MATHEMATICA Policy Research

REPORT

FINAL REPORT

Outcomes from a Certification Program for Early Career Professionals in Supply Chain Management

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EXECUTