Does Developmental Education Improve Labor Market Outcomes? Evidence From Two States

A CAPSEE Working Paper

Michelle Hodara
Education Northwest

Di Xu
Community College Research Center
Teachers College, Columbia University

December 2014

The authors contributed equally to this work. The authors gratefully acknowledge Thomas Bailey, Shanna Smith Jaggars, Clive Belfield, Judith Scott-Clayton, Jonah Rockoff, Jeffrey Wooldridge, Madeline Joy Trimble, Vivian Liu, and Jennifer Hill for their valuable comments and suggestions on this paper. This paper would not have been possible without the partnership of the Virginia and North Carolina community college systems, which provided high-quality data and expert guidance on the state contexts for this research. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305C110011 to Teachers College, Columbia University. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

For information about authors and CAPSEE, visit capseecenter.org

Abstract

Nationally, about two thirds of community college students are referred to developmental education. Thus far, research on the effectiveness of developmental education has focused on students' academic outcomes; in this paper, we examine the economic consequences of developmental education for students. Using longitudinal student-unit record data from two large community college systems linked to wage record data, we estimate the labor market returns to developmental credits versus college-level credits for two cohorts of students who attended community college in North Carolina and Virginia. While both states' implemented new placement exams and developmental education course structures and curricula beginning in 2012, during the time period under study, both states' developmental education programs and policies were fairly traditional and similar to those of other states nationwide.

We find that, in both states, earning developmental reading and writing credits led to an increase in earnings, which is primarily attributed to an increased likelihood of employment. These findings suggest that earning developmental English credits may represent an improvement in academic literacy skills that are valuable in the labor market and improve individuals' employability. In contrast, in both states, developmental math credits had negative impacts on earnings. That is, the opportunity costs associated with developmental math credits, particularly for those assigned to the lowest levels of the developmental math (and thus to the longest course sequences), tended to outweigh the potential labor market value these credits may bring. The negative impact of developmental math coursework on wages provides support for nationwide efforts to shorten the long-sequence structure of developmental mathematics, and to teach math skills that are applicable to students' real-world needs.

Contents

1. Introduction

A community college education can yield substantial labor market benefits to students. In a review of more than 20 studies on the returns to community college, Belfield and Bailey (2011) found that the average gain in earnings from an associate degree was 13 percent for men and 22 percent for women, and that the average gain in earnings from some college-level credits (and no degree) was 9 percent for men and 10 percent for women. While these studies provide important information on the returns to schooling for students who are able to persist through their college career and earn a credential or at least some college credits, they shed little light on the economic returns to a community college education for a large proportion of the student population that these institutions serve: students deemed academically underprepared who start college in developmental education and leave college before earning a credential.

Nationally, about two thirds of community college students are considered academically underprepared for college-level coursework—these students are typically referred to developmental education, which is intended to prepare students for college-level coursework in math and English (Bailey, Jeong, & Cho, 2010). Yet, many of these students drop out before enrolling in any college-level courses (Bailey et al., 2010), and among those who do successfully progress into college-level courses, many do not earn a credential or degree. For example, among recent high school graduates who took at least one developmental course in community college, only one quarter earned a degree within eight years (Attewell, Lavin, Domina, & Levey, 2006). As a result, developmental education may represent the primary form of postsecondary education that many community college students receive.

While numerous studies have explored the impact of developmental education on student outcomes using quasi-experimental strategies[1] (e.g., Bettinger & Long, 2009; Boatman & Long, 2010; Calcagno & Long, 2008; Dadgar, 2012; Hodara, 2012; Martorell & McFarlin, 2011; Scott-Clayton & Rodriguez, 2012; Xu, 2013), almost all such studies exclusively examine the effects of developmental education on college outcomes, such as enrollment in and completion of college English and math, persistence from year to year, and degree completion. Overall, research has found little evidence that developmental education helps improve the college outcomes of students who were considered academically underprepared for college-level coursework when they first enrolled. Given the overwhelmingly negative or null impacts of developmental education on student academic outcomes (Calcagno & Long, 2008; Martorell & McFarlin, 2011; Scott-Clayton & Rodríguez, 2012), there has been an increasing national push to reform these programs.

However, developmental education may provide other benefits without necessarily improving academic outcomes. For example, the literacy and numeracy skills imparted in these courses may improve students' abilities to function as employees and therefore improve their

[1] See Bailey, Jaggars, and Scott-Clayton (2013) for a detailed explanation of the quasi-experimental methodology these studies use.

labor market options and performance (McCabe, 2000). Given the large proportion of students taking developmental courses at community colleges across the country, policymakers, taxpayers, and students themselves would benefit from knowing whether or not developmental education yields any labor market benefits to students and how such benefits compare with the benefits of college-level credits. Additionally, given that a substantial proportion of community colleges students drop out early from college after taking a small number of courses, the question of how developmental education labor market outcomes compare with college-level labor market outcomes is particularly important to policymakers who are considering how to maximize the labor market benefits of higher education to these students. Yet, since most existing studies of labor market returns to postsecondary education focus on returns to college credentials or college-level credits only, we do not know the economic value of developmental education credits or the extent to which the economic returns to developmental education are comparable to the returns to college-level credits.

Using longitudinal student-unit record data from the North Carolina and Virginia community college systems linked to wage data before and after college enrollment, we fill this research gap by estimating the labor market returns to developmental math and English (i.e., reading and/or writing) credits in terms of their impact on wages and employment, and compare those labor market returns with the returns to college-level credits. Both state systems have recently undergone substantial reforms to their developmental education sequences; the time period under study in this paper occurred prior to those reforms, when both states's developmental education systems were quite similar to those of other states nationwide (see Hodara, Jaggars, & Karp, 2012).

The longitudinal data structure allows us to use an individual fixed effects model, a method that has been commonly used in the job-training literature (e.g., Dyke, Heinrich, Mueser, Troske, & Jeon, 2006; Jacobson, LaLonde, & Sullivan, 2005). Specifically, we first examine each student's quarterly earnings growth over time and then compare the size of this growth across students who obtained different amount of credits through various categories of courses.[2] The major advantage of an individual fixed effects model over traditional Mincerian models[3] in estimating returns to various types of credits lies in the ability to control for any unobserved individual characteristics that remain constant over time.

Overall, we find that, in each state, earning developmental reading and writing credits increases wages due to an increased likelihood of employment, though we find no direct impact on wages conditional on employment. Labor market benefits to developmental English are even higher in some cases than the benefits to college-level credits, indicating that for students who lack literacy skills, language skills gained in developmental English courses may have a strong impact on their probability of employment in the labor market. Yet, the literacy skills imparted in

[2] See Jacobson et al. (2005) for a detailed explanation of applying an individual fixed effects model to estimating the economic returns to credits.
[3] Mincerian models estimate earnings at a given time as a function of prior education, prior work experience, and other individual characteristics (Mincer, 1974).

developmental English courses do not seem to directly improve student earnings among those who are already employed, which may provide additional motivation for colleges to improve the quality of their developmental English programs.

In contrast to the results for developmental English, we find a consistent negative impact of developmental math on wages. The negative impact is particularly strong for students placed in the lowest levels of math, who must complete a long sequence of developmental math courses (in some cases, three or even four courses) before they are allowed to take college-level math or other college-level courses with math prerequisites. This finding provides support to the growing view that current conventional developmental math course curricula may fail to impart the kinds of skills and knowledge students need to be successful in the labor market, and that a long sequence of developmental education courses imposes considerable opportunity costs on students that may outweigh its benefits, thus leading to negative impacts on individual earnings.

The possibility that taking developmental courses may impose opportunity costs on students and therefore result in zero or even negative returns is further supported by the attenuated returns to developmental English and negative returns to developmental math credits for students who placed into college English and college math but nonetheless took developmental courses. These results provide further support for improving the accuracy of developmental course placement.

In the following section, we introduce a framework for understanding the labor market impacts of developmental education and review relevant prior studies. We then describe the data, research context, and sample. Next, we describe our methodology. Then, we present our results and conclude with a discussion of the findings and their implications for policy.

2. Conceptual Framework and Relevant Literature

An Initial Framework for Understanding the Labor Market Impacts of Developmental Education

An educational intervention can impact students through multiple mechanisms, some of which may be unintended. Scott-Clayton and Rodríguez (2012) proposed three potential mechanisms through which developmental education courses influence students' college outcomes in positive and negative ways: developing students' academic skills, diverting students away from college courses, and discouraging student persistence and progression.

We apply a similar conceptual framework to our study and propose three mechanisms through which developmental education courses can influence labor market outcomes. Developmental education may influence labor market outcomes through: (1) *positive skill development* that improves college performance and that benefits students in the labor market;

(2) *opportunity costs* that may negatively influence students' wages through both foregone earnings and the inhibiting of students' ability to accumulate work experience; and (3) a heterogeneous mix of positive skill development and "negative" opportunity costs for different types of students, which might lead to *heterogeneous effects* of developmental education by student characteristics. Below, we describe each mechanism and summarize relevant research.

Positive Skill Development

All college students face direct costs from tuition and fees and opportunity costs from forgone earnings and work experience because of their time away from the labor market. But a large set of studies from the field of economics has shown that college is worth this investment of time and resources (e.g., see reviews of the literature by Ashenfelter, Harmon, & Oosterbeek, 2000; Card, 1999). A college education can improve one's skills (Monks, 2000; Rumberger & Tomas, 1993; Weisbrod & Karpoff, 1968), and college degrees signal a certain level of skills and ability, improving employability and allowing for career advancement (Weiss, 1995). Skill development and/or positive signaling of skill development result in gains in earnings over an individual's lifetime. College degrees are also connected to many other positive outcomes, including higher levels of civic participation, healthier lifestyles, greater job satisfaction, and economic, educational, and health benefits that are passed down to one's children (Baum, Ma, & Payea, 2010).

Similarly, developmental education may be worth the investment of time and resources if it effectively develops students' skills. Developmental education courses may help underprepared students develop strong math and English skills as well as learning strategies and other non-academic skills that prepare students for the demands of college-level coursework (Boylan, 2001). These skills also have the potential to benefit students in the labor market. For example, quantitative literacy skills, such as arithmetic and algebraic applications taught in developmental mathematics, have a strongly predictive relationship with a young adult's probability of employment (Rivera-Batiz, 1992). In addition, English proficiency and strong communication skills have long been tied to a greater likelihood of employment and increased wages for immigrant populations (Chiswick & Miller, 2007). Therefore, if developmental education successfully imparts skills that are desirable in the labor market, the knowledge and skills gained in developmental education courses should have a positive impact on students' earnings and probability of employment, regardless of whether they earn a credential or not.

On the other hand, students may benefit little from developmental courses if the skills imparted in these courses are of little value for subsequent learning in college-level courses and in the labor market. Prior research suggests three reasons why students who take developmental coursework may not benefit from positive skill development. The first is related to instruction. One of the most in-depth qualitative studies of developmental education examined classroom instruction in 169 developmental education classes at 29 community colleges in California (Grubb, 2013). Researchers found a prevalence of "remedial pedagogy." They described this instructional approach in the following way:

> This approach emphasizes drill and practice (e.g., a worksheet of similar problems) on small subskills that most students have been taught many times before. … Moreover, these subskills are taught in decontextualized ways that fail to clarify for students the reasons for or the importance of learning these subskills. (Grubb, 2013, p. 52)

Remedial pedagogy does not include the types of tasks students are expected to complete in college courses, and it is not directly connected to the content, skills, or knowledge needed in any particular field of study. Developmental education courses characterized by remedial pedagogy may fail to impart the kinds of skills and knowledge students need to be successful in college coursework, and they may have little value in the labor market if students do not gain useful skills and knowledge that can be applied or transferred to real-world situations and work environments.

Second, since developmental education courses educate students with lower academic preparedness, on average, peer effects may offset positive instructional effects if having peers with lower academic preparedness has a negative impact on individual motivation and learning outcomes (Martorell & McFarlin, 2011). Third, remediation might also trigger a "stereotype threat" (Steel & Aaronson, 1995) by stigmatizing students, which could negatively influence individual motivation and learning. These negative psychological factors that prevent positive skill development may be most prevalent among students who are misplaced. For example, in the Scott-Clayton and Rodríguez (2012) model, developmental assignment may serve as a message to students that they are not "college material" (p. 6) and may gradually diminish students' degree aspirations, particularly as they encounter additional academic obstacles. Although Scott-Clayton and Rodríguez found limited evidence of developmental education's discouragement effect overall, the negative discouragement effect was significant and large for 19 percent of students. These students, who were placed in developmental reading but not developmental writing, were potentially *underplaced*—that is, students who could have succeeded in college-level English but were inaccurately placed in developmental reading. Misplacement into developmental education may be particularly discouraging and stigmatizing, thus preventing any positive skill development from developmental coursework and leading to poor progression into college-level courses and to early dropout. Considering that underplacement is fairly common when test scores are used as the sole determinant of student assignment to developmental education (Belfield & Crosta, 2012; Scott Clayton, 2012), the overall impact of developmental courses on either student academic or labor market outcomes may be dragged down by particularly large and negative effects of underplacement on academically prepared students who are nonetheless referred to remediation.

"Negative" Opportunity Costs

As noted, individuals attending college either exit the labor market or work less, and so are faced with opportunity costs from forgone earnings and work experience. The opportunity costs due to developmental education may outweigh its positive benefits (we thus refer to these as "negative" opportunity costs for brevity's sake). We describe two reasons why developmental education may incur opportunity costs.

First, compared with direct enrollment in college-level coursework, enrollment in developmental education may negatively influence student labor market outcomes by "crowding out attainment of academic credits" (Martorell & McFarlin, 2011) if the returns to college-level credits substantially outweigh those to developmental credits. Specifically, many community college students drop out from college early for a number of reasons, including family and work responsibilities. Since many college courses have prerequisite requirements, students assigned to a developmental sequence cannot enroll in many college-level courses until they complete their developmental requirements. As a result, among the large proportion of early dropouts, developmental education students spend their limited time in college in developmental coursework, while "college-ready" students spend their limited time in college in college-level coursework (Scott-Clayton & Rodriguez, 2012); both groups accrue credits that may be valued differently in the labor market.

Second, the traditional developmental sequence structure increases the chance that students incur negative opportunity costs. As we explain in more detail in the next section, traditional developmental math, reading, and writing programs typically consist of a set of multiple courses that students must enroll in sequentially. As a result, students at the lowest levels are often required to complete two or more semesters of developmental coursework in the corresponding subject area. The length and complexity of the developmental sequence increases the opportunity costs of schooling, in that students need to spend extra time and resources on developmental education instead of in the labor market gaining wages and working experience.

Heterogeneous Effects

So far our conceptual framework deals only with the average effects of developmental credits on student labor market outcomes. However, it is unreasonable to assume that the impacts of developmental education are homogeneous across all students. In particular, there are at least two mechanisms that may lead to heterogeneous impacts of developmental credits on student outcomes. First, students vary in their academic preparedness and therefore may benefit differently from developmental courses. While an English developmental course may indeed help "develop" student language skills for those who have limited English proficiency, it may add little value and only impose additional cost to students who are already proficient in English.

Second, the impacts of developmental training may also vary by its intensity, where a longer sequence of developmental course requirements may be more likely to incur unintended negative effects due to the increased economic and academic burden on students. Indeed, several studies focusing on student academic outcomes have found heterogeneous impacts of developmental education based on level of placement (Boatman & Long 2010; Dadgar, 2012; Hodara, 2012; Scott-Clayton & Rodriguez, 2012; Xu, 2013). For example, while a large body of research has found there to be no difference in outcomes among students who start in developmental education versus college-level coursework *on average* (Calcagno & Long, 2008; Martorell & McFarlin, 2011; Scott-Clayton & Rodriguez, 2012), both Dadgar (2012) and Xu (2013) found that students assigned to the lowest level of developmental sequence are subject to worse academic outcomes than similar students assigned to the level above the lowest level. Both authors argued that the economic and academic burden imposed by a long sequence of developmental education courses may outweigh any potential benefits. For example, in a three-course sequence, students have to complete three semesters of non–college-credit bearing coursework before progressing into college coursework, a delay that may impose heavier opportunity costs and increase the likelihood that students will leave college before entering college-level, credit-bearing courses.

Prior Research on the Labor Market Benefits of Developmental Education

Given the widespread prevalence and the importance of the developmental education function, there is surprisingly little evidence on its impacts on student labor market outcomes. While a series of studies has explored returns to community college credits overall and found a positive earnings premium (see Belfield & Bailey, 2011, for a review of these studies), these studies either did not distinguish between different types of courses or did not specifically identify developmental education (i.e., remedial) credits. Examples of the latter case are two studies (Grubb, 1993; Kane & Rouse, 1995) that used the National Student Longitudinal Survey on the high school graduating class of 1972 (NLS-72) to estimate the returns to "academic" or "college" credits and "vocational" credits. NLS-72 collected complete college transcripts from survey respondents that included remedial courses and grades (Adelman, 1995). But neither study (Grubb, 1993; Kane & Rouse, 1995) mentioned remedial credits or described how they treated them, so it is unclear whether they were included in the college/academic or vocational categories or excluded from both categories.

Another eight studies used data that did not include course transcript information; these studies estimated the labor market returns to additional years of community college without earning a credential. For example, four of these studies (Averett & Dalessandro, 2001; Gill & Leigh, 2000; Leigh & Gill, 1997; Surette, 2001) used the National Student Longitudinal Survey of Youth on the high school graduating class of 1979 (NLSY-79). NLSY-79 includes self-reported degree attainment data, allowing researchers to identify students who attended community college without earning a degree. It is likely that this sample includes a large proportion of students who took developmental education, given that the majority of community college students begin in developmental education and are identified by the college as regularly enrolled students, even if they have not yet entered college-level coursework. Yet, even if the sample included developmental education students, we do not know whether returns differed between developmental and college-level credits.

Focusing on displaced workers in Washington State, Jacobson et al. (2005) differentiated among different types of community college credits and explicitly mentioned basic skills coursework. Specifically, courses were divided into "quantitative or technically oriented vocational courses" and "non-quantitative courses." The latter group included non-vocational college courses and "basic skills education" courses. Jacobson et al. (2005) found that credits from "quantitative or technically oriented vocational courses" increased quarterly earnings by $15.72 for men and $17.13 for women, while credits from "non-quantitative courses" had no impact on earnings. However, it is difficult to infer what this result means regarding the returns to developmental credits, since the authors grouped college courses and basic skills education courses together.

The most relevant evidence on labor market returns to developmental education so far comes from one study in Texas (Martorell & McFarlin, 2011) that estimated the effect of developmental education on both student academic and labor market outcomes. Using a regression discontinuity approach that compared students just above and below test score cutoffs for remediation, Martorell and McFarlin found little evidence that the students who scored close to the remediation placement cutoff benefited from remediation, either in terms of academic outcomes or labor market earnings.

Martorell and McFarlin's (2011) study makes an important initial step toward understanding the labor market benefits of developmental education. However, due to the empirical design,[4] the analytical sample was restricted to a small proportion of students around the test score cutoff, which substantially limits the generalizability of the findings. In addition, the study did not differentiate between different developmental subject areas when exploring labor market outcomes, but instead focused on whether a student was in remediation for any subject. As a result, the "no effects" finding may simply be an average between negative and positive impacts on labor market returns of different developmental education subjects on students around the cutoff. Finally, the study explored returns to developmental education overall rather than to cumulative credits, and the results therefore cannot be directly compared to the labor market benefits of college-level credits.

The current study builds on previous studies and seeks to fill a gap in both the literature on the effects of developmental education and the returns to a community college education. It does so by examining the impact of developmental credits on labor market outcomes and how it compares to the impact of college-level credits. Furthermore, this paper provides the first evidence on the heterogeneous impacts of developmental education on labor market outcomes (due to data constraints, this section of the paper focuses on Virginia only).

[4] See Bailey, Jaggars, and Scott-Clayton (2013) for a detailed explanation of the regression discontinuity design.

3. Study Background

Data and Research Context

The central question posed in this study is whether developmental education improves individual labor market outcomes. We answer this question with data from two different states to explore whether there are consistent patterns of wage returns to developmental education across states with distinct labor market conditions. Specifically, we use restricted-use datasets from the Virginia Community College System (VCCS) and the North Carolina Community College System (NCCCS); both are linked to quarterly wages from unemployment insurance (UI) wage record data.[5] Both datasets also have National Student Clearinghouse (NSC) data, so degree attainment is based on receipt of credentials (i.e., short- and long-term certificates) and degrees at any college in the United States that reports to the NSC. About 96 percent of postsecondary institutions in the United States report to the NSC (National Student Clearinghouse, n.d.).

Both states' community college systems comprise a mix of large and small colleges, as well as institutions located in rural, suburban, and urban settings. However, the North Carolina system is much larger, and thus the North Carolina study sample is larger. NCCCS has 58 community colleges and is the third largest community college system in the United States. According to the Integrated Postsecondary Education Data System (IPEDS), fall 2012 total enrollment at the North Carolina community colleges was 244,815 students. VCCS has 23 community colleges. According to IPEDS, total fall 2012 enrollment at these 23 colleges was 192,895 students.

Both states systems are centralized, so the colleges in both states use a fairly standardized set of policies to assess incoming students' level of college readiness and then place them into the appropriate coursework (Hodara et al., 2012). Both systems have undergone substantial reform to their developmental education sequences beginning first in Virginia in 2012. The time period of this study occurred prior to the redesign of the assessment and placement process for incoming students and developmental education math and English course structures and curricula. During the time period of this study, both states still used fairly traditional developmental education sequences similar to those of other states nationwide. Specifically, during the time period of our study, North Carolina offered four levels of developmental math and three levels of developmental reading and writing; Virginia offered three levels of developmental math and two levels of reading and writing.

Developmental courses tend to cover similar general topics (Grubb, 2013). In North Carolina, the two lowest level math courses (Basic Math Skills and Essential Mathematics) covered arithmetic, solving basic computations, geometry, and some introductory elements of

[5] While the NCCCS dataset includes wage record data from only the state of North Carolina, the VCCS dataset includes wage record data from five states (Virginia, Maryland, New Jersey, Ohio, Pennsylvania, and West Virginia) and the District of Columbia (Washington, DC).

algebra and statistics. The next course, Introductory Algebra, taught beginning algebra concepts, and the highest level course, Intermediate Algebra, prepared students for college-level algebra. Similarly, in Virginia, the lowest level of developmental math covered arithmetic, the middle level introductory algebra, and the highest level covered intermediate algebra and prepared students for college algebra. In North Carolina, for the developmental writing and developmental reading courses, the lowest level courses taught basic writing and reading skills, such as constructing complete sentences and building vocabulary. The middle level courses focused on writing a coherent essay and identifying main ideas. The highest level courses prepared students for college English, focusing on reading college-level texts and writing a college-level essay. Similarly, in Virginia, the lowest level reading and writing courses also covered basic writing and reading skills, while the highest level reading and writing courses developed competencies in reading and writing necessary to succeed in college English.

In both systems, developmental education courses served as prerequisites to college math and English, as well as other college courses. As a result, in math, for example, students at the lowest levels needed to complete three or four semesters of developmental coursework before they could enroll in college math and courses that had math prerequisites. In English, students at the lowest levels needed to complete two or three semesters of developmental reading and two or three semesters of developmental writing before they could enroll in college English and courses that had English prerequisites.

Sample

The sample in Virginia includes first-time students who entered one of the 23 Virginia community colleges in the summer or fall of 2006; we track the transcript and employment records of these students from 2005 to 2013, where we have at least one year of pre-enrollment wage records, and transcript and wage records for seven years since college entry. Using a similar tracking window, the sample in North Carolina includes students who entered NCCCS colleges in summer or fall 2003. These students were tracked from 2002 to 2010, also with at least one year of pre-college wage records and seven years of transcript and wage information since college enrollment.[6]

We limit the sample as follows. We exclude from the sample individuals who earned more than $100,000 in a quarter since these are extreme outliers representing less than 0.1 percent of the sample in both states. We also exclude individuals who have zero wages across all quarters because these individuals did not seem to enter the labor market at all; again, this group

[6] Datasets from VCCS and NCCCS track students over different time periods: VCCS tracked student transcript and employment records from 2005 to 2013, while NCCS tracked student transcript and employment records from 1996 to 2010. To allow for more reliable estimates using an individual fixed effects model, we need both pre-college and post-college wage records as well as the longest tracking time available from college enrollment. Therefore, we chose the 2006 cohort in Virginia, which allowed for the longest tracking time (i.e., seven years from college enrollment), and the 2003 cohort in North Carolina, which allowed for the same tracking period as the Virginia cohort.

represents a relatively small proportion of the total sample. Finally, given that most individuals are not active in labor market below 18 or above 65 years of age, we impose age restrictions and drop quarters in which an individual was younger than 18 or older than 65 years.[7]

All wages are adjusted to 2010 dollars to account for inflation. To link the course transcript data (which contain records for three semesters per year) with wage record data (which contain records for four quarters per year), we create three wage quarters by averaging first and second quarter wages. The average of first and second quarter wages are linked to the spring transcript records, third quarter wages are linked to the summer semester, and fourth quarter wages are linked to the fall semester.

Table 1 provides characteristics of the study sample in each state, compared with the characteristics of a nationally representative sample of community college students. The North Carolina and Virginia samples are similar in that slightly over two-thirds of students are White and that both samples have a larger proportion of Black community college students and a smaller proportion of Hispanic community college students compared with the national sample. The North Carolina sample is older than both the national sample and Virginia sample, and the Virginia sample is younger than the national average. Finally, the largest difference across the samples is developmental education enrollment. Nearly 70 percent of the national 2003 cohort took at least one developmental education course, compared with 57 percent of the Virginia 2006 cohort and only 40 percent of the North Carolina 2003 cohort.

We also present selected outcomes for North Carolina and Virginia community college students who took developmental education (Table 2) to illustrate two main points. First, students who took at least one developmental education course in both community college systems tended to have very low degree attainment. Therefore, the vast literature on returns to college credentials does not provide much insight into the benefits of a community college education for these students, the majority of whom earned a fair number of credits on average (42 total credits, 3 developmental math credits, and 3 developmental English credits) but did not earn a credential. Second, despite the fact that few students who took developmental education earned degrees, on average, students' quarterly wages increased after college. This study will fill a gap in knowledge by identifying whether different types of credits are tied to improvements in community college students' labor market outcomes.

[7] In a robustness check, we keep all quarters in, and the results are not qualitatively different from those presented in the study.

Table 1. Characteristics of Study Sample Compared With Nationally Representative Sample of Community College Students

	National Sample	North Carolina Community Colleges	Virginia Community Colleges
Sample size	7,095	87,835	21,796
College entry term	fall 2003	fall 2003	fall 2006
Gender			
Female	57%	58%	55%
Male	43%	42%	45%
Race/ethnicity			
Black	14%	26%	21%
Hispanic	16%	3%	6%
White	61%	65%	64%
Other	9%	5%	9%
Age upon entry			
Average age (in years)	24	26	22
19 or younger	56%	44%	54%
20–23	17%	15%	26%
24–29	9%	13%	9%
30 or older	18%	28%	11%
Developmental education enrollment			
Took any developmental education	68%	40%	57%
Took developmental math	60%	33%	46%
Took developmental reading/writing	17%	23%	34%

Note. Data based on author calculations using the U.S. Department of Education, National Center for Education Statistics, BPS: 2009 Beginning Postsecondary Students study using the NCES QuickStats tool. BPS:2009 contains student-level data on a nationally representative sample of students who enrolled in college for the first time in 2003/04, tracked to 2009. We report data on students who started in a public, two-year college only. Sample size is approximate since BPS:2009 reports approximate sample sizes.

Table 2. Outcomes of Students in Study Sample Who Took Developmental Education

	North Carolina Community Colleges, 2003 Cohort	Virginia Community Colleges, 2006 Cohort
N	35,134	12,423
Average credits earned		
Total credits earned	42	42
Developmental English credits	3	3
Developmental math credits	3	3
Degree attainment		
Short-term certificate	3%	2%
Long-term certificate	5%	3%
Associate degree	15%	16%
Bachelor's degree or higher	7%	10%
Average quarterly wages		
Before community college	$1,804	$1,512
During community college	$2,601	$1,542
After community college	$3,366	$1,928

4. Methodology

Individual Fixed Effects Model

The major challenge in exploring the economic returns to college is that some unobserved individual characteristics, such as motivation and ability, may influence both educational outcomes and individual earnings (Ashenfelter et al., 2000; Card, 1999, 2001). We might be concerned, for example, that the same students who are able to complete more credits or earn a credential are likely to have some positive qualities that also benefit them in the labor market. To address potential problems of omitted variable bias, we take advantage of the panel data structure, which includes multiple wage observations for each student before, during, and after college enrollment, and employ an individual fixed effects model. This approach has been commonly used in the job-training literature (Dyke et al., 2006; Jacobson et al., 2005) and has been recently adapted by several researchers to examine returns to schooling (e.g., Cellini & Chaudhary, 2012; Dadgar & Weiss, 2012; Jepsen, Troske, & Coomes, 2011). The major advantage of an individual fixed effects model over a traditional Mincerian model in estimating returns to credits is the ability to control for any unobserved individual characteristics that are constant over time.

Equation (1) presents the basic model that we use to examine returns to community college credits:

$$Y_{it} = \alpha_i + \beta_1 \text{Total Credits}_{it} + \beta_2 \text{Technical Credits}_{it} + \beta_3 \text{Developmental English Credits}_{it} + \beta_4 \text{Developmental Math Credits}_{it} + \beta_5 \text{Awards}_{it} + \beta_5 \text{CreditsAttempted}_{it} + \beta_5 \text{OtherCollege}_{it} + A_{it} + \mu_{it} \quad (1)$$

where Y_{it} represents an individual i's quarterly earnings at time t, which depends on observed and unobserved student-specific fixed effects α_i.

Our primary variables of interest are credits accumulated prior to each quarter (i.e., coefficient estimates β_1, β_2, β_3, and β_4). Due to potential variation in the returns to different types of credits, we divide credits into college-level credits and developmental credits. We further divide college-level credits into academic credits (e.g., humanities, science, social science, etc.) or technical credits (e.g., nursing, manufacturing, protective services, etc.).[8] We classify developmental credits by subject area: developmental math credits versus developmental reading and writing credits (which we combine into a single category of developmental English credits).

Total Credits_{it} is the total number of credits individual i completed prior to quarter t. Therefore, we compare students who completed the same number of credits but who varied in their mix of credit types. Since the model controls for three specific types of credits (technical credits, developmental English credits, and developmental math credits), β_1 is interpreted as the change in earnings associated with a one-credit increase that does not belong to any of these three categories—that is, to college-level credits in an academic field.[9] β_2, β_3, and β_4 are interpreted as the additional change in earnings associated with a one-credit increase in the corresponding category of credits respectively. As a result, $\beta_1 + \beta_2$ represents the increase in quarterly earnings for each one-credit increase in college-level credits in a technical field, $\beta_1 + \beta_3$ represents the increase for each one-credit increase in developmental English, and $\beta_1 + \beta_4$ represents the increase for each one-credit increase in developmental math.

---

[8] We divide college-level credits into technical and academic categories based on the Classification of Instructional Program (CIP) course codes and a taxonomy to categorize CIP codes from Jenkins and Cho (2012). CIP codes that fall under the following three categories from Jenkins and Cho (2012) are considered academic credits: (1) arts, humanities, and English, (2) mathematics and science, and (3) social and behavioral sciences. CIP codes that fall under all other categories outlined in Jenkins and Cho (2012) are considered technical credits. VCCS provided HEGIS codes rather than CIP codes in the transcript, and we use the following crosswalk to convert CIP codes into HEGIS codes and distinguish academic and technical credits: http://nces.ed.gov/pubs2002/cip2000/crosswalkHG90.asp

[9] Some credits, such as credits from recreational education and college success courses, do not fall under any of these four categories. Yet, they only represent a very small proportion of credits in both states (in VCCS, only 7 percent of the students had ever earned any such credits, which represent less than 1 percent of the total credits earned; in NCCCS, only 13 percent of the students had ever earned any such credits, which represent around 2 percent of the total credits earned). In a robustness check, we exclude these credits from the model and the results remain the same as those presented in the tables.

Using college-level academic credits as the base group has the advantage of enabling direct comparisons between the labor market benefits of developmental credits versus traditional college-level credits and therefore can help examine the extent of the "crowding out" effects: Does developmental education incur negative impacts on student labor market outcomes if developmental requirements crowd out attainment of academic credits?

Considering that credentials can signal employers about an individual's productivity and therefore may have economic value in addition to the accumulated human capital inherent in the associated bundle of credits (Bahr, 2014; Weiss, 1995), we also control for receipt of credentials and degrees at any college in the United States. The vector award (Award_{it}) indicates the type of award(s) a student has attained by the beginning of a given quarter and contains four dichotomous variables: bachelor's degree, associate degree, long-term certificate, and short-term certificate. These different awards are not mutually exclusive; therefore, a student may have multiple awards by the beginning of a quarter.

We include two variables to account for the opportunity cost (in terms of forgone earnings) associated with college attendance. The first variable is $\text{CreditsAttempted}_{it,}$ which is the total number of credits enrolled in at NCCCS or VCCS during the current quarter. The second variable, OtherCollege_{it}, indicates whether the student is enrolled in any college outside of the community college system in that quarter. We use NSC enrollment data to create this variable. Finally, we include a dichotomous variable for "Ashenfelter's dip."[10] Specifically, we are concerned that a negative income shock prior to college enrollment may influence both college enrollment and earnings patterns. We adjust for this possibility by including indicators for two quarters prior to community college entry represented by A_{it} in the model.

In a second model, we include a series of quarter-specific fixed-effects (γ_t) in order to capture any trends in earnings over time and any seasonal or economic shocks in a particular quarter (Wooldridge, 2002).

$$\begin{aligned}\text{Y}_{it} &= \alpha_i + \beta_1\text{Total Credits}_{it} + \beta_2\text{Technical Credits}_{it} + \\ &\beta_3\text{Developmental English Credits}_{it} + \beta_4\text{Developmental Math Credits}_{it} + \\ &\beta_5\text{Awards}_{it} + \beta_5\text{CreditsAttempted}_{it} + \beta_5\text{OtherCollege}_{it} + A_{it} + \gamma_t + \mu_{it}\end{aligned} \quad (2)$$

Differentiating Returns Over Time

So far, our model only provides an overall estimate of how earnings change in proportion to accumulated credits on average, which does not allow the impacts of credits to depend on whether the student is still in college. Yet, as mentioned previously, schooling may lead to some foregone earnings. This is referred to as a "lock-in" effect in job-training literature (Andersson, Holzer, Lane, Rosenblum, & Smith, 2013; van Ours, 2004), meaning that participation in

[10] Ashenfelter's dip was originally identified by Ashenfelter (1978) and refers to the pattern that the average earnings of participants in job training programs are subject to a decline in a short period of time prior to program participation. This pattern is mainly due to the fact that individuals are more likely to consider work training opportunities soon after they lose their jobs.

training may inhibit students' ability to work to their full wage potential. Although we partly address this problem by controlling for the total number of credits attempted and whether a student is enrolled in colleges out of the community college systems during the current quarter, students may still experience negative, short-run returns to credentials earned and/or credits accumulated before leaving college. For example, some students may not take any courses during the summer, but may still be subject to foregone earnings by working part-time or working in a temporary position that does not fully capture their human capital.

In addition, researchers have also identified a reverse Ashenfelter's dip immediately after students leave college, in which students' earnings tend to be lower than they eventually become in the long term (Jacobson et al., 2005). Since our primary interest is in the effect of developmental education on student earnings in the long run, it is important to capture these temporal patterns in schooling effects. Specifically, in our third model, we build on the econometric model used by Jacobson and colleagues (2005) to differentiate between returns to credits in college and post-enrollment and returns to credits in the short-term and long-term by adding a term that takes into account returns to credits during different time periods in a student's life. We interact this term with each of the four credit variables from equation (1) (i.e., total credits, technical credits, developmental English credits, and developmental math credits). In addition, we interact each of the four credit variables from equation (1) with an indicator of whether or not the student is enrolled in college in the term or not. An example of these interactions with the total credit variable is below:

$$\beta_1 \text{ Total Credits}_{it} + \beta_2 (\text{Total Credits}_{it} * \text{Beforecollexit}_{it}) + \beta_3 (\text{Total Credits}_{it} * (\frac{1}{t-leave_i})) \qquad (3)$$

where $(\frac{1}{t-leave_i}) = 0$ before college exit and the dichotomous variable leave_i is equal to the quarter immediately following college exit.

In model (3), the long-run effects of various types of community college credits are given by the parameter β_1, while the two interaction terms capture in-college β_2 and short-run deviations from the long-run effects β_3. The dichotomous variable $\text{Beforecollexit}_{it}$ is equal to 1 when students are enrolled in college. This variable is interacted with different types of cumulative credits to capture the in-college derivations from the returns to credits in the long run. The term $(\frac{1}{t-leave_i})$ is equal to 1 in the quarter immediately after a student leaves college, and converges to zero with the passage of time. The interaction between different types of cumulative credits and $(\frac{1}{t-leave_i})$ captures short-run deviations in the returns to credits in the period immediately after a student leaves college from the returns over the long-run. Thus, for each type of credit, the coefficients on the main term (β_1) measure the impact when both interaction terms are equal to or converge toward zero (i.e., $\text{Beforecollexit}_{it} = 0$ and $(\frac{1}{t-leave_i})$ converges to zero), which would be the long-run effect of different types of credits. As previously stated, the two interaction terms capture in-college and short-run deviations from the long-run effects, respectively. This specification allows for the possibility that the returns to credits may be smaller or even negative while students are enrolled or immediately leave college, while the labor market benefits may accumulate over time before leveling off in the long-run.

Validity of the Individual Fixed Effects Approach

Our research design is intended to identify the effects of earning developmental education credits on student earnings over time. While an individual fixed effects approach can effectively address any student characteristics that are constant over time, the validity of the estimates is based on the assumption that the wage growth trend will be the same among individuals in the absence of any educational training. In other words, the individual fixed effects model will effectively address a situation where a student has a constant advantage in wage earnings over time, but will be problematic if students who earn more credits, especially more credits through developmental education courses, inherently follow a different wage growth trajectory than students who earn fewer credits or different types of credits.

Although we cannot directly rule out this possibility, we can explore the extent of this problem by comparing the pre-college wage trajectories of students with different amounts of developmental credits. This is the time when students had not been exposed to college training, and therefore, substantial between-student differences in their wage trajectories imply that the changes of wages may be different even in the absence of any college coursework. Therefore, in Appendix A, we divide students into four groups based on the total number of developmental course credits they eventually earned and present figures that illustrate the pre-enrollment wage trajectories of these four groups.

In both states, despite a small constant wage gap favoring students who did not earn any developmental credits, the four groups generally shared similar wage trajectories prior to college entry. This finding provides important support to the validity of our design, since if students with different amounts of developmental credits generally had similar wage trajectories prior to college enrollment, it would be more plausible to attribute changes in their wage trajectories to the college coursework.

Additionally, building on Jacobson’s model (Jacobson et al., 2005), in a robustness check we include individual-specific time trends in addition to fixed effects in model (3). This not only addresses any unobserved individual characteristics that are constant over time (e.g., gender, race), but also effectively controls for any unobserved individual factors that are changing at a constant rate over time (e.g., age, working experiences). Allowing for this richer form of individual-specific heterogeneity in the wage growth rate further addresses selection bias in estimating returns to credits.

Examining the Mechanism Underlying Impact on Wages

In our main models, the outcome is quarterly wages, and quarters with no reported UI earnings are assigned values of zero earnings. However, in addition to understanding the overall effects of credits on earnings, we are also interested in understanding what is driving the overall impact, since schooling could influence earnings through at least two distinct ways: by influencing an individual's probability of employment, and by increasing or decreasing wages conditional on employment. Identifying the mechanism underlying the impact of different types of community college credits on wages is critical to having a meaningful understanding of the results and using them to inform policy and practice. In particular, evidence that earning developmental education credits increases wages for individuals who are employed would suggest that, regardless of progression into college-level coursework or credential attainment, the developmental program indeed has a positive impact on increasing an individual's efficiency or productivity in the labor market. On the other hand, the impacts of developmental education on employment would be particularly impactful for individuals who are unemployed.

Therefore, for our full model (model specification 3) that differentiates between returns over time, we separately estimate two outcomes. The first identifies the impact of community college credits on the probability of employment. The employment outcome is a dichotomous variable, and individuals receive a 1 in quarters where wages are greater than zero, and a 0 in quarters where wages are zero or missing.[11] The second identifies the impact of community college credits on earnings among those who are employed during that quarter. We use the same wage outcome as the main model, but now wages are set to missing in quarters when they are 0.

