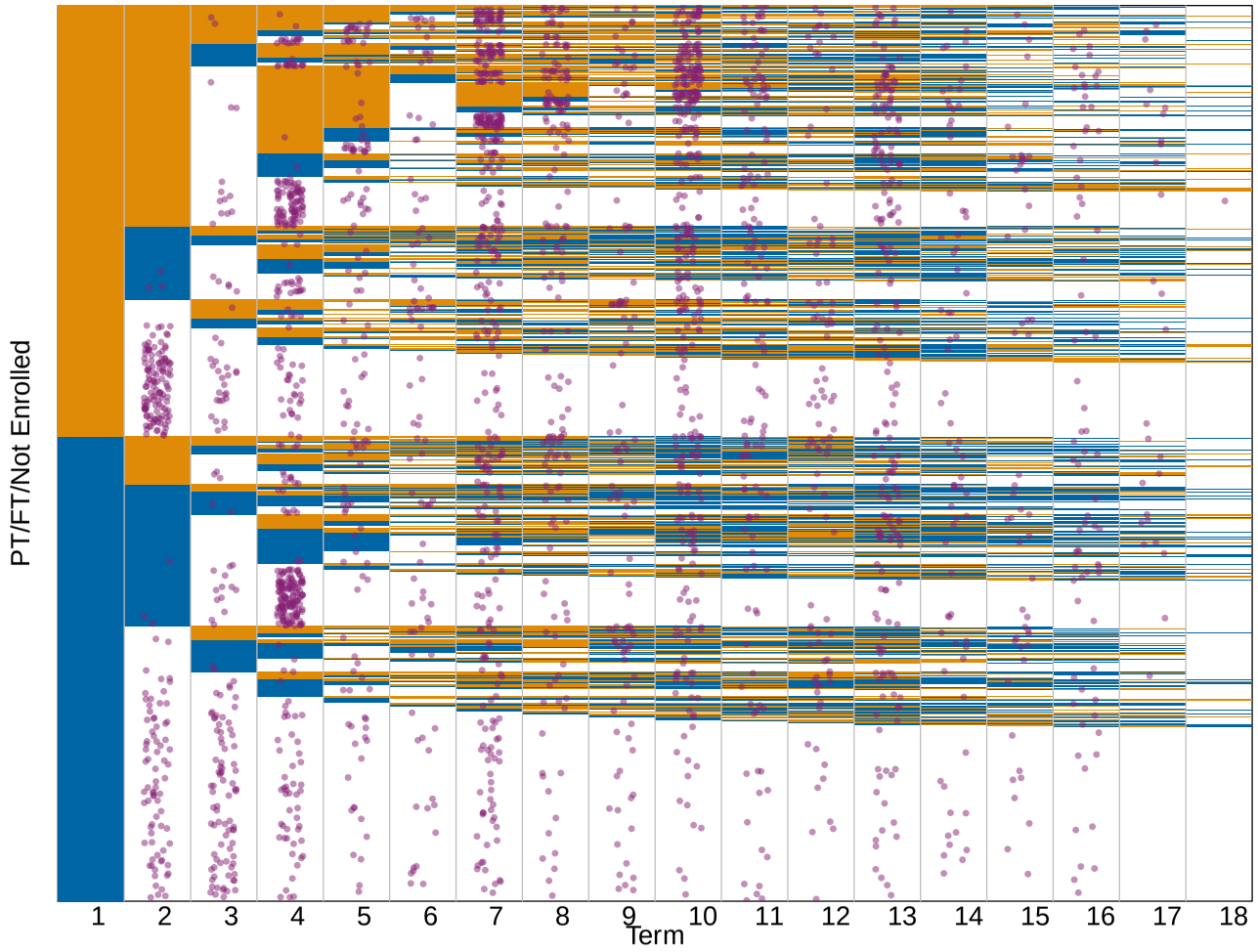
Note: Each thin row represents a student, each column a term. Combining thin rows of students with the same enrollment intensity status in each column results in bars of color. Blue bars indicate part-time enrollment; orange bars, full-time enrollment; white space, non-enrollment. Only three patterns are shown in this image.

Figure 2.3: Image of All Enrollment Intensity Patterns Showing when Students Graduate



Note: Each thin row represents a student, each column a term. Combining thin rows of students with the same enrollment intensity status in each column results in bars of color. Blue bars indicate part-time enrollment; orange bars, full-time enrollment; white space, non-enrollment. An indicator mark shows that the student earned a credential. Legend entries for indicator marks, some of which overlap, are Short-term Certificate (244 students), Long-term Certificate (157), Associate of Arts (538), Associate of Science (56), and Associate of Applied Science (658). Some students have award dates in terms in which they have no enrollment record, resulting from late filing of award paperwork or a delay in recognizing transfer credit, among other reasons.

Figure 2.4: Image of All Enrollment Intensity Patterns Showing when Students Transfer



Note: Each thin row represents a student, each column a term. Combining thin rows of students with the same enrollment intensity status in each column results in bars of color. Blue bars indicate part-time enrollment; orange bars, full-time enrollment; white space, non-enrollment. Each of the 2,656 purple indicator marks, some of which overlap, indicate a student's first term enrolled in a four-year institution.

Table 2.2: Clusters of Enrollment Patterns Generated From K-Means Algorithm

Cluster	Name	No. Students	Pct Students	No. of Terms	Pct FT	FT-PT	FT-FT	PT-PT	PT-FT	Non-Enroll	Consecutive FT-PT	Consecutive FT-FT	Consecutive PT-FT	Consecutive PT-PT	Switches	First Interrupt 1 Term	First Interrupt 2 Terms	First Interrupt 3 Terms
1	Full-Time Persisters	2858	20%	4.50	89%	0.07	0.61	0.02	0.03	0.50	0.03	0.45	0.01	0.01	0.47	3.25	5.55	6.12
2	Early Leavers	4998	35%	1.25	30%	0.02	0.02	0.06	0.01	1.00	0.00	0.00	0.00	0.00	0.07	2.00	2.13	2.31
3	Early Persistent Switchers	1958	14%	4.10	49%	0.28	0.10	0.12	0.21	0.53	0.22	0.06	0.05	0.14	2.01	3.06	4.36	5.23
4	Mostly Part-Timers	2376	16%	4.12	6%	0.03	0.01	0.63	0.02	0.54	0.01	0.01	0.43	0.01	0.26	3.09	4.66	5.58
5	Early Attachers	728	5%	8.67	59%	0.21	0.32	0.16	0.18	0.2	0.19	0.30	0.14	0.16	3.29	8.13	9.63	10.00
6	Later Attachers	1511	10%	9.28	49%	0.18	0.28	0.28	0.15	0.43	0.12	0.19	0.17	0.09	3.06	3.05	11.13	13.14

Note: Clusters were formed using k-means algorithm. *FT-PT* indicates a ratio of the number of changes from full-time to part-time enrollment to the number of terms enrolled, ignoring gaps. *Consecutive FT-PT* is a ratio of the number of changes from full-time to part-time enrollment in consecutive semesters to the number of terms enrolled. *Non-Enroll* is a ratio of the number of times an enrollment is followed by no enrollment to the number of terms enrolled. *First Interrupt 1 Term* is the term in which the student experienced her first enrollment interruption of one term. *First Interrupt 2 Terms* is the term in which the student experienced her first enrollment interruption of two consecutive terms.

Table 2.3: Samples of Patterns Found in Clusters

Cluster	Example	Most Frequent
Full-Time Persisters	111111.....	11.....
Early Leavers	0...0.....	0.....
Early Persistent Switchers	11.01.....	10.....
Mostly Part-Timers	0..00.....	00.....
Early Attachers	11011..0.....	11011.....
Later Attachers	11.11.11.10.00....	11.10.00.....

Note: Each example pattern is one of several chosen for illustrative purposes.

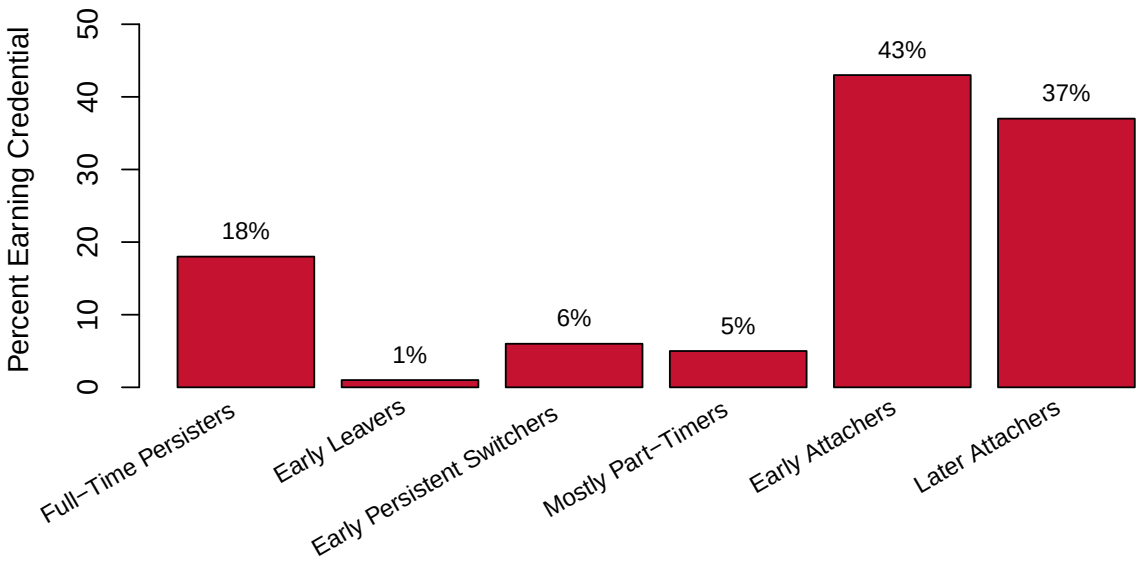


Figure 2.5: Graduation Probabilities within Five or Six Years by Enrollment Pattern Cluster

Table 2.4: Mean Student Characteristics by Cluster

	Full-Time Persisters	**Early Leavers**	**Early Persistent Switchers**	**Mostly Part-Timers**	**Early Attachers**	**Later Attachers**
Female	49%	48%	50%	54%	52%	53%
Age (at entry)	20.51	25.97	21.21	25.12	22.43	20.41
Age $\leq$ 19	81%	51%	75%	54%	70%	82%
Age 20-26	10%	18%	13%	17%	12%	9%
Age $\geq$ 27	9%	31%	12%	29%	18%	9%
White	62%	56%	55%	56%	58%	64%
Black	26%	31%	29%	28%	17%	18%
American Indian	0%	1%	0%	0%	0%	1%
Asian	2%	2%	3%	2%	6%	3%
Hispanic	3%	4%	4%	5%	4%	4%
Mixed Race	1%	1%	0%	1%	1%	1%
Nonresident Alien	6%	6%	7%	7%	14%	9%
HS Diploma	93%	87%	90%	85%	93%	94%
GED	3%	7%	6%	6%	4%	3%
No HS Diploma	4%	6%	4%	9%	3%	3%
Received Fin. Aid in 1st Term	45%	21%	36%	21%	33%	29%
Received Pell in 1st Term	34%	15%	27%	16%	22%	23%
SES Index	3.37	3.44	3.4	3.5	3.53	3.48
College-Ready Assignment						
Overall	10%	8%	9%	8%	11%	9%
Math	13%	9%	11%	8%	15%	13%
English	56%	51%	55%	54%	57%	57%
Reading	52%	50%	49%	51%	55%	53%
Entering Season						
Fall entrants	83%	52%	72%	73%	72%	76%
Spring entrants	12%	36%	19%	19%	15%	19%
Summer entrants	4%	11%	9%	8%	13%	5%

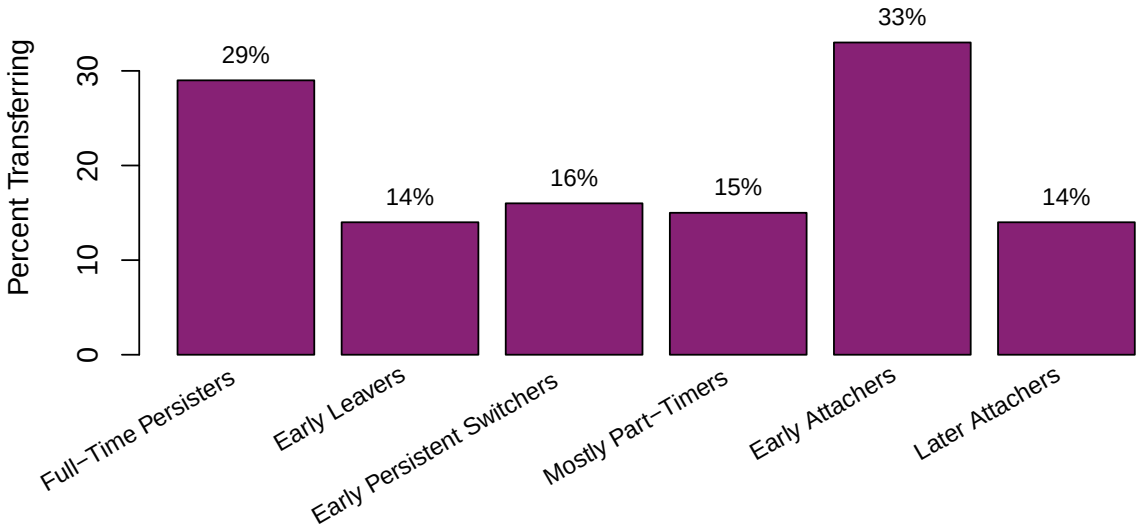


Figure 2.6: Transfer Probabilities within Five or Six Years by Enrollment Pattern Cluster

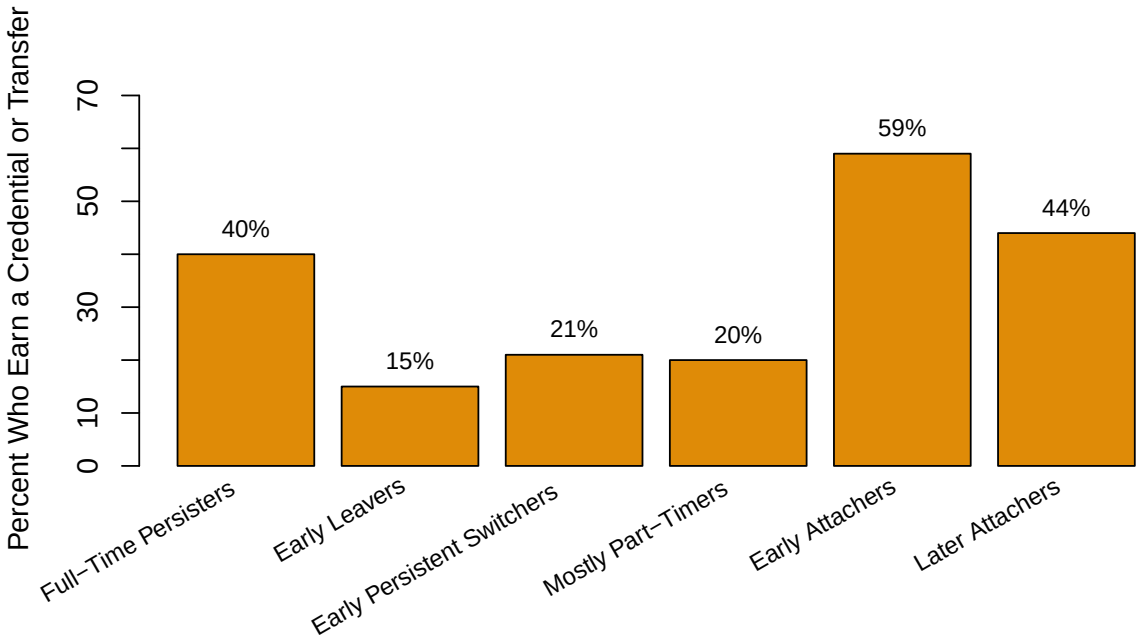


Figure 2.7: Percent Who Transfer or Earn a Credential within Five or Six Years by Enrollment Pattern Cluster

Appendix for Essay 2

K-Means Clustering Algorithm

K-means is a "hill-climbing" algorithm that seeks to maximize the differences between clusters and minimize the differences within clusters (Hastie, Tibshirani, & Friedman, 2009). Variables used in the clustering algorithm are strictly related to the patterns generated by student course-taking. They include the total number of terms enrolled, the percentage of full-time terms, the number of full- to part-time, part- to full-time, full- to full-time, and part- to part-time transitions as a fraction of the number of terms (both with and consecutively or without gaps), the total number of transitions between full-time and part-time states, and the locations of the first breaks in enrollment of one, two, and three terms (to capture shorter and longer stop-out behavior). All variables are scaled such that their means are 0 and standard deviations are 1. I executed the algorithm so that it produced three to ten clusters and determined that six clusters had good separability by within sum of squares measures.

Table 2.5: Sample Student Features: Demographic Information

Panel A			
Student Characteristic	**Mean**	**SD**	**N**
Female	0.501	0.500	14,429
Age (continuous)	23.341	9.062	14,426
Age ≤ 19	0.652	0.476	14,426
Age 20-26	0.141	0.348	14,426
Age ≥ 27	0.207	0.405	14,426
White	0.579	0.494	13,833
Black	0.272	0.445	13,833
American Indian	0.005	0.067	13,833
Asian	0.026	0.160	13,833
Hispanic	0.040	0.196	13,833
Mixed Race	0.006	0.080	13,833
Nonresident Alien	0.071	0.258	13,833
HS Diploma	0.892	0.311	14,327
GED	0.053	0.224	14,327
No HS Diploma	0.055	0.229	14,327
Received Financial Aid in First Term	0.294	0.455	14,429
Received Pell Grant in First Term	0.216	0.412	14,429

Table 2.6: Sample Student Features: Traits Derived from Census Area

Panel B		
Quintiles from Census Neighborhood	**Frequency**	**Percent**
Average Household Income		
1	1,264	9.1
2	1,370	9.9
3	1,746	12.6
4	2,687	19.4
5	6,780	49.0
Bachelor's Degree or Above		
1	1,217	8.8
2	1,425	10.3
3	1,923	13.9
4	3,127	22.6
5	6,155	44.5
Employed in Management/Professional		
1	1,692	12.2
2	1,642	11.9
3	2,047	14.8
4	2,992	21.6
5	5,474	39.5
Non-English Spoken at Home		
1	1,388	10.0
2	1,336	9.6
3	2,192	15.8
4	4,314	31.2
5	4.617	33.3
Percent with Healthcare Coverage		
1	4,539	32.8
2	3,832	27.7
3	2,498	18.0
4	1,510	10.9
5	1,466	10.6

Table 2.7: Sample Student Features: Developmental Education Placement

Panel C		
Education Level	**Frequency**	**Percent**
Developmental Education		
College Level	1,021	9.0
One Subject	4,212	37.1
Two Subjects	2,680	23.6
Three Subjects	3,432	30.3
Math Developmental Education		
College Level	1,214	11.0
One Level Below	1,638	14.9
Two or More Levels Below	8.171	74.1
English Developmental Education		
College Level	5,760	54.5
One Level Below	2,535	24.0
Two or More Levels Below	2,276	21.5
Reading Developmental Education		
College Level	5,506	51.2
One Level Below	3,215	29.9
Two or More Levels Below	2,033	18.9

Figure 2.8: Enrollment Intensity Patterns for *Full-Time Persisters* (top), *Early Leavers* (middle), and *Early Persistent Switchers* (bottom)

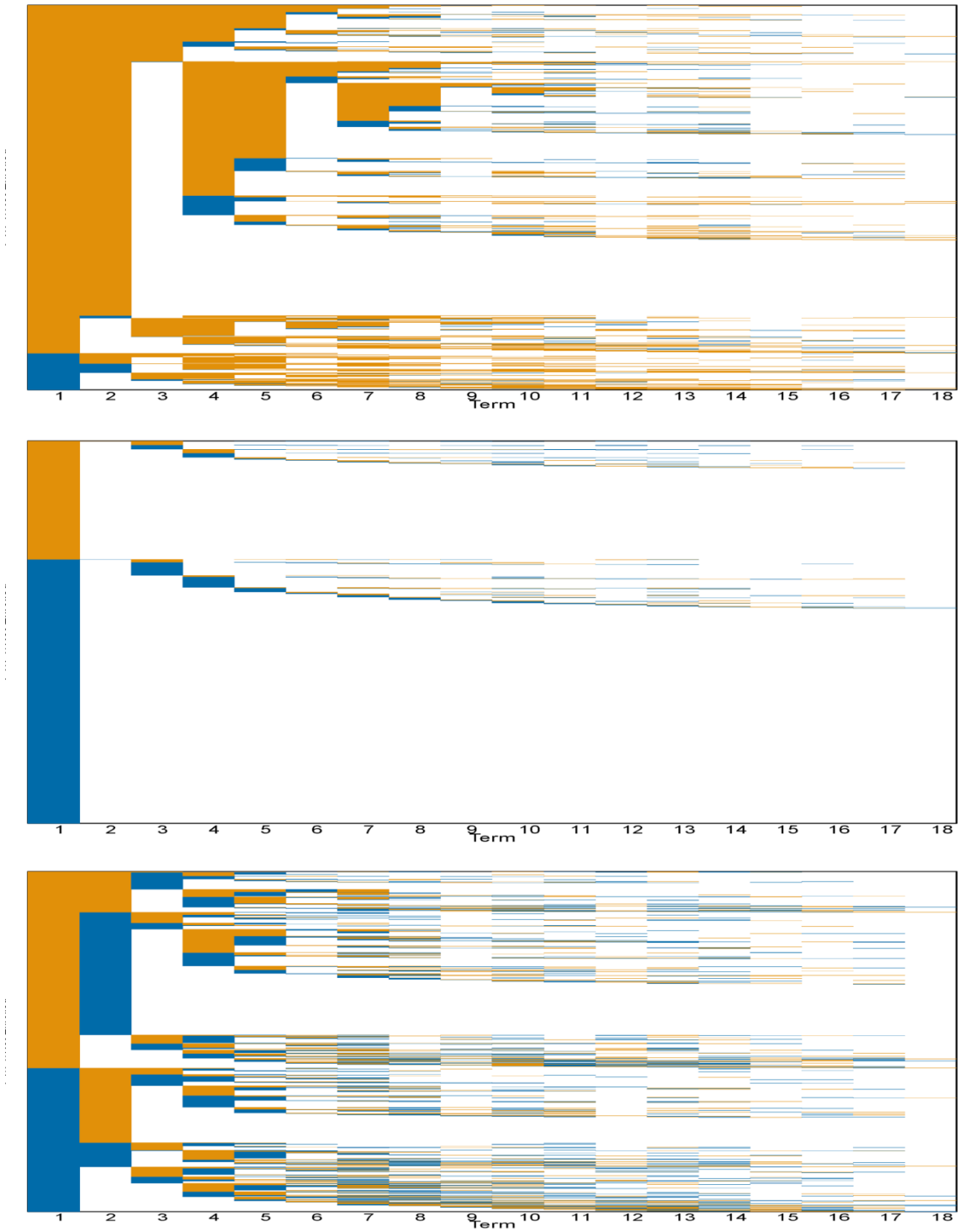
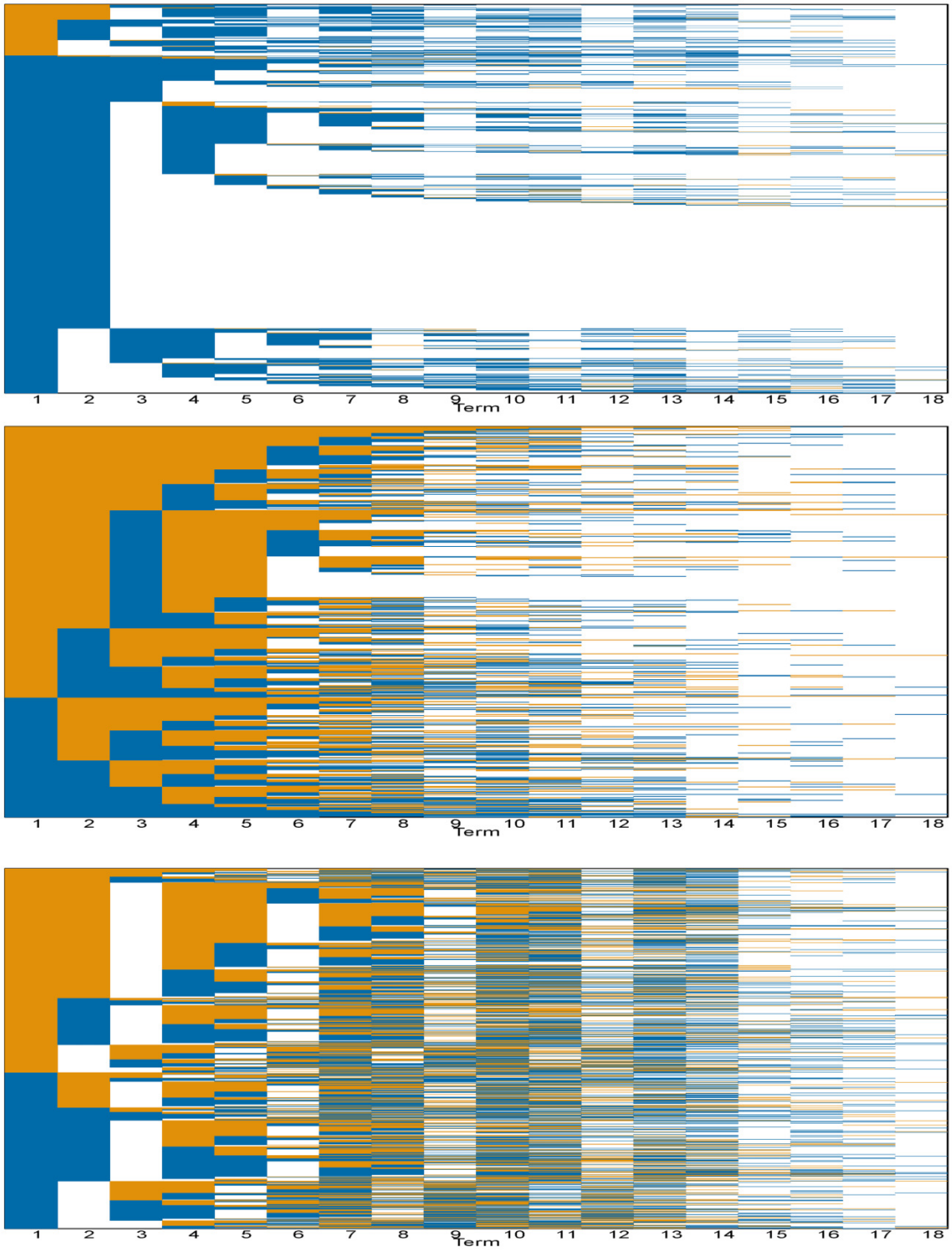


Figure 2.9: Enrollment Intensity Patterns for *Mostly Part-Timers* (top), *Early Attachers* (middle), and *Later Attachers* (bottom)



3

Can Community Colleges Afford to Improve Completion? Measuring the Costs and Efficiency Consequences of College Reforms*

3.1 Introduction

Colleges are under increasing scrutiny to document that they are using tax dollars appropriately, and policymakers are under pressure to implement reforms that will increase college completion rates without increasing costs (Bailey, 2011). The Obama administration has set ambitious goals for increased attainment of college credentials, particularly associate degrees and occupational certificates. Given current funding constraints, community colleges will have to make substantial improvements in institutional efficiency in order to meet the administration's goals (Jenkins, 2011). To determine whether the colleges can make such changes, it is necessary to understand what efficiency means in this context and how it should

*This essay is joint work with Clive Belfield and Davis Jenkins.

best be analyzed. Unfortunately, in many economic and policy discussions of college performance and education reforms, terms such as "efficiency," "productivity," and even "unit cost" are used loosely and sometimes interchangeably. For example, President Obama's January 2012 Blueprint for Keeping College Affordable refers to "federal support to tackle college costs" when in fact the support is intended to reduce student fees (The White House, Office of the Press Secretary, 2012). As another example, discussed in detail in Powell, Gilleland, and Pearson (2012), college personnel sometimes equate reductions in cost, by which they actually mean expenditure, with deteriorations in quality (which would imply no change in cost, strictly defined). Moreover, as argued below, research evidence on efficiency within the postsecondary sector has not yielded results that have helped colleges to increase their efficiency levels.

In this paper we set out an economic model that directly calculates the implications for efficiency defined as expenditures per outcome of reforms intended to improve completion rates at the college level. Research is now increasingly focused on student persistence and completion both for equity and efficiency reasons. Over prior decades there has been a substantial expansion of access to college, but this access has not been matched by improvements in completion; in fact, disadvantaged groups' greater opportunity to enroll has been accompanied by lower completion rates, exacerbating socioeconomic stratification of higher education attainment. To better understand this phenomenon, research has examined persistence: in an exhaustive review, Tinto (2012) summarizes evidence on mediating factors such as expectations, support, and assessment, and feedback. Yet, missing from this evidence base are two key issues. One, which is acknowledged, is that these reforms require additional resources. The other issue, not acknowledged and the focus of our research, is that reforms that increase persistence then create resource pressures in later years.

By definition, increasing completion rates means students will have to stay in college for longer, incurring greater expenditures but also generating additional revenues. Having more students persist will change how colleges operate – from their course mix to their advising and academic support services - and this will impact the way they manage resources. Therefore

it is critical to understand how improvements in student progression and completion affect efficiency.

Simulations using our model are performed to improve our understanding of the economic implications of college efforts to strengthen student pathways to completion. We emphasize that this is an alternative approach to that applied in most other studies of efficiency but one which we believe has three advantages. First, our approach models college completion as a longitudinal process based on students' course-taking patterns and college resources over multiple years. This process, which corresponds directly with how students progress through college, cannot be accurately captured in a single-year cross-sectional study or annualized approach (Laband & Lentz, 2004; Powell, Gilleland, & Pearson, 2012). Second, our model is intended to help colleges plan and evaluate systemic reforms aimed at improving student retention and completion, particularly those reforms that are explicitly targeted at increasing college graduation rates. Our efficiency analysis can be related directly to specific reforms that colleges may be considering. Finally, our approach includes an analysis of the revenue implications of reforms, i.e. what the implications are for college budgets.

The model starts with an economic "baseline" for a cohort of first-time students at a college: its current completion rate, expenditures and revenues. For any given reform, we first calculate the increased proportion of students who would progress through toward completion of an award. Next, we calculate the economic implications of increases in progression and completions. These economic implications are expressed in terms of key metrics: completions, expenditures, revenues, net revenues (expenditures minus revenues), and efficiency (defined as awards per dollar of expenditure). We also derive an intermediate metric "pathway spending". This metric helps explain how the model works and it provides useful information on subgroups of students. The economic model simulates the effects for these metrics relative to the cohort baseline. Different reforms can then be compared in terms of how much they might increase the numbers of students completing, how they might differentially affect expenditures and revenues, and how much they could increase efficiency.

The primary contribution of our research is to explain this economic model of college

efficiency. As a second contribution we apply the model as a case study on a single community college. To populate the model we use detailed data from the college's student transcripts matched to credit-level cost data and relevant funding formulae. Unlike previous studies, our model uses unit record data on student course-taking and on costs of providing these courses. This enables us to estimate resource use with a high degree of precision. Importantly, we distinguish these two contributions. The importance of the model lies in its explanatory power as a simplification of reality. Any results from the model will of course depend on the specific parameter values that are plugged in. These values may be disputed but alternative values can easily be assumed. This allows the results to be subjected to full sensitivity testing.

This paper is structured as follows. Section 3.2 reviews the theory and evidence on efficiency in the postsecondary sector, describes the basic framework of our model, and discusses the merits of using student progression and completion data to measure efficiency. Section 3.3 provides formal definitions of each of the economic metrics and reports baseline statistics for the single college examined. Section 3.4 presents results for the metrics from a series of simulations of the model that are based on the college's meeting a set of key performance indicators, or intermediate measures, of student progression that they expect will increase completion rates over time. Section 3.5 summarizes our results and considers the policy implications arising from wider application of this model.

3.2 Economic Measures for Community Colleges

3.2.1 Prior Research

Efficiency is the production of a given output at the lowest possible cost. There is, however, considerable disagreement about what colleges produce, with most researchers arguing that measuring "output" in education is difficult, both conceptually and empirically (Dolan & Schmidt, 1994; Levin, 1991; Sullivan, Mackie, Massy, & Sinha, 2012). Colleges produce more than one output, and they receive funding from multiple sources, each of which may

have a different valuation of output. Moreover, there is legitimate debate over the extent to which a college is responsible for student outcomes (Winston, 1999). Community colleges may claim that their outcomes simply reflect student characteristics, aptitudes, and preferences, and that as open-access public institutions they have only limited influence over these factors. Hence, some may question whether efficiency and productivity can be accurately determined in higher education: Institutions, it is claimed, either spend whatever money they have, an assertion noted over three decades ago by Bowen (1980), or allocate resources based on internal rules and formulas rather than on strict efficiency considerations. Nevertheless, there is still considerable scope for colleges to spend efficiently or wastefully, and ultimately all public enterprises should be held accountable for their use of public funds; increasingly this is being done. In fact, on the former point, Syverson (2011) has concluded that, "studies of the private sector industries have documented, virtually without exception, enormous and persistent measured productivity differences" (p. 326). By necessity, therefore, it is important to examine efficiency in higher education even as there may be much debate over how it should be measured.

There has been very limited research on efficiency within the community college sector. We are aware of only two studies, and neither is strictly an efficiency study; rather, both investigate whether colleges with more resources generate better outcomes. Based on individual-level data, Bound, Lovenheim, and Turner (2010) found no link between completion rates and resources, although the resource measure - the student-faculty ratio - may be questioned as a proxy for resource levels. Using individual survey data merged with IPEDS, Stange (2012a) found no positive effect on student outcomes of instructional expenditures per student, faculty salaries, or the proportion of faculty who were full time. However, the outcome of analysis was community college students' attainment of a bachelor's degree, which applies to only a subset of community college students. The implications of these studies are presumably that colleges with higher spending are less efficient than colleges with lower spending: they spend more but have the same outcomes. Alternatively, the implication may be that spending on these particular inputs is inefficient and that it would be preferable to

increase spending on other inputs (e.g., non-instructional expenditures). Regardless, this evidence is insufficient in two respects - it provides no obvious way to calculate the extent of inefficiency at the college level, and it offers limited policy guidance on how to become more efficient.

For four-year colleges, there is considerably more literature. Some of it includes all public institutions, but pooled evidence has limited applicability for community colleges. Typically, community colleges do not have large research budgets; they do not enroll graduate students; and 40 percent of their awards are vocational certificates, not degrees (Bailey & Belfield, 2012; Gansemer-Topf & Schuh, 2006; Laband & Lentz, 2004). Methodologically, most of this literature has either been regression-based or applied stochastic frontier models. For a clear exposition of the two and the value of the latter, see Archibald and Feldman (2008). For a more complex structural equation model using IPEDS data, see Powell et al. (2012).[1]

These methods have advantages in that they are formal and technical. But they may have less utility for helping community colleges improve to meet new efficiency goals. First, they tend to be applied using cross-sectional annual analyses: output in a given year is expressed as a function of inputs in that year. However, college completion is a process whereby students take courses and earn credits over multiple years: College completion rates in any given year reflect the resources and programs delivered to cohorts of students who enrolled a few years earlier. An annual model is most appropriate for a college in a "steady state" where dropout is a linear decay process over time. In contrast, most community colleges have large initial enrollments and then experience very steep dropout rates in the first couple terms. The fraction of students who are close to graduation is therefore a relatively small proportion of the overall enrollment at the college (as well as being atypical in terms of credit

[1]Regression-based approaches include Webber and Ehrenberg (2010) and Zhang (2009). For stochastic frontier analysis, see Agasisti and Johnes (2010) and Kempkes and Pohl (2010). A companion strand of literature has focused either on estimating cost functions (the association between costs and input prices) or on identifying economies of scale (the association between enrollment size and output). See, for example, Cohn, Rhine, and Santos (1989), De Groot, McMahon, and Volkwein (1991), Watkins, Harter, and Wade (2005), Laband and Lentz (2004), Toutkoushian (1999).

accumulation).

Second, colleges need results that yield straightforward implications for reforms to improve college efficiency. Leaving aside the difficulties of interpreting stochastic frontier results, these models are calibrated to yield a frontier of efficient colleges and a subset of inefficient colleges (even super-efficiency scores do not appear to fully discriminate across all colleges; see Archibald and Feldman (2008, Table A1)). By implication, only the subset of inefficient colleges should improve. More importantly, these methods cannot be easily linked to any reforms that might increase efficiency. For example, it is not possible to apply the results from a stochastic frontier model to identify how improvements in advising practices, curriculum structures, remedial testing, or math instruction will influence efficiency (see the discussion of possible efficiency-enhancing reforms in Jenkins & Rodriguez, 2013).

Finally, an economic model of college completion must address the financial implications of changes in provision. Colleges face financing constraints and cannot implement reforms - regardless of their efficiency - if these reduce college net revenues.[2] It is not sufficient that a college knows how to increase completion rates; it must also balance its budget. This constraint is almost never incorporated in the economic literature cited above and rarely considered in policy discussions of reforms to improve efficiency. We suspect that funding is one reason why reforms are either short-lived (colleges simply cannot afford to implement them for long or at a sufficient scale) or ineffectual (their expense is offset by deteriorations in the quality of provision elsewhere in the college.) Therefore, changes in completion, expenditures, and revenues must all be derived simultaneously as part of an economic analysis.

[2]Efficiency may be increased by reallocation of existing resources such that expenditures do not increase. We suspect that this type of efficiency gain is not large and that greater efficiency gains would come from making investments in additional resources (e.g., to improve instructional quality). Regardless, even if expenditures remain constant, the change in revenue must still be calculated.

3.2.2 A New Economic Model of College Efficiency and Student Completion

The economic model we outline below is an attempt to address these challenges. It models college completion as a process over time. It is linked directly to reforms that might improve efficiency and it estimates the financial implications of reforms. The model is based on four key metrics: output; expenditure and revenue (and hence net revenue); and efficiency (expenditure per unit of output). We link these metrics by calculating pathway spending per student: the amount the college spends on each student as they progress through college. (In this sense the model is resource-based and does not model strategic behaviors of students as agent-based economic models do). We define each of these terms in general terms here; in a later section, we specify parameter values for our sample college.

3.2.2.1 Output

To calculate efficiency it is necessary to specify what output community colleges produce. Bailey (2011) sets out the two main missions: vocational and academic college programs that can lead to transfer to a four-year program, and focused vocational training programs that are designed for workers or job-seekers.[3] Community colleges produce many different awards: 56 percent are associate degrees, 23 percent are short-term certificates, and 21 percent are moderate to long-term certificates (Horn, Li, & Weko, 2009). As well, large numbers of students transfer to four-year institutions with the intention of completing a four-year degree. A recent study by National Student Clearinghouse Research Center (Shapiro et al., 2012) calculated the transfer rate (defined as any institutional change irrespective of timing or duration) by cross-referencing student enrollments at different colleges: one-in-five public two-year college students will transfer to a four-year institution. Our definition of output emphasizes completion of an award at the original community college: output is

[3]A third mission is continuing educationwhich includes general interest courses for individuals and customized training for firms. This mission is not analyzed here on the assumption that it is independently self-financing.

the number of associate degrees and certificates awarded within a given year, weighted by the number of credits required to attain them (see also Harris & Goldrick-Rab, 2010).[4] Since preparing students to transfer to four-year schools is an explicit part of the typical community college's mission, the credits students accumulate before transferring to a four-year institution are also considered as output produced by the community college (even though many of these students do not graduate from their destination college).

Our measure of output counts all award-based credits as equivalent and so values the outputs of higher education primarily in relation to completion. The measure gives zero weight to the credits accumulated by students who never complete an award. Finally, lateral transfer is also given zero weight: the credits of students who complete an award at a different two-year college are not counted as part of the origin college's output.[5] These students could have completed their award at the original institution but did not do so. We emphasize completion for several reasons. The majority of students enroll in college with the aspiration that they will complete their program (or transfer to complete a program elsewhere). Colleges are increasingly under pressure from policymakers to improve completion rates, even if only because these rates seem so low. An emphasis on completion therefore aligns the incentives of colleges with those of students and policymakers.[6] Finally, alternative measures of output are less satisfactory: if output is expressed in terms of total credits accumulated, then there

[4]An alternative way of concatenating output, set out by Massy (2011), is to count credits completed and perhaps to include a greater weight for students who complete their credential (Johnson, 2009). This output measure de-emphasizes completion: it rewards colleges based on enrollment and so provides them with very little incentive to increase completion rates. For a discussion of other alternatives, see Sullivan, Mackie, Massy, and Sinha (2012, Appendix A)

[5]We do not split credits for lateral transfers across colleges. This requires data on where the student goes and their subsequent performance that most colleges do not have. Also, very few transferees end up earning a credential anyway. Finally, counting lateral transfers would reinforce a negative incentive, whereby colleges that students do not "like" and so leave for a substitute college are rewarded for the credits they provided.

[6]Researchers also emphasize college completion. In a recent volume, Tinto (2012, p. 6) states: "What matters is not simply attending college but completing a degree."

is very little scope for efficiency gains and costs become indistinguishable from expenditures; and it is infeasible (and probably unnecessary) to value output based on total accumulated earnings of college students.[7]

3.2.2.2 Pathways to completion

Critical to understanding how this output is produced is the concept of student pathways to completion, or the sequence of courses and enrollments that leads to a credential. Fundamentally, a college's annual output reflects several prior years of resources for a given cohort of students. Associate degrees, as well as many certificates and diplomas, cannot be completed in a single year. Instead, output is produced as a result of a particular cohort of students' following pathways of courses through college; the only way to increase output is to influence these pathways in ways that increase rates of student progression.

In following a path of courses through college, students take credits in various disciplines to meet the requirements for their chosen credentials. There are many ways that students' pathways influence a college's completion rate. Many students simply fail to complete an award or are unable to satisfy the college's graduation requirements. Some of them drop out of college entirely, while others transfer to a two- or four-year institution without first earning a degree (Crosta, 2013). Some students have been enrolled for five or more years and have accumulated many college credits but not earned a credential (Cho & Ran, 2013). Many students get delayed because they must take remedial education courses (Bailey, Jeong, & Cho, 2010). As these courses do not count toward a college credential, unnecessarily lengthy remedial education sequences mean that fewer students will ever take college courses and even fewer will graduate. Many other community college students enroll part time or

[7]It is possible to adjust these outputs to more closely reflect their economic value and the most straightforward way to do this is to weight student outcomes according to their economic value in the labor market or to apply a sheepskin multiplier (Kelly, 2009, Figure 2). However, based on Kelly's (2009) analysis, the overall effect is small output would be only a couple of percentage points differentand there are practical challenges in applying such weights. Generally, although there are differences in labor market earnings across awards, the evidence is unlikely to be precise enough or complete enough to calculate these weights.

intermittently, combining pursuit of an award with employment or family responsibilities (Crosta, 2013; Dadgar, 2012). Moreover, many students take "surplus" courses beyond the basic catalog requirements (for example, most associate degree holders have more than 60 credits) (Zeidenberg, 2012). Students may change their program of study, or lack awareness of the program requirements, or they may have to wait to be accepted into a high-demand program, such as nursing. Taking surplus courses slows down or even hinders progress toward completion, and it also increases expenditures.

Therefore, one important way for colleges to improve efficiency is to improve pathways, making sure that students only take courses that are necessary and that as many students as possible complete the entire sequence of coursework required for their award.[8] Research by Jenkins and Cho (2012) highlights why this is important. Fundamentally, acquiring an education credential is a process. The responsibility of college personnel is to improve that process. Registration personnel should provide accurate guidance to students on entry to college, optimally assigning students to remediation or the appropriate entry-level courses. Students who enter without clear goals for college and careers should be helped to explore options (Deil-Amen & Rosenbaum, 2003; Scott-Clayton, 2011). Advisers should provide useful information for students during their college career, identifying the optimal sequence of courses to achieve their academic and career goals and supporting students who may be struggling. For example, instructional personnel should ensure that the curriculum and coursework are well aligned internally so that students who pass courses are prepared for subsequent coursework, and well aligned externally so that programs prepare students to succeed in further education and in career programs for employment.

Critically, we argue that reforms to improve completion - and so to increase output - should be understood in terms of how they influence pathways for a given cohort of students. It is not possible to increase completion rates simply by augmenting resources to all

[8]The other important way is to reduce expenditures for a given pathway. However, if the quality of the program is a function of expenditures, as many faculty believe, then reducing expenditures per pathway may not reduce the cost per pathway.

students and probabilistically expecting more students to graduate. Most community college students leave after one year, having accumulated only a few credits. Thus, to increase the completion rate it is necessary instead to invest sufficient resources in students along their college pathway such that these students do then graduate. The completion rate will increase by only a small amount if all students accumulate a few extra credits.

3.2.2.3 Expenditures and revenues

The last part of this economic model is the financial effect on the college. Annually, community colleges spend approximately $50 billion across enrollment of over seven million students, and this expenditure must be funded from revenues (public funding or tuition fees). However, as argued above, annual expenditures are not an ideal way to understand how colleges allocate resources or should allocate them when the interest is in how efficiently their resources are spent.

Instead, the measure of expenditures used here is directly related to students' pathways. Colleges spend resources on each student as he or she progresses through college. These resources include administration and overhead as well as support services, but the largest single expense is for course instruction. Since spending is higher on students who take more courses, the further a student progresses through college, the higher are expenditures. Of course, the further a student progresses, the more likely it is that he or she will graduate from college.

We define the expenditures tied to student pathways as "pathway spending" i.e., the amount of resource required to follow a particular pathway. Spending will be higher on students who take more courses, as it will be on students who take courses in relatively expensive areas (e.g., laboratory courses or radiography programs). Colleges can measure the costs per pathway for various subgroups of students that might be of interest. In practice, a college may wish to focus on the most common pathways, e.g., students who begin in remediation or initially enroll full time or enroll in a specific program, to ascertain the cost for students who follow such a pathway. For the students in a given cohort, the sum of

their individual pathway spending represents the entire expenditure of the college on the cohort. For the model used here, total expenditures are not considered annually but rather are summed across an entire cohort of students over a given period of time.

Analogously, we derive revenue per pathway and total revenues. College revenues come from a mix of fees and government subsidies. Both revenue sources are primarily determined by the number of credits each student accumulates: As students take more classes, fees go up and so do government subsidies, since funding formulae are at least partially enrollment-driven. Thus, revenue per pathway can be derived, i.e., the amount of revenue the college gets per particular pathway can be ascertained. Students who take more courses should generate more revenue, as would students who take courses that are either charged or funded at a relatively high rate. For the students in a given cohort, the sum of their individual pathway revenues represents the entire revenue of the college from the cohort.

Straightforwardly, costs and revenues can be compared - either at the pathway level or in the aggregate for a cohort. Absent substantial borrowing or reserve holdings, aggregate costs and revenues should be in balance. However, a particular pathway's cost need not equal the pathway's revenue. As students progress through college, some will take a relatively expensive pathway whose revenues do not fully cover the costs. These students are being subsidized. Other students will take a low-cost pathway with revenues exceeding expenditures. These students are subsidizing other students at the college. Changing students' pathways may therefore not affect expenditures and revenues in exactly the same way.

The model emphasizes two basic elements. First, to increase completion rates it is necessary to get students into pathways that lead to awards. Second, if colleges do improve their completion rates, their costs must necessarily increase - the students must have taken more credits.[9] Yet, if revenues do not increase proportionately, then the college will have to cut other programs, likely leading to a fall in the completion rates of subsequent cohorts (assum-

[9]The only way to increase completions without increasing costs would be to restrict enrollment to students with a higher probability of completion. As community colleges are open-access institutions, this option is not viable.

ing the college cannot borrow or run deficits). In fact, increases in expenditures to exceed increases in revenue from a given reform can be anticipated: as students progress further in college they tend to take relatively more expensive courses. Typically, college-level courses are more expensive than remedial courses, since the latter are more likely to be taught by adjunct instructors, and upper-level courses are more expensive than lower-level courses, since they are more likely to be taught by full-time instructors, have smaller class sizes and, in the case of career programs, require expensive equipment. If fees are not perfectly calibrated to these differences, more student progression will result in negative net revenue. This loss in revenue will have to be offset, perhaps by increasing class sizes for other cohorts.

3.2.2.4 Efficiency

The model links student progression to completion and, by including costs, yields a straightforward measure of college efficiency: expenditure per unit of output. For each college, efficiency is the ratio of total expenditures to total output within a given period of time. For a given completion rate, lower expenditures means greater efficiency; and for a given expenditure, higher completion rates mean greater efficiency. Expressed as a ratio, this efficiency measure captures the consequences for both completion and expenditures.

The efficiency measure is responsive to differences in how students progress through their program of study. When students accumulate surplus credits (or more than they need to graduate), expenditures increase but the number of completions does not; efficiency is therefore lower (Romano, Losinger, & Millard, 2011). When students are in remedial education, there are expenditures even as these students are not accumulating credits to help them complete a college credential; again, efficiency is lower. Finally, when students accumulate many credits but never complete an award, efficiency is significantly lower. In fact, from an efficiency standpoint, if students are to ultimately dropout it is better that they do it earlierbefore the college has allocated substantial resources to themthan later. The least efficient student is one who completes most, but not all, of the courses required for an award.

Only by applying a pathway model do these consequences become clear. This efficiency measure shows the economic trade-off across different pathways. Some pathways are more efficient than others, i.e. spending is lower per completion. For example, students who enter directly into college-level classes are more likely to progress further and so require greater spending than students who first enter into remediation. The numerator of the efficiency ratio increases. However, college-ready students are more likely to complete their credential. The denominator of the efficiency ratio also increases. For efficiency gains to be realized, the denominator (completions) has to rise proportionately more than the numerator (costs) and it is an empirical issue as to which is dominant. Health programs offer a notable illustration of this issue: students who follow a nursing degree pathway will take relatively expensive courses but they are much more likely to complete an associate degree than other students. Cost per completion may therefore be lower or higher for these programs.

For evaluating reforms, each of the economic metrics serves a separate purpose. The disaggregated metric – pathway cost – is critical for understanding how the model operates: the economic results depend on moving students onto more efficient pathways without jeopardizing completion rates..[10] But all the metrics are salient for colleges. Reforms must increase completion rates, although the fundamental test of a reform is whether the college has become more efficient. This involves moving students onto more efficient pathways. However, even efficiency-enhancing reforms must not create financial pressures for the college: net revenue cannot be strongly negative.

The model is designed to interpret student progression as an economic phenomenon; it can therefore be linked to evidence on how students do progress through college and what practices improve progression rates. The model should therefore help colleges plan, prioritize and evaluate reform strategies for increasing completion. At this stage, our model does not include data on the costs of these reforms. The model predicts the economic consequences

[10]This model is not disaggregated at the departmental level. Students take many courses across different departments, and so a single department is not wholly responsible for ensuring that each student completes an award.

conditional on a successful reform being implemented. By implication, this prediction is informative as to how much the college could spend on such a reform and still break even and so has value in guiding colleges on which reforms to focus on. To our knowledge, this information on the economic consequences of reforms, which is necessary but not sufficient for decision-makers, has received almost no attention.

3.3 The Model Structure and Baseline Data

In this section we first specify the basic structure of the model and the data required to populate it and then report baseline results for the study's sample college.

3.3.1 Economic Metrics

The study defines the college completion rate in terms of associate degree equivalents awarded within five years of the cohort's enrollment (see Appendix Table 3.10, top panel). Each associate in arts (AA) degree is worth one unit, and all other awards are weighted based on the average number of non-remedial credits students actually accumulate for a given award (see Appendix Table 3.11).[11] All awards are counted, even if a student receives more than one. This definition of the college completion rate also includes transfers to a four-year institution. Each transfer student is weighted according to the credits accumulated before transfer relative to the credits needed for an associate degree. (Thus a student who transfers after earning seven credits would be weighted at 0.1). Zero weight is given for students who are no longer enrolled after five years but received no credential and did not transfer, for students who are still enrolled in the college in year five but have not received an award, and for students who initially enrolled at the college but either transfer to a two-year institution or go on to receive a sub-baccalaureate award such as a certificate or associate degree at another college.

[11]For example, if the average AA degree holder accumulates 70 credits and the average certificate holder accumulates 35 credits, a certificate is valued at 0.5.

Pathway spending and total expenditures are defined as the amounts spent on a given cohort of students from their initial entry into the college and for five years thereafter (see Table 3.10, middle panel). The total expenditure amount is the sum of spending on all the pathways students take (the number and types of credits attempted during each student's time in college and how much the college spends on those credits and other services). To compute spending on instruction, we match courses attempted on student transcripts to cost-per-credit-hour data provided by USACC. Indirect instructional expenditures and non-instructional expenses are estimated from the college's annual expenditures. We estimate the total amount spent on the cohort each year and then allocate this amount by headcount or by credit hours attempted for each student in each year. The result of the process is that each student in the cohort has an expenditure value attached to her.

Pathway revenues and total revenues are defined as the amount of revenue for a given cohort of students from their initial entry into the college and for five years thereafter (see Table 3.10, bottom panel). In general, revenue is composed partly of fee income, which is the sum of registration fees (initial charge on entry to college), enrollment fees (a fixed amount per semester), and tuition fees for each course taken. Revenue is also composed of public subsidies; these are a function of state and local government funding formulae, which include a mix of block grants and per-student allocations. In this case study, college revenues are derived mostly from state and county funds (tuition and fees are sent to the state and reallocated across all colleges), where state funds are enrollment driven and county funds are relatively flat from year to year. To approximate these conditions, we consider a student revenue amount that is based on the number of credits and courses attempted, allowing for courses that are funded at a higher rate to bring in more revenue than those funded at lower rates.[12]

Net revenue is defined as the difference between total expenditures and total revenues for

[12]Our revenue model is an approximation of reality that captures the largest features of revenue. True college revenue is generated by a complex funding formula that depends on data elements not available for this study.

a cohort of students over the first five years. At baseline, net revenue should be calibrated to zero: the college cannot spend more than it gets in revenue (abstracting out deficit financing or reserve accumulation).

Finally, efficiency is defined as the cost per unit of output, i.e., total expenditures divided by the numbers of associate degree equivalents. Efficiency can be measured both at the college level and for each pathway. In both cases, the efficiency measure applies the metrics as defined above, where completion is expressed in terms of associate degree equivalents and all measures are calculated for a given cohort over a five-year window.

It should be emphasized that these metrics are reported for a cohort of students that enters the college within a given year and is followed over some fixed period of time (in this case, five years). The model can be calculated for any assumed duration, although it is essential that all metrics are calculated for the same duration. But the results are not "annual." There are many other students already attending the college before the study cohort enrolls, and over the course of the five-year period many new students will enroll. Importantly, there are also many students taking non-credit courses at the college; as these students are not the focus of initiatives to improve completion rates, their expenditures and revenues are not factored into the model simulations. Therefore, the expenditure and revenue figures presented here should not be interpreted as the overall totals for a given year and may not reflect amounts that are immediately familiar to colleges.

3.3.2 Baseline Data for the Sample Community College

The study's example of the model uses data from a single community college (called here U.S.A. Community College [USACC]), for the cohort of students who first enrolled in the college in 2005-06. Data on pathways are drawn from student-level transcripts. Data on costs come from the general ledger accounts of the college, which report spending disaggregated by department and by function (instruction, student support, administration) and, in some cases, by course. Data on revenue are derived from the fee structure of the college and the state funding formula. At the most disaggregated level, expenditures and revenues are

matched to student transcripts.[13]

Table 3.1 presents basic descriptive information about the college. At USACC, the headcount of first-time enrollment in college-credit (award-bearing) programs is 3,800. Tracked over five years, USACC will spend on average $13,970 on each of these students such that the total expenditure is $53.1 million.[14]

Table 3.1: Pathway Costs, Output, and Costs per Completion at USACC

Student Characteristics	**Number of students [1]**	**Pathway Cost [2]**	**Output [3]**	**Cost per Completion [= 1*2/3]**
All students in 2005-06	3800	$13,970	477	$111,310
Full-time in first semester	1530	$19,580	271	$110,660
Part-time in first semester	2280	$10,220	206	$112,930
Field:				
Allied Health	111	$30,560	24	$142,050
Mechanics/Repair	120	$21,710	15	$172,470
Liberal Arts/Science	1460	$17,250	222	$113,300
Business/Marketing	170	$16,320	24	$117,890
Initial Placement:				
College-ready	200	$19,670	53	$74,180
DE placement level 1	880	$18,040	157	$100,820
DE placement level 2	580	$17,860	80	$129,680
DE placement level 3	860	$15,390	76	$173,390

Notes: College credits only; not developmental education credits. Weights are based on the average duration to complete the award. Only data for curriculum (award-bearing) students are reported. Numbers rounded to nearest ten.

There is significant variation across pathways. As shown in column 2 of Table 3.1, there

[13]The college provided the data. It should be noted that not all colleges have these data in this format; the study college has made intensive and comprehensive efforts to collect expenditure data at the appropriate level of disaggregation.

[14]The college also has substantial non-credit offerings. The headcount is 6,300, with a per student average pathway cost of $3,700 and a total expenditure for the cohort of $23 million. In fact, the full 2005 cohort model suggests that non-credit programs subsidize credit programs.

are large differences in pathway spending according to whether the student was full time or part time at first enrollment; the former requires approximately twice as much resource as the latter. There is one grouping shown in the table for which there is not a big difference in pathway spending: whether students enrolled college-ready or were placed into remedial education. The amount of resource USACC spends per student is quite close whether the student enters directly into a college-level program or into remediation ($15,390-$19,670).[15]

As a result of these expenditures USACC yielded a total output of 477 associate-degree equivalents over the five years covered in the study. The cost per unit of output is therefore $111,310. (Although this figure may seem high, estimates of the fiscal benefits per community college degree by Trostel (2010) are $137,000. These fiscal benefits are only the taxpayer benefits - not the student benefits - and the taxpayer provides less than 75 percent of total funding.)

Critically, pathways chosen by students within this college vary significantly both in terms of spending and in terms of how many students who follow a given pathway complete an award. Table 3.1 shows the spending for some selected pathways and the number of awards accumulated by students who follow that pathway, allowing a calculation of the efficiency of the pathway.

For some pathways the differences in efficiency are small. At USACC, students who enroll full time in their first semester follow a pathway that entails almost double the spending of students who initially enroll part time. However, these full-time students yield 56 percent of the college's output (271 out of 477) despite being only 40 percent of enrollees. Measured in terms of overall efficiency, students who enroll either part-time or full-time in the first semester are almost equally efficient - the pathway costs per completion are $112,930 and $110,660, respectively.

Pathways by field show more heterogeneity. The pathway spending for students who are in Allied Health are significantly higher than those in Mechanics/Repair, Business/Marketing,

[15]These amounts are all above the average pathway spending because assessment data are not available for a substantial number of students who therefore cannot be clearly identified as college-ready or not.

and General Liberal Arts/Science. However, when we adjust for differences in completion rates, the Mechanics/Repair field is the least efficient pathway. Its cost per completion is $172,470, compared with $142,050 for students in Allied Health, $117,890 for those in Business/Marketing, and $113,300 for those in General Liberal Arts/Science. The most striking difference across pathways is by initial placement level. Students who are college-ready follow pathways that require more resources than students who are placed into remedial education (Table 3.1, column 2). But their much higher completion rates are such that their pathways are much more efficient. The cost per completion for a student who initially places into college-level courses is $74,180; the cost per completion for students who place into remedial education are higher by 36 percent, 75 percent, and 134 percent, respectively, depending on whether students were referred to remedial coursework at one, two, or three levels below college-level.

3.4 Increasing Completion Rates and Efficiency

The model used in this study can be easily applied to evaluate the economic consequences of specific policies or interventions that are intended to improve completion rates. As noted above, the menu of reforms is extremely large, even as supportive evidence for any particular reform is thin (see the full discussion in Jenkins & Rodriguez, 2013). Indeed, perhaps the lack of positive evidence reflects the fact that many strategies consist of discrete practices: if colleges are to improve completion rates substantially, they will most likely have to implement changes in practice at various stages along the student's pathway (Jenkins, 2011). Reforms focused on one phase of the student experience - for example, efforts to improve the readiness of incoming students or to increase the effectiveness of college remediation for those who arrive unprepared - are unlikely to be sufficient. Indeed, they may be more costly if they simply defer dropout until a later semester.

Rather than choose specific policies or interventions for evaluation, we look at intermediate measures of student progression that are correlated with graduation rates. We refer

to these intermediate measures as key performance indicators (KPIs). Using intermediate measures should give colleges an early indicator of the likely efficiency consequences of a reform, thereby allowing them to implement a set of interventions aimed at increasing each KPI along the pathway from entry to completion. Specifically, we ask how our economic metrics change assuming that some reforms bring about change in a KPI.

Ideally, policymakers would have information on the effectiveness of a reform, what it costs to implement, and the economic consequences of so doing. Unfortunately, evidence on the costs of implementing specific reforms is lacking. Very few reforms have any reliable costs data: in a thorough and comprehensive review of reforms to improve completion rates, Tinto (2012) includes no discussion of how much these reforms would cost. Therefore, our economic model does not include the costs of implementing any reform but only the economic consequences of doing so. If implementation costs were available, however, these could be easily incorporated into the model. To illustrate the scope and utility of the model, we therefore run the model for these intermediate KPIs. In economic modeling, any results are a function both of how the model is built and the specific parameter values inserted.

3.4.1 Key Performance Indicators

Here, KPIs are specified in relation to a student's initial entry into college, progression through college, and completion of an award. Colleges may choose their own KPIs (or targets for each KPI) based on their own practices. Those used here reflect principles of practice drawn from the literature on organizational effectiveness in community colleges and other sectors (Jenkins & Cho, 2012).

Examples of KPIs that relate to students' initial period in college and how connection to and entry into college may ultimately influence completion rates include the number of students who are recent high school graduates who are placed into remedial education and the number of students who pass college math in their first or second year or college English in their first or second year.

Potential strategies to bring about improvements in these KPIs might include early di-

agnostic testing and remediation in high school, improved high school-college curriculum alignment, more effective college "on-ramps" to help students explore options for college and careers and choose a program area of interest, mainstreaming readier students with supports, and improved integration of basic skills instruction with college-level content.

Examples of KPIs that relate to progress - from entering a program of study to completing about 75 percent of program requirements - include the number of students who persist from year one to year two, who earn 12 or more credits by the end of the first year, and who earn 24 or more credits within two years.

Potential strategies to improve these KPIs include the creation of structured, coherent programs of study aligned with requirements for further education and employment, stepwise guidance for students toward selection of a major, and the requirement that students have an education plan or a prescribed course map. Other more general strategies include enhanced monitoring of student progress and more frequent feedback and support for students.

Finally, two KPIs that relate explicitly to completion of a credential are the number of students who transfer to a four-year institution with an award and the number who obtain an associate degree conditional on already having 30 or more credits after five years in college. Potential strategies to bring about an increase in these two KPIs include alignment of program requirements to ensure transfer students have junior standing in their major and alignment of Career Technical Education (CTE) program requirements to allow for career advancement for graduates. Colleges might also encourage concurrent enrollment with a four-year college, and states could adopt state policy incentives for completing an associate degree prior to transfer, as is the case in Florida.

3.4.2 Simulations to Meet Key Performance Indicator Targets

We used our data from USACC to simulate the economic effects of increasing these key performance indicators relative to the baseline. In these simulations, we chose 20 percent improvements for illustration purposes only. In practice, colleges would choose target KPI improvements based on what they believed is feasible given the strategies they plan to

implement.

The simulations for each KPI worked as follows. First, we "moved" 20 percent more students from the baseline sample of students into the desired category.[16] Second, we calculated the economic consequences of having a different composition of students. Finally, we reported these consequences relative to the baseline. For example, the first progress KPI target is to improve persistence from year one to year two by 20 percent. Thus we randomly removed students from the baseline sample who were not persisting and randomly added more students who were persisting. Keeping the total number of students constant, we made these replacements until the persistence rate was 20 percent higher. This increase changed the college's expenditures because the pathway costs of the removed students differed from the pathway costs of the added students. We then calculated the new completion rates, expenditures, revenue, net revenues, and efficiency consequences. We performed this simulation 1,000 times and took the average of the 1,000 simulations.

We simulated the economic effects on the assumption that these KPIs had been met, i.e., by calculating them based on the new sample created by the simulations. The strategies identified above offer plausible ways that such increases might occur. However, since we did not calculate how much these strategies would cost to implement, it is not appropriate to compare reforms directly. Clearly, costs should be factored into the decision-making process, but they will depend on which strategies are selected.

3.4.3 Model Simulation Results

The results for meeting the KPI targets are shown in Tables 3.2-3.4. For each KPI target, the direction of the results is the same - there are increases in completions, expenditures, and revenues; and, with one exception, efficiency increases. There are, however, variations

[16]This is accomplished by determining the number of students required to improve the desired category by 20 percent, randomly removing this number of students from the opposite category, and replacing them with randomly selected students from the desired category.

in effects with respect to net revenue.[17]

Table 3.2 shows that helping more students pass college math in the first year has a bigger impact on five-year completion rates than helping students complete college English in the first year, even as the latter KPI will affect more students (49 instead of 46). The simulations show that the KPI for English raises completions by 1.9 percent, compared with 2.5 percent for math. Correspondingly, improving English pass rates also leads to much lower gains in efficiency than improving math pass rates (0.8 percent compared with 1.5 percent). For both targets, costs and revenues increase but the effect on net revenue is opposite in sign. A similar pattern is observed if the window for passing college math or English is extended to two years. Improving math pass rates leads to more completions and larger efficiency gains. These targets yield the same net revenue pattern, with increases in passing college math resulting in more spending than increases in passing college English. The final early KPI target is to increase the number of recent high school graduates who start college-ready rather than being placed into developmental education. As shown in Table 3.1, college-ready students have much higher completion rates and are much more efficient. This is reflected in the results in Table 3.2: A 20 percent increase in college-ready students would increase completions by 4.5 percent, and efficiency would improve by 3.6 percent.

Table 3.3 shows the economic consequences of meeting each of the three progress KPI targets. Achieving these benchmarks would be a much more ambitious endeavor than meeting the early KPI targets: The number of completions is much higher (at 8.8 to 12 percent), but expenditures also increase significantly more (6.4 to 12.9 percent). Increasing the persistence rate is extremely expensive - costs for this cohort are predicted to be 12.9 percent higher than baseline. Of course, revenues will increase. Meeting two of these three KPI targets will increase expenditure more than it will increase revenue, resulting in a loss of net revenue. Although completions will rise, efficiency is actually reduced in the case of the persistence KPI target. This surprising result arises because helping students persist from the first to

[17]Net revenue is calibrated to zero at baseline. Therefore comparisons of net revenue reflect the difference between the simulated expenditure and revenue as a proportion of the baseline expenditure.

second year would yield more completions but at a very high cost. Effectively, many more students are persisting, but for a large fraction remaining in college longer simply postpones the point at which they drop out. Despite increasing the completion rate by the largest amount (+12 percent), strategies to improve persistence from the first to the second year by themselves are inefficient in terms of cost per completion.

Table 3.4 shows the results from meeting the two award KPI targets: a 20 percent increase in awards for those with 30 or more credits and a 20 percent increase in students who transfer with an award. Meeting either KPI target would substantially improve the outcomes picture with mixed results on the economic picture. The number of completions would increase by 12.4 percent for awards for those with 30+ credits or by 21.8 percent for those who transfer with an award. The gains in efficiency would also be very high, at 10.4 percent and 13.5 percent, respectively. However, these two targets have very different implications for costs. Reducing the number of "lingerers" would only add 0.7 percent to costs; decreasing the number of students who transfer without a credential would increase costs more significantly (5.3 percent).

As a final illustration of the model, we can simulate results for a given increase in the completion rate. That is, rather than report results based on targeted increases in intermediate KPI measures (e.g., through persistence with outcomes achieved more quickly) we simulate what improvements in KPIs would be necessary to increase completion by a given percentage and then estimate the economic effects.

These simulations are shown in Table 3.5, based on the assumption that the college wishes to increase its completion rates by 10 percent, i.e., from 477 to 521. To accomplish this goal by increasing the first-year math completion rate would require an increase in the number completing first-year math from 412 to 721 students, i.e., a 75 percent increase. College expenditures would increase by 3.4 percent and efficiency would improve by about 5 percent (not including the cost of a strategy to bring about an increase in the math passing rate). Alternatively, the college might seek to attain a 10 percent increase in completion by improving persistence. To do so, an additional 273 students would need to persist, i.e.,

15 percent more students would need to persist from the first to the second year. This increase would raise college expenditures by 9.7 percent and efficiency would fall, in this case by almost 1 percent. Finally, a third alternative is to reduce the number of lingerers (those with 30 or more credits but no award). To increase the completion of lingerers by 10 percent, their number would have to fall from 231 to 196, i.e., by 15 percent. College expenditures would increase, although only by 0.5 percent. The college's efficiency would increase by about 8 percent.

Thus, the economic model is structured so that simulations can be run either forward - from changes over time in first-time student behavior to estimated completion rates - or backward - from desired changes in completion rates to the necessary changes in student behavior. However, it should be emphasized that in all models the cost of bringing about the change is not included; only the cost should a given change occur is included.

3.4.4 Sensitivity Analysis

The simulation strategy employed in the previous section changes the composition of the student body as some students are randomly removed and others are essentially double counted. One potential concern is that although the simulated cost and efficiency changes reflect the underlying KPI change, they also reflect the selection of different types of students. To illustrate this point, consider the progress KPI of earning at least 24 credits within two years of starting college. Table 3.6 presents the racial makeup of these two groups. It is clear that Whites, Asians, and those with unknown race are represented more highly in the group of students that earned at least 24 credits within two years, whereas Black students make up a larger portion of students in the group that has not earned at least 24 credits within two years. Therefore, when the simulation to increase this KPI removes students from the latter group and replaces them with students from the former group, the results is to change the racial makeup of the simulated student body that is used to compute economic metrics. We find a similar phenomenon when looking at race and sex interactions.

In addition, the program mix (student majors) does not remain constant in simulation.

Table 3.7 shows a clear difference in programs between students who persist and those who do not. About 52 percent of persisters are in Liberal Arts programs compared to 26 percent of non-persisters. More non-persisters are undeclared compared to persisters (56 percent vs 22 percent).

To adjust for this selection issue, we alter the simulation so that the sampling performed on the desired student group stratifies by race-sex or by field of study cells. This procedure serves to keep the racial and gender composition or program major of the student body constant during the simulation process so that we, at a minimum, preserve some of the original sample characteristics.[18] Simulation results with stratifed sampling by race and sex are presented in Table 3.8 and by program major in Table 3.9 for all of our KPIs.

Comparing Table 3.8 to the simulation results in Tables 3.2-3.4, we find a slight attenuation in our measures of completions, costs, and cost per completion. The lack of stratification by race and sex in our original models does not seem to have been driving the interpretation of any results. Though this does not rule out other forms of selection, it is encouraging that simulation results are robust to maintaining basic sample characteristics constant. The stratification results for program field, as shown in Table 3.9, generate some changes in simulated net revenue compared to our original simulations - in general net revenue magnitudes are slightly larger when holding the distribution of fields constant. Perhaps the most striking change under this set of simulations is that all KPIs become efficient, even ones like persistence that were not efficient earlier. Although the sensitivity tests do not profoundly change the interpretation of the KPI simulations, they do suggest that there is room to continue improving our model.

[18]Of course, there are other groups that are not held constant during the simulation, such as financial aid receipt, that may also be important to consider. This sensitivity analysis presents results from just two of many different stratification options.

3.5 Conclusions and Research Implications

Despite annual expenditures of approximately $50 billion annually, very little is known about efficiency within the community college sector. Direct economic research evidence is limited and yields technical results that may be hard to interpret and that do not reflect the "production process" of students enrolling in a sequence of courses over time that must be completed to ensure graduation. Institutional research recognizes the importance of student progression (Tinto, 2012), but does not analyze how progression affects resources. Thus, research on higher education to date can provide little guidance on efforts to improve college efficiency.

Our model is intended to address both issues, as well as calculate the fiscal consequences of reforms to improve efficiency. By emphasizing student pathways over time, we are able to calculate the resources required both for students who complete their awards as well as for the large fraction of students who do not complete an award. These pathways are then linked to a parsimonious set of economic metrics – expenditures/revenues, efficiency, and net revenues – that allow for a full economic evaluation of how reforms would affect each college. This approach is considerably different from other production function models.

The model and these metrics are broadly applicable across the spectrum of community colleges; the model is also flexible in that colleges can choose their own definition of output. However, the main advantage of this model-based approach is that it allows us to simulate the effects of actual reform strategies that colleges might adopt to improve completion rates. We can calculate the increase in completion rates relative to baseline when colleges move students to more efficient pathways and thereby increase student progression and completion rates. Then, we can derive the changes across the economic metrics. Critically, this model is not prescriptive: it only provides information on what would happen if such a reform was implemented. The results indicate how much resource is needed to sustain an open-access mission, for example, or how efficiency levels will differ across colleges with difference distributions of student readiness. Important issues such as the implications of a reform with regard to equity or the open-access mandate of community colleges are not part of the model. Consider, for example, if "inefficient" students are counseled or screened out in light of the

model. That type of policy could have deleterious effects for racial and gender subgroups, resulting in outcomes that are antithetical to broader social goals of equality of opportunity and economic mobility. It is vital for institutions and policymakers to consider these types of risks when evaluating strategies for improving efficiency. The model provides a framework for beginning to understand these implications, but it does not capture equality and equity concerns.

Results from simulations using data from the study college highlight several concerns. First, it is quite difficult to increase the college completion rate substantially - many students who fail to complete are far short of meeting program requirements. Second, increasing the completion rate requires sizeable increases in expenditure. Some of this expenditure will be offset by increases in fees. But for colleges with historical public funding formulae or absolute funding constraints, or with pricing policies that involve significant cross-subsidies, improving completion rates for one cohort of students may mean fewer resources for subsequent cohorts (in all likelihood leading to lower completion rates). Third, these first two conclusions imply that efficiency gains may be very hard to achieve - it is hard to increase the completion rate and doing so will typically require more resources. Therefore, although there are efficiency gains from meeting these performance targets, such gains are constricted.

Finally, not all reforms are equal in terms of improving efficiency or balancing expenditures to revenues. Strategies for increasing completion rates have very different implications for costs, revenues, net revenues, and efficiency levels. For the sample college at least, there would be substantial gains in completion rates and efficiency from helping students transfer with an award and from helping students with 30+ credits to graduate. In contrast, simply getting students to persist is both an expensive and inefficient reform. Strictly, these model results only apply to the single college for which we have data. Other colleges, with different baseline completion rates, expenditures, and funding formulas may have different results.[19] With data from additional colleges, it should prove possible to validate these general findings as well as provide specific information for other colleges on the economic consequences of

[19]We have found similar simulation results in one other college.

reforms to raise the completion rate.

Table 3.2: The Economic Consequences of Meeting Early Key Performance Indicator Targets

KPI Target of a 20 Percent Increase in an Outcome	**Improvement Over Baseline**	**Percent Change in Economic Metric**				
		Completions	**Cost**	**Cost per Completion**	**Revenue**	**Net Revenue**
Passing college math in first year	231 pass college math in first year (+20% = 46 more passing)	2.5%	0.9%	-1.5%	0.8%	-0.1%
Passing college English in first year	245 pass college English in first year (+20% = 49 more passing)	1.9%	1.1%	-0.8%	1.1%	0.08%
Passing college math within two years	409 pass college math within two years (+20% = 82 more passing)	5.1%	2.0%	-2.9%	1.8%	-0.1%
Passing college English within two years	468 pass college English within two years (+20%=94 more passing)	3.5%	2.7%	-0.7%	2.8%	0.09%
Recent high school graduates who start college-ready and not in developmental education	121 recent grads start college-ready (+20% = 24 more passing)	4.5%	0.7%	-3.6%	-0.2%	-0.9%

Table 3.3: The Economic Consequences of Meeting Progress Key Performance Indicator Targets

KPI Target of a 20 Percent Increase in an Outcome	**Improvement Over Baseline**	**Percent Change in Economic Metric**				
		Completions	**Cost**	**Cost per Completion**	**Revenue**	**Net Revenue**
Persisting from year one to year two	364 additional students persist	12.0%	12.9%	0.8%	12.2%	-0.7%
Earning 12+ credits (vs. not earning 12+ credits)	234 additional students earn at least 12 credits	8.8%	6.4%	-2.2%	6.6%	0.2%
Earnings 24+ credits (vs. not earning 24+ credits)	185 additional students earn at least 24 credits	10.9%	7.3%	-3.2%	7.1%	-0.2%

Table 3.4: The Economic Consequences of Meeting Award Key Performance Indicator Targets

		Percent Change in Economic Metric				
KPI Target of a 20 Percent Increase in an Outcome	**Improvement Over Baseline**	**Completions**	**Cost**	**Cost per Completion**	**Revenue**	**Net Revenue**
Lingerers (30+ credits with no award after 5 years)	46 lingerers continue on to receive an associate degree	12.4%	0.7%	-10.4%	0.1%	-0.6%
Transferees without credential (from transfer with credential group)	123 more students transfer with credential	21.8%	5.3%	-13.5%	5.8%	0.5%

Table 3.5: The Economic Consequences of Increasing the Completion Rate by 10 Percent

Strategy	Improvement Over Baseline	Percent Change in Economic Metric				
		Completions	**Cost**	**Expenditure per Unit of Output**	**Revenue**	**Net Revenue**
Increase college math pass rate in one year	309 (75%) more students would need to pass math in first year	10%	3.4%	-5.4%	2.9%	-0.6%
Increase persistence from first to second year	273 (15%) more students would need to persist	10%	9.7%	0.6%	9.1%	-0.5%
Decrease lingering	35 (15%) fewer students would need to linger	10%	0.5%	-7.9%	0.0%	-0.4%

Table 3.6: Racial Composition of Students who Did and Did not Earn at Least 24 Credits by Second Year

	Earn $\geq$ 24 Credits	Earn $<$ 24 Credits
White	61%	54%
Black	18%	31%
Asian/Pacific-Islander	4%	2%
Hispanic	5%	4%
Multiple	2%	3%
Unknown	11%	6%
Total	100%	100%

Table 3.7: Fields of Study of Students who Did and Did not Persist from Year 1 to Year 2

	Persisters	Non-persisters
Liberal Arts and Sciences	52%	26%
CTE	12%	7%
Business	5%	4%
Education	2%	2%
Health	4%	2%
Mechanics	4%	3%
Undeclared	22%	56%

Table 3.8: KPI Simulations Results with Stratified Sampling by Race and Sex

	Improvement Over Baseline				
	Completions	Cost	Cost per Completion	Revenue	Net Revenue
Passing college math in first year	2.2%	0.7%	-1.4%	0.7%	0.0%
Passing college English in first year	1.7%	1.0%	-0.6%	1.1%	0.1%
Passing college math within two years	4.5%	1.8%	-2.6%	1.7%	-0.1%
Passing college English within two years	3.2%	2.6%	-0.5%	2.7%	0.1%
Recent high school graduates who start college-ready and not in developmental education	5.1%	0.6%	-4.2%	-0.3%	-0.9%
Persisting from year one to year two	11.3%	12.7%	1.3%	12.0%	-0.7%
Earning 12+ credits (vs. not earning 12+ credits)	8.4%	6.3%	-1.9%	6.5%	0.2%
Earnings 24+ credits (vs. not earning 24+ credits)	10.4%	7.3%	-2.7%	7.1%	-0.2%
Lingerers (30+ credits with no award after 5 years)	21.5%	5.4%	-13.2%	5.8%	0.4%
Transferees without credential (from transfer with credential group)	12.3%	0.8%	-10.3%	0.2%	-0.6%

Table 3.9: KPI Simulations Results with Stratified Sampling by Field of Study

	Improvement Over Baseline				
	Completions	Cost	Cost per Completion	Revenue	Net Revenue
Passing college math in first year	2.5%	0.9%	-1.5%	0.8%	-0.1%
Passing college English in first year	1.9%	1.2%	-0.7%	1.2%	0.0%
Passing college math within two years	5.2%	2.0%	-3.1%	1.8%	-0.2%
Passing college English within two years	4.2%	3.0%	-1.2%	2.9%	-0.1%
Recent high school graduates who start college-ready and not in developmental education	4.2%	1.3%	-2.8%	0.2%	-1.1%
Persisting from year one to year two	13.0%	10.8%	-1.9%	9.9%	-0.9%
Earning 12+ credits (vs. not earning 12+ credits)	10.2%	5.4%	-4.3%	5.7%	0.3%
Earnings 24+ credits (vs. not earning 24+ credits)	13.5%	6.8%	-5.9%	6.8%	0.0%
Lingerers (30+ credits with no award after 5 years)	11.7%	0.6%	-9.9%	0.2%	-0.4%
Transferees without credential (from transfer with credential group)	21.4%	5.1%	-13.4%	5.7%	0.6%

Appendix for Essay 3

Table 3.10: Economic Metric Equations

Completions (Q)	
Equation	$Q = \alpha AA + \beta CS + \delta CL + \rho TR1 + \epsilon TR2 + \gamma TR3 + \lambda Z$
AA	Associate degrees
CS	Certificate $<$ 1 year
CL	Certificate 1+ year
TR1	Transfer with award to 4-year college
TR2	Transfer with no award to 4-year college
TR3	Bachelor's degree at other college
Z	No longer enrolled, no credential, no transfer, still enrolled after five years, certificate at other 2-year college
Expenditures (E)	
Equation	E = DI + II + NI + K
DI	Direct Instructional Expenses Wages of FT and PT faculty in the classroom (including their SS payments)
II	Indirect Instructional Expenses Equipment, materials and other expenses
NI	Non-instructional Expenses Source_1: IPEDS (Instsupp01, Acadsupp01, Studserv01, Opermain01) Source_2: Sample College general ledger (Presidential, Administrative, Instructional, Educational support, Finance/administrative)
K	Capital Expenses
Allocation formulae	Per enrollee, per credit, multiples of DI
Revenues (R)	
Equation	R = F + T + G
F	Fees paid by students
T	Tuition charges per course
G	Government subsidy per student based on state funding formula
Allocation formulae	Per enrollee, per credit

Note: $\alpha = 1.00$, $\lambda = 0.00$, $\beta, \delta, \rho, \epsilon, \gamma$ vary per college.

Table 3.11: Outcomes for USACC: Weights for Outcomes

Outcome	Mean Number of Credits	Outcome Weight
AA degree	80	1.000
AS degree	94	1.172
AAS degree	87	1.086
Certificate $\leq$ 1 yr.	71	0.885
Certificate $<$ 1 yr.	60	0.753
Transfer to 4-year institution without credential	20	0.252
No longer enrolled; no credential no transfer		0.000
Still enrolled at college in Year 5 with 30+ credits		0.000
Certificate or associate (other two-year college)		0.000

Notes: College credits only; not remedial education credits. Weights are based on the average duration to complete the award.

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