Virginia-Specific Analysis of Heterogeneity by Placement Level

Finally, we conduct an additional analysis to examine potential heterogeneity in the impacts of developmental courses by placement level. This may be informative to several policy-relevant questions about developmental education. First, given the growing concern that a considerable proportion of prepared students may be underplaced in developmental education, exploring the impacts of developmental credits on college-ready students can help answer whether misplacement does indeed incur negative impacts on labor market outcomes for students who should not have been assigned to a developmental sequence. In addition, considering the increasingly popular trend of shortening developmental sequences, examining the potential variation in labor market outcomes among students who were assigned to different levels of developmental education can add another perspective to this ongoing debate.

The VCCS data include the reading, writing, and math placement test scores that students earned when they took the college placement exams. Based on students' score performance on the placement tests, colleges placed students in either college-level courses or in

[11] For the dichotomous variable "whether a student is employed," we use both linear probability and logistic regression to estimate the model, and the results follow the same pattern. Therefore, we present the results from the linear probability model for easier interpretation.

different levels of developmental education (with differing course sequence lengths) for both English and math. We use this information to determine students' developmental placement levels in English and math respectively.[12] Then, we conduct an additional analysis to further explore whether the impacts of developmental education on labor market outcomes varied by developmental placement level for English and math. We conduct this analysis for the Virginia sample only because North Carolina data do not include placement scores.

5. Results

Overall Returns to Developmental Education Credits

Table 3 presents returns to earning one additional credit from different categories of courses respectively. The panel on the left presents average returns based on the most basic model (equation 1), while the panel in the middle presents average returns from the model that controls for quarter fixed effects (equation 2). As noted in the methodology section, since we control for total number of any credits in each model, the coefficient of "total any credits" captures the returns to college-level academic credits, while the returns to other types of credits are captured by adding the coefficient of "total any credits" to the coefficient of a particular type of credit.

In general, returns to all types of credits were positive, except for developmental math courses. Specifically, based on the basic model (panel on the left), every college-level credit earned in an academic field led to an average quarterly wage increase of $14 in North Carolina and $8 in Virginia. College-level credits earned in a technical field led to significantly higher returns in both states, but in a much more pronounced way in Virginia, where each technical credit led to an increase in quarterly wages of $32 ($8 + $24), which is double the average returns to credits earned in an academic field.

Returns to credits earned in developmental English were also substantially higher than returns to college-level academic credit in both states. For each developmental English credit earned, students' wages increased by about $34 ($14 + $20) in North Carolina and $26 ($18 + $8) in Virginia per quarter. By multiplying returns to a credit by three, we can illustrate returns to a typical three-credit course. A three-credit developmental English course increased quarterly wages by $102 in North Carolina and $78 in Virginia.

[12] According to VCCS, the majority of colleges rely on the writing test scores to decide students' developmental writing and reading level. Therefore, we use writing placement test scores to determine students' English placement level.

Table 3. Quarterly Returns to Different Types of Credits

Credit Type (see explanation in text)	Basic Model		Basic Model—Accounts for Economic Shocks		Long-Run Returns	
	NC	**VA**	**NC**	**VA**	**NC**	**VA**
Total credits	\$14***	\$8***	\$4***	\$11	\$4***	\$12***
College technical	\$2***	\$24***	\$4***	\$22***	\$14***	\$18***
Developmental English	\$20***	\$18***	\$18***	–\$1	\$17***	–\$7*
Developmental math	–\$23***	–\$24***	–\$25***	–\$33***	–\$22***	–\$66***
R-squared	0.62	0.54	0.62	0.55	0.62	0.55
Number of students	87,835	21,796	87,835	21,796	87,835	21,796

Note. See Table A.1 in the Appendix for basic model regression results, and Table A.2 for regression results for long-run returns. All coefficient estimates are rounded to nearest ones place.

*** $p < .01$, ** $p < .05$, * $p < .1$

In contrast, for every developmental math credit earned, students' wages decreased by \$9 (\$14 – \$23) in North Carolina per quarter and \$16 (\$8 – \$24) in Virginia. Therefore, each three-credit developmental math course a student completed amounted to a quarterly loss in earnings of \$27 in North Carolina and \$48 in Virginia.

The panel in the middle further controls for quarter fixed effects to account for wage increase over time as well as wage fluctuation due to seasonal shocks. For example, one important seasonal shock for the North Carolina cohort after they left college and for the Virginia cohort just when they started college was the Great Recession from 2007 to 2009. As expected, the returns to each type of credit become smaller after quarter fixed effects are added, and the returns are no longer significant for either college-level credits in an academic field or developmental English credits in Virginia. Yet, returns to schooling may be temporarily depressed while students are still enrolled in college and in the quarters immediately after credential receipt or exiting college. As a result, overall returns to credits may mask substantial in-college and short-term deviations from the returns in the long run. Therefore, in the next section, we present the long-term effects of credits based on model (3), which also controls for quarter fixed effects but further differentiates returns over time.[13]

The Long-Term Impact of Developmental Credits on Labor Market Outcomes

In general, returns to credits while students are still in college or immediately after enrollment are negative or not statistically significant (see Table A.2 in the Appendix). As a result, the long-run returns to credits (shown in the right panel in Table 3) are generally larger than the overall returns averaged across time (the middle panel) except for developmental math credits, where the negative returns seem to increase over time. Specifically, a developmental English credit increased quarterly wages by about $5 ($12 – $7), and a developmental math credit decreased quarterly wages by about $54 ($12 – $66) in Virginia. That is equivalent to an increase in wages of about $15 for a three-credit developmental English course and a decrease in wages of $162 for a three-credit developmental math course. In North Carolina, long-run returns were also larger for college academic and technical credits but similar for developmental credits: A developmental English credit increased quarterly wages by about $21 ($4 + $17), and a developmental math credit decreased quarterly wages by about $18 ($4 – $22), which is equivalent to $63 per quarter for each developmental English course and –$54 per quarter for each developmental math course. The patterns of results remain similar even after we add individual-specific time trends in addition to fixed effects as a robustness check.[14]

These results illustrate that the benefits of earning college academic, college technical, and developmental English credits on an individual's labor market earnings grew (Virginia) or were sustained (North Carolina) seven years from college entry. Similarly, the negative impact of developmental math on wages grew in Virginia and stayed fairly similar in North Carolina. As we discuss in more detail below in the section on "Returns Based on Course Placement Level," the negative, long-run impact of developmental math credits on wages suggests that the time required to complete developmental math course sequences not only directly results in forgone earnings but may also negatively influence students' long-run earnings.

Mechanisms Underlying Impact on Wages

A college education can impact individual earnings through either increasing the likelihood of employment or increasing earnings for those who are already employed. Table 4 presents the long-run separate impact of different credits on the probability of employment and on earnings conditional on employment, respectively.

In each state, while college-level credits led to significant gains in both outcomes, it seems that the positive returns to developmental English credits were almost entirely driven by

[13] We only present the long-term returns to different types of credits in Table 3 for easier interpretation and comparison with results from the other two model specifications; the full results from model 3 are available in Appendix Table A.2.
[14] Results from this robustness check are not presented here to save space, but are available upon request.

the extensive margin (i.e., by increasing the probability of employment). Yet, the effect size of developmental English credits on student employment in the long run were noticeably larger than that of either type of college-level credits in both North Carolina and Virginia. Specifically, earning a college academic credit increased the probability of employment by one tenth of a percentage point per quarter; earning a college technical credit doubled the effect to one fifth of a percentage point; and earning a developmental English credit more than doubled the effect again, to more than half of a percentage point per quarter in both states. For a three-credit developmental English course, this is equivalent to increasing the probability of employment by 1.8 percentage points per quarter. In contrast, developmental math credits seem to have either null or negative impacts on both the probability of employment and earnings conditional on employment.

Table 4. Long-Term Effects of Credits Earned on Probability of Employment and on Wages Conditional on Employment

	North Carolina, 2003 Cohort (N = 87,835)		Virginia, 2006 Cohort (N = 21,796)	
Credit type	**Probability of Employment**	**Quarterly Wages if Employed**	**Probability of Employment**	**Quarterly Wages if Employed**
Total credits	0.001***	$2**	0.001***	$15***
College technical	0.001***	$10***	0.001***	$18***
Developmental English	0.005***	$2	0.005***	–$36***
Developmental math	–0.001	–$36***	–0.003***	–$122***
R-squared	0.70	0.39	0.71	0.37
Number of students	87,835	87,835	21,796	21,796

Note. See Table A.2 in the Appendix for full regression results. All coefficient estimates are rounded to nearest ones place.

*** $p < .01$, ** $p < .05$, * $p < .1$

These results suggest that the main labor market benefit of developmental English is increasing an individual's probability of employment in the labor market rather than career advancement or promotion among those who are already employed. Yet, for students whose poor academic literacy and English proficiency skills may act as a strong impediment to finding a job, the language skills imparted in these courses seem to substantially improve their chance of employment, with an effect size that even outweighs that of college-level courses.

Returns Based on Course Placement Level

Finally, we explore the potential heterogeneous effects of developmental education on student labor market performance by developmental placement level. As shown in Table 5, there are substantial variations in the impacts on both earnings and employment for students assigned to different developmental levels.

Table 5. Long-Term Effects of Credits Earned on Different Outcomes for Virginia Students by Their Course Placement Level in Math and Writing, 2006 Cohort

	Quarterly Wages	Probability of Employment	Quarterly Wages if Employed
Total credits	$4	0.002	–$48**
Returns to developmental English credits by writing course placement level			
College level	–$9	0.002	–$48**
Highest level	$22***	0.006***	$12
Lowest level	$0	0.005***	–$30***
Returns to developmental math credits by math course placement level			
College level	–$113***	–0.009*	$2
Highest level	$20*	0.007***	–$77***
Middle level	–$31***	–0.002*	–$91***
Lowest level	–$117***	–0.004**	–$200***

Note. See Appendix Table A.3 for more detailed results. All coefficient estimates are rounded to nearest ones place.

*** $p < .01$, ** $p < .05$, * $p < 0.1$

In general, for both English and math, the largest returns are observed among students just one level below college-ready (i.e., the highest level). For English, the returns to a developmental English credit for students assigned to the highest level of developmental writing was $26 ($4 + $22); for math, the returns were also significantly positive, at $24 ($4 + $20), both of which are noticeably larger than the labor market benefits of college-level credits in an academic field ($4). Yet, consistent with the overall pattern of results illustrated in Table 4, such positive impacts were mainly driven by the impact of developmental coursework on increasing the probability of employment, while returns to wages conditional on employment were negative or statistically insignificant. These results suggest that developmental coursework is most beneficial to students who place one level below college-level coursework through a substantially increased probability of employment.

Alternatively, the economic returns to developmental education for students assigned to lower levels were less positive or more negative: For English, the returns to a developmental English credit for students assigned to the lowest level of developmental writing were no different from the returns to a college academic course (i.e., $4); for math, the returns were consistently negative, and the magnitude of such negative effects became larger the lower the course placement level in math.

There are at least two potential explanations for the negative impacts of developmental math on students assigned to the middle and lowest levels. First, compared to the highest level course, the content of the middle and lowest level courses that these students were required to take may have had little value in the labor market. To explore this possibility, we separately examine the returns to developmental math credits earned in different developmental math courses for the particular group of students assigned to the two lowest levels of developmental math (71,204 wage records for 2,333 students). Results indicate that there were no substantial differences in returns to credits earned from the highest developmental math courses and from the middle and lowest level courses ($p = 0.43$). In other words, credits from the middle and lowest level courses did not have less value in the labor market than credits from the highest level course.

The other possibility is simply that, even if the math content had value in the labor market, the opportunity costs associated with taking multiple developmental math courses substantially outweighed any positive skill development. Therefore, opportunity costs were largest for students who placed in the lowest level course.

The possibility that taking developmental courses may impose opportunity costs on students and may therefore result in zero or even negative returns is further supported by the attenuated returns to developmental English and negative returns to developmental math credits for students who placed in college English and college math. About 15 percent of students in Virginia were assigned to college-level English but took developmental English, and 13 percent of students were assigned to college-level math but took developmental math. There are two potential reasons why students may end up taking developmental education even though they scored at or above the "college-ready" cutoff score on the placement test. First, the placement level variable may not accurately reflect the placement level for all students since the placement variable is based on system-level policies, and some colleges have their own standards for placement. Some colleges may have slightly higher standards, so students deemed college-ready by the system may have actually been assigned to developmental education at their college. Second, students may have been advised or simply chose to take developmental education even though they scored at or above the "college-ready" cutoff score on the placement test. In either case, our results highlight the labor market impacts of earning developmental credits on students who were deemed academically prepared by the system standards but who took developmental courses for idiosyncratic reasons.

Overall, we identify substantial heterogeneity in returns to developmental credits by placement level. Specifically, the returns to a developmental English credit for students who placed in college English was –\$5 (\$4 – \$9) while the returns to a developmental math credit for students who placed in college math was –\$109 (\$4 − \$113). These results suggest that for students who are considered academically prepared, the opportunity costs associated with taking developmental courses far outweigh their potential benefit, leading to negative returns to developmental credits. This finding also further supports a discouragement effect for students who are potentially misplaced into developmental education.

6. Conclusion

Our study addresses a major gap in the scholarly research by adding to the limited evidence on the returns to developmental education. Our findings are consistent across North Carolina and Virginia. For the 2003 community college entrants in North Carolina and 2006 community college entrants in Virginia, we find evidence of positive skill development from earning developmental English credits, which improved individuals' probability of employment. Results from Virginia, however, illustrate heterogeneity in the returns to developmental English credits based on students' placement level: the positive impact of earning developmental English on the likelihood of employment was limited to students placed at the highest level. In terms of the effects of developmental math credits, for the same cohorts in North Carolina and Virginia, we find evidence that opportunity costs from earning developmental math credits outweighed any benefits, resulting in decreased wages over the long term and decreased the probability of employment.

Implications of English Results

In both Virginia and North Carolina, community college students' earnings increased due to earning developmental English credits. This increase was many times larger than returns to college-level credits, suggesting that developmental English may be worth students' time and resources even if they do not progress into college coursework. In both states, however, this increase was entirely driven by a positive impact on the likelihood of employment, not on quarterly wages. In other words, developmental English courses, particularly for students assigned to the highest level, represents a benefit for individuals whose language skills posed a great impediment to securing a job, but the credits did not lead to increases in wages through career advancement or promotion.

Current English acceleration reforms that have been in place across all Virginia community colleges since spring 2013 and all North Carolina community colleges since fall 2014 may further enhance the benefits of developmental English on students' labor market outcomes that we found in this study. In both states, the developmental redesign involved combining reading and writing sequences into a single, shorter developmental English sequence, aligning the developmental English curriculum to college-level English, and allowing students who place into the highest developmental course to take college English and developmental English concurrently. Similar models in other states have had a positive impact on students' likelihood of completing college English and college credit accumulation (Jaggars, Hodara, Cho, & Xu, in press), and thus may lead to improvements in wages as well. Future studies should explore the impact of the new developmental English programs in Virginia and North Carolina on individuals' wages, employment, and wages conditional on employment.

Implications of Math Results

In contrast, we find negative impacts of developmental math on both the likelihood of employment and quarterly wages. In both states, developmental math sequences were longer than reading and writing sequences, and in Virginia, while the majority of developmental English students were assigned to the highest level of reading and/or writing, the majority of developmental math students were assigned to the middle level. This suggests that students assigned to developmental math had to complete more semesters of developmental education before they reached college-level coursework than students assigned to only developmental reading and/or writing courses. The negative impacts of developmental math credits on labor market outcomes provide further motivation for many of the developmental math reforms taking place across the country. In particular, changes to sequence length and curriculum may address two mechanisms underlying the negative impact of developmental math on labor market outcomes.

First, the negative results may be driven by opportunity costs that outweigh any positive skill development. In other words, the time required to complete developmental math credits and progress into college-level math and other courses with college-math prerequisites both increases foregone earnings and negatively influences long-run earnings by preventing students from accumulating work experience. Math acceleration reforms that have been in place at all Virginia community colleges since spring 2012 and all North Carolina community colleges since fall 2013 are intended to decrease the time it takes for students to complete their developmental math requirements and thus reduce the opportunity costs of taking developmental math.

A second reason for the negative impact of developmental math on labor market outcomes may be a lack of positive skill development. In particular, the algebra-based content of the developmental math courses, at least during the time period of this study, may not have been tied to the quantitative literacy skills required in the labor market. A curricular math reform that is growing in popularity replaces the traditional algebra-based developmental math curriculum with a statistics-based developmental math sequence designed for liberal arts students. These new statistics-based pathways focus on teaching mathematics content that can be applied to solve everyday problems, content that may be more closely aligned with the skills liberal arts students need to be successful in their degree programs and the labor market (Cullinane & Treisman, 2010; Merseth, 2011). The new pathways also seek to promote the development of non-academic skills such as time management, motivation, and self-efficacy.

Implications of Heterogeneity

Our results regarding the heterogeneous impact of earning developmental math and English credits based on what developmental level (and thus what length of sequence) students were placed in provide further support for improving the accuracy of course placement. Recent research suggests that inaccurate course placement is quite pervasive, and that more students are underplaced (placed in developmental education when they could have succeeded in college-level courses) than overplaced (placed in college-level courses when they needed developmental education) (Belfield & Crosta, 2012; Scott Clayton, 2012). College staff may be less likely to recognize the problem and pervasiveness of underplacement because students who were underplaced may be doing quite well in their developmental courses (Jaggars & Hodara, 2011). Yet, underplacement may have serious consequences for students' longer term outcomes by discouraging their college progression (Scott-Clayton & Rodriguez, 2012) and, as our results suggest, harming students' labor market outcomes. Specifically, we find that returns from earning both developmental math and English credits were lower and often negative among students placed in lower levels of developmental education. This finding underscores the importance of placing students in the *highest* level of coursework in which they are predicted to succeed, so as to improve college success as well as labor market outcomes. Further, we find that students considered academically prepared who instead enrolled in developmental education were subject to negative returns to developmental credits, suggesting that the opportunity costs of taking developmental courses outweigh any benefits among students who are underplaced.

Overall, our results suggest that the impact of credits on labor market outcomes depends on a balance of positive skill development and "negative" opportunity costs. All education bears opportunity costs, but developmental education is particularly costly because the courses do not count toward a degree program. By shortening the developmental education sequence, acceleration reforms are working to minimize the opportunity costs associated with spending time and resources in courses that do not count toward a degree program. However, developmental education of some kind is also a necessary function of open-access institutions who educate all students who apply. Therefore, to increase the benefit of developmental coursework through positive skill development, postsecondary institutions must attend to curriculum and instruction. Some recent acceleration reforms incorporate curricular and instructional improvements by aligning curriculum to the skills and knowledge needed in college coursework and by enhancing instructional rigor (Edgecombe, Cormier, Bickerstaff, & Barragan, 2013). Our study suggests that developmental education has the potential to have a positive impact on labor market outcomes by increasing positive skill development and minimizing the associated opportunity costs.

References

Adelman, C. (1995). *The new college course map and transcript files: Changes in course-taking and achievement, 1972-1993. Based on the Postsecondary Records from Two National Longitudinal Studies* (NCES 19958001). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Andersson, F., Holzer, H. J., Lane, J. I., Rosenblum, D., & Smith, J. (2013). *Does federally-funded job training work? Nonexperimental estimates of WIA training impacts using longitudinal data on workers and firms* (NBER Working Paper No. 19446). Cambridge, MA: National Bureau of Economic Research.

Ashenfelter, O. (1978). Estimating the effect of training programs on earnings. *Review of Economics and Statistics*, *60*(1), 47–50.

Ashenfelter, O., Harmon C., & Oosterbeek, H. (2000). *A review of estimates of the schooling/earnings relationship, with tests for publication bias* (NBER Working Paper No. 7457). Cambridge, MA: National Bureau of Economic Research.

Attewell, P., Lavin, D. E., Domina, T., & Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education*, *77*(5), 886–924.

Averett, S., & Dalessandro, S. (2001). Racial and gender differences in the returns to 2-year and 4-year degrees. *Education Economics*, *9*(3), 281–292.

Bailey, T., Jeong, D. W., & Cho, S.-W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review*, *29*(2), 255–270.

Bailey, T., Jaggars, S. S., & Scott-Clayton, J. (2013). Characterizing the effectiveness of developmental education: A response to recent criticism. *Journal of Developmental Education*, *36*(3), 18–25.

Bahr, P. R. (2014). *The labor market return in earnings to community college credits and credentials in California.* Ann Arbor, MI: University of Michigan, Center for the Study of Higher and Postsecondary Education, School of Education.

Baum, S., Ma, J., & Payea, K. (2010). *Education pays: The benefits of higher education for individuals and society* (Trends in Higher Education Series). Retrieved from College Board website: http://trends.collegeboard.org/downloads/Education_Pays_2010.pdf

Belfield, C. R., & Bailey, T. (2011) The benefits of attending community college: A review of the evidence. *Community College Review*, *39*(1), 46–48.

Belfield, C. R., & Crosta P. M. (2012). *Predicting success in college: The importance of placement tests and high school transcripts* (CCRC Working Paper No. 42). New York, NY: Columbia University, Teachers College, Community College Research Center.

Bettinger, E., & Long, B. T. (2009). Addressing the needs of underprepared students in higher education: Does college remediation work? *Journal of Human Resources*, *44*(3), 736–771.

Boatman, A., & Long, B. T. (2010). *Does remediation work for all students? How the effects of postsecondary remedial and developmental courses vary by level of academic preparation* (An NCPR Working Paper). New York, NY: National Center for Postsecondary Research.

Boylan, H. R. (2001). Making the case for developmental education. *Research in Developmental Education*, *12*(2), 1–4.

Calcagno, J. C., & Long, B. T. (2008). *The impact of postsecondary remediation using a regression discontinuity approach: Addressing endogenous sorting and noncompliance* (NBER Working Paper No. 14194). Cambridge, MA: National Bureau of Economic Research.

Card, D. (1999). The causal effect of education on earnings. In O. Ashenfelter & D. Card (Eds.), *Handbook of labor economics* (Vol. 3A, pp. 1801–1863). Amsterdam, The Netherlands: Elsevier.

Card, D. (2001). Estimating the return to schooling: Progress on some persistent econometric problems. *Econometrica*, *69*(5), 1127–1160.

Cellini, S. R., & Chaudhary, L. (2012). *The labor market returns to a for-profit college education* (NBER Working Paper No. 18343). Cambridge, MA: National Bureau of Economic Research.

Chiswick, B. R., & Miller, P. W. (2007). *The economics of language: International analyses*. New York, NY: Routledge.

Cullinane, J., & Treisman, P. U. (2010). *Improving developmental mathematics education in community colleges: A prospectus and early progress reports on the Statway Initiative.* Paper presented at the NCPR Developmental Education Conference, New York, NY.

Dadgar, M. (2012). *Essays on the economics of community college students' academic and labor market success* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses. (Accession Order No. 3506175)

Dadgar, M., & Weiss, M. J. (2012). *Labor market returns to sub-baccalaureate credentials: How much does a community college degree or certificate pay?* (CCRC Working Paper No. 45). New York, NY: Community College Research Center, Teachers College, Columbia University.

Dyke, A., Heinrich, C. J., Mueser, P.R., Troske, K. R., & Jeon, K. S. (2006). The effects of welfare-to-work program activities on labor market outcomes. *Journal of Labor Economics*, *24*(3), 567-607.

Edgecombe, N., Cormier, M. S., Bickerstaff, S., & Barragan, M. (2013). *Strengthening developmental education reforms: Evidence on implementation efforts from the Scaling Innovation project* (CCRC Working Paper No. 61). Retrieved from Community College Research Center website: http://ccrc.tc.columbia.edu/publications/strengthening-developmental-education-reforms.html

Gill, A. M., & Leigh, D. E. (2000). Community college enrollment, college major, and the gender wage gap. *Industrial and Labor Relations Review*¸ *54*(1), 163–181.

Grubb, W. N. (1993). The varied economic returns to postsecondary education: New evidence from the class of 1972. *Journal of Human Resources*, *28*(2), 365–382.

Grubb, W. N. (with Gabriner, R.). (2013). *Basic skills education in community colleges: Inside and outside of classrooms.* New York, NY: Routledge.

Hodara, M. (2012). *Language minority students at community college: How do developmental education and English as a second language affect their educational outcomes?* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Accession Order No. 3505981)

Hodara, M., Jaggars, S. S., & Karp, M. M. (2012). *Improving developmental education assessment and placement: Lessons from community colleges across the country* (CCRC Working Paper No. 51). New York, NY: Columbia University, Teachers College, Community College Research Center.

Jacobson, L., LaLonde, R., & Sullivan, D.G. (2005). Estimating the returns to community college schooling for displaced workers. *Journal of Econometrics*, *125*, 271–304.

Jaggars, S. S., & Hodara, M. (2011). *The opposing forces that shape developmental education: assessment, placement, and progression at CUNY community colleges* (CCRC Working Paper No. 36). New York, NY: Columbia University, Teachers College, Community College Research Center.

Jaggars, S. S., Hodara, M., Cho, S.-W., & Xu, D. (in press). Three accelerated developmental education programs: Features, student outcomes, and implications. *Community College Review*. Retrieved from http://crw.sagepub.com/content/early/2014/09/29/0091552114551752.full.pdf+html

Jenkins, D., & Cho, S.-W. (2012). *Get with the program: Accelerating community college students' entry into and completion of programs of study* (CCRC Working Paper No. 32, Rev. ed.). Retrieved from CCRC website: http://ccrc.tc.columbia.edu/publications/get-with-the-program.html

Jepsen, C., Troske, K., & Coomes, P. (2012). *The labor-market returns to community college degrees, diplomas, and certificates* (IZA Discussion Paper No. 6902). Bonn, Germany: Institute for the Study of Labor.

Kane, T. J., & Rouse, C. E. (1995). Labor-market returns to two- and four-year college. *American Economic Review*, *85*(3), 600–614.

Leigh, D. E., & Gill, A. M. (1997). Labor market returns to community colleges: Evidence for returning adults. *Journal of Human Resources*, *32*(2), 334–353.

Martorell, P., & McFarlin, I. (2011). Help or hindrance? The effects of college remediation on academic and labor market outcomes. *The Review of Economics & Statistics*, *93*(2), 436–454.

McCabe, R. H. (2000). *No one to waste: A report to public decision-makers and community college leaders*. Washington, DC: Community College Press.

Merseth, K. K. (2011). Update: Report on innovations in developmental mathematics—moving mathematical graveyards. *Journal of Developmental Education*, *34*(3), 32–39.

Mincer, J. (1974). *Schooling, experience, and earnings.* New York, NY: Columbia University Press.

Monks, J. (2000). The returns to individual and college characteristics: Evidence from the National Longitudinal Survey of Youth. *Economics of Education Review*, *19*(3), 279–289.

National Student Clearinghouse. (n.d.). NSC enrollment coverage: School profiles. Retrieved from http://nscresearchcenter.org/wp-content/uploads/NSC_COVERAGE.xlsx

Rivera-Batiz, F. L. (1992). Quantitative literacy and the likelihood of employment among young adults in the United States. *Journal of Human Resources*, *27*(2), 313–328.

Rumberger, R. W., & Thomas, S. L. (1993). The economic returns to college major, quality and performance: A multilevel analysis of recent graduates. *Economics of Education Review*, *12*(1), 1–19.

Scott-Clayton, J. (2012). *Do high-stakes placement exams predict college success?* (CCRC Working Paper No. 41). New York, NY: Columbia University, Teachers College, Community College Research Center.

Scott-Clayton, J., & Rodríguez, O. (2012). *Development, discouragement, or diversion? New evidence on the effects of college remediation* (NBER Working Paper. No. 18328). Cambridge, MA: National Bureau of Economic Research.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test-performance ofAfrican-Americans. *Journal of Personality and Social Psychology, 69*(5), 797–811.

Surette, B. J. (2001). Transfer from two-year to four-year college: An analysis of gender differences. *Economics of Education Review, 20*, 151–163.

van Ours, J. C. (2004). The locking-in effect of subsidized jobs. *Journal of Comparative Economics*, *32*(1), 37–52.

Weiss, A. (1995). Human capital vs. signalling explanations of wages. *Journal of Economic Perspectives*, *9*(4), 133–154.

Weisbrod, B. A., & Karpoff, P. (1968). Monetary returns to college education, student ability, and college quality. *The Review of Economics and Statistics*, *50*(4), 491–497.

Wooldridge, J. (2002). *Econometric analysis of cross section and panel data*. Cambridge, MA: MIT Press.

Xu, D. (2013). *Three essays on the impact of cost-saving strategies on student outcomes* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses database. (UMI No. 3561734).

Appendix: Full Results

Figure A.1. Wage Trajectories of Virginia Students by Number of Developmental Credits Earned (0, 3, 6, and More Than 6), 2006 Cohort

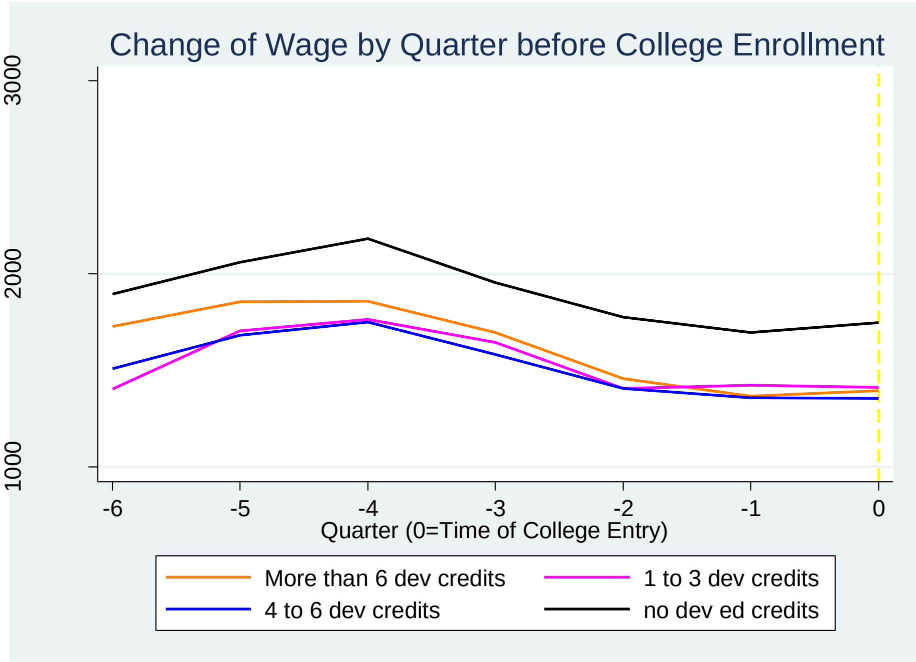

Figure A.2 Wage Trajectories of North Carolina Students by Number of Developmental Credits Earned (0, 3, 6, and More Than 6), 2003 Cohort

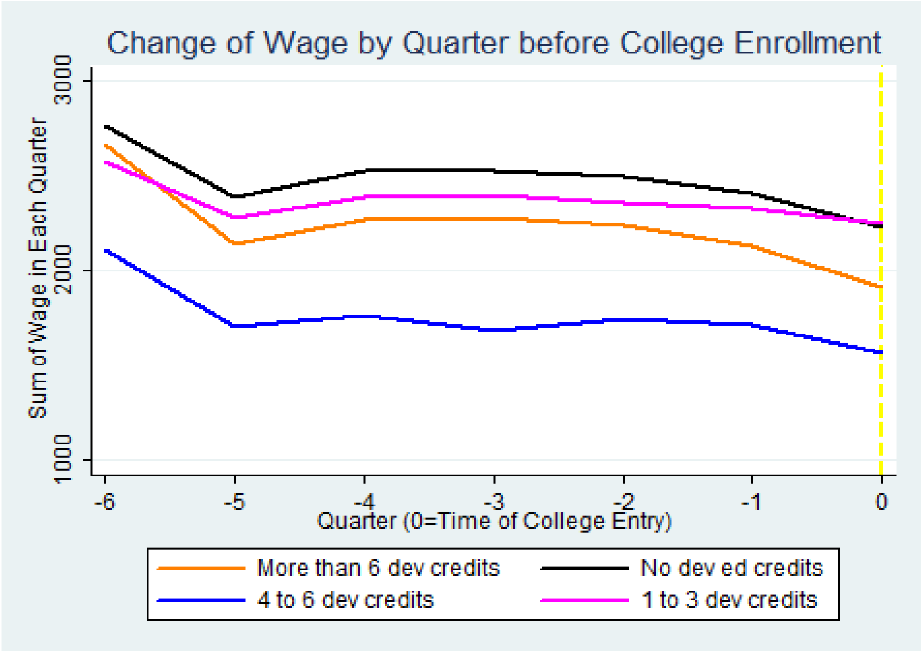

Table A.1. Individual Fixed Effects Results

	Basic Model		Add Quarter Fixed Effects	
	NC	VA	NC	VA
Total cumulative credits per quarter	13.65***	8.08***	3.89***	0.11
	(0.31)	(0.40)	(0.33)	(0.43)
Cumulative technical credits per quarter	1.62***	23.78***	3.80***	21.50***
	(0.49)	(0.69)	(0.49)	(0.69)
Cumulative developmental English credits per quarter	19.66***	17.50***	18.37***	–1.24
	(1.65)	(2.63)	(1.65)	(2.66)
Cumulative developmental math credits per quarter	–23.14***	–23.91***	–25.43***	–33.23***
	(2.17)	(2.64)	(2.17)	(2.63)
Credits attempted per quarter	–75.61***	–46.28***	–62.66***	–47.39
	(0.57)	(0.90)	(0.64)	(1.06)
Enrolled outside community college system in quarter	–667.30***	–941.36***	–502.00***	–951.22***
	(4.95)	(13.79)	(5.55)	(13.82)
Earned short-term certificate	219.00***	–141.50***	63.21***	–193.06***
	(22.76)	(37.83)	(22.70)	(37.68)
Earned long-term certificate	1,171.00***	–52.33*	1,141.00***	–41.84
	(31.97)	(30.55)	(31.80)	(30.52)
Earned associate degree	1,227.00***	210.48***	1,274.00***	325.97
	(18.41)	(18.98)	(18.44)	(19.24)
Earned bachelor’s degree	2,698.00***	1102.34***	2,505.00***	829.69
	(20.33)	(21.65)	(20.54)	(22.12)
Ashenfelter’s dip	–344.20***	–517.44***	–118.20***	–36.74
	(7.97)	(15.67)	(14.44)	(41.62)
Quarter fixed effects			X	X
R-squared	0.62	0.54	0.62	0.55
Number of students	87,835	21,796	87,835	21,796
Number of observations (students × quarters)	2,206,229	657,078	2,206,229	657,078

Note. Table presents coefficient estimates from equations (1) and (2) in paper. Robust standard errors are in parentheses.

*** $p < .01$, ** $p < .05$, * $p < 0.1$

Table A.2. Individual Fixed Effects Results, Full Model for All Outcomes

	Quarterly Wages		Wages if Employed		Probability of Employment	
	NC	VA	NC	VA	NC	VA
Total cumulative credits per quarter	4.08***	12.11***	1.96**	15.34***	0.0010***	0.0011***
	(0.39)	(0.63)	(0.47)	(0.96)	(0.0001)	(0.0001)
Total cumulative credits per quarter × in college	–1.04**	–12.88***	–5.10***	–25.90***	0.0013***	0.0003***
	(0.35)	(0.59)	(0.40)	(0.87)	(0.0000)	(0.0001)
Total cumulative credits per quarter × k	–1.65**	–16.33***	1.08*	–33.14***	0.0010***	0.0003*
	(0.55)	(1.05)	(0.62)	(1.75)	(0.0001)	(0.0002)
Cumulative technical credits per quarter	13.92***	18.11***	10.14***	17.66***	0.0010***	0.0013***
	(0.57)	(1.02)	(0.70)	(1.51)	(0.0002)	(0.0002)
Cumulative technical credits per quarter × in college	–23.36***	–0.64	–12.46***	9.48	–0.0041***	–0.0010***
	(0.49)	(1.10)	(0.58)	(1.60)	(0.0001)	(0.0002)
Cumulative technical credits per quarter × k	–11.33***	–0.64	–7.93***	11.80***	–0.0012***	–0.0014***
	(0.82)	(1.10)	(0.93)	(3.01)	(0.0002)	(0.0003)
Cumulative developmental English credits per quarter	16.58***	–7.07*	1.60	–35.86***	0.0046***	0.0047***
	(1.92)	(3.80)	(2.35)	(5.79)	(0.0006)	(0.0006)
Cumulative developmental English credits per quarter × in college	4.15**	8.15**	9.83***	37.12***	–0.0022***	–0.0034***
	(1.45)	(3.79)	(1.69)	(5.61)	(0.0004)	(0.0006)
Cumulative developmental English credits per quarter × k	–8.98***	3.89	–3.28	28.73***	–0.0011**	–0.0014
	(2.52)	(7.45)	(2.81)	(10.38)	(0.0006)	(0.0012)

Cumulative developmental math credits per quarter	–22.17***	–65.85***	–36.17***	–121.63***	–0.0010	–0.0028***
	(2.51)	(4.22)	(2.98)	(6.17)	(0.0007)	(0.0001)
Cumulative developmental math credits per quarter × in college	–13.48***	42.22***	5.40**	89.60***	–0.0045***	0.0009
	(2.01)	(4.29)	(2.33)	(6.14)	(0.0006)	(0.0007)
Cumulative developmental math credits per quarter × k	–2.91	48.43***	0.61	93.86***	–0.0006	–0.0016
	(3.58)	(8.37)	(4.04)	(11.55)	(0.0007)	(0.0014)
Credits attempted per quarter	–43.77***	–36.40***	–40.32***	–56.61***	–0.0047***	–0.0014***
	(0.72)	(1.13)	(0.83)	(1.63)	(0.0001)	(0.0002)
Enrolled outside community college system in quarter	–451.80***	–802.80***	–433.00***	–1004.46***	–0.0171***	–0.0974***
	(5.58)	(14.97)	(6.64)	(23.47)	(0.0011)	(0.0024)
Earned short-term certificate	–47.86**	–219.40***	–187.60***	–213.02***	0.0404***	–0.0064***
	(22.83)	(37.70)	(28.27)	(59.75)	(0.0063)	(0.0061)
Earned long-term certificate	938.48***	–56.98*	763.80***	–46.28	0.0813***	0.0156***
	(31.82)	(30.50)	(36.89)	(49.15)	(0.0087)	(0.0049)
Earned associate degree	1,011.14***	290.00***	966.70***	249.97***	0.0573***	0.0265***
	(18.84)	(19.31)	(22.26)	(30.12)	(0.0048)	(0.0031)
Earned bachelor’s degree	2,589.35***	814.00***	3,081.10***	1,183.74***	0.1150***	0.0685***
	(20.06)	(22.90)	(24.34)	(39.68)	(0.0051)	(0.0037)
Ashenfelter’s dip	22.84	–18.00	–9.61	–20.12	–0.0078***	0.0012
	(15.08)	(41.50)	(17.14)	(54.74)	(0.0018)	(0.00678)

Quarter fixed effects	X	X	X	X	X	X
R-squared	0.62	0.55	0.70	0.71	0.39	0.37
Number of students	87,835	21,796	87,835	21,796	87,835	21,796
Observations (students × quarters)	2,206,229	657,078	1,449,996	305,909	2,206,229	657,078

Note. These models include two sets of interaction terms with cumulative credits earned per quarter. Credits are interacted with "in college," which is equal to 1 in quarters when students are in college and 0 in quarters after college. Credits are also interacted with "k," which is equivalent to the inverse of the number of quarters since college exit. "K" is equal to "1" and the largest in the quarter immediately following college exit and converges to 0 over time. The main terms represent the returns to different types of credits in the long-term after college exit; the "in college" interaction terms represent the returns to different types of credits in quarters when students are enrolled in college; and the "k" interaction terms represent the returns to different types of credits in the short-term after college exit. Robust standard errors are in parentheses.

*** $p < .01$, ** $p < .05$, * $p < 0.1$

Table A.3. Virginia-Only Individual Fixed Effects Results, Full Model for All Outcomes

	Quarterly Wages	Probability of Employment	Wages if Employed
Total credits	4 (1)***	0.001 (0.000)***	8 (1)***
Returns to developmental English credits by writing course placement level			
College level	–9 (13)	0.002 (0.002)	–48 (19)**
Highest level	22 (6)***	0.006 (0.001)***	12 (9)
Lowest level	0 (5)	0.005 (0.001)***	–30 (8)***
Returns to developmental math credits by math course placement level			
College level	–113 (26) ***	–0.009 (0.005)*	2 (37)
Highest level	20 (11)*	0.007 (0.002)***	–77 (16)***
Middle level	–31 (5)***	–0.002 (0.001)*	–91 (8)***
Lowest level	–117 (8)***	–0.004 (0.001)**	–200 (13)***
R-squared	0.51	0.36	0.67
Observations	399,853	399,853	182,076

Note. Only coefficient estimates on the main effect for total credits, developmental English credits by placement level, and developmental math credits by placement level are presented. The main effects represent the returns to different types of credits in the long-term after college exit. Robust standard errors are in parentheses.

*** $p < .01$, ** $p < .05$, * $p < .1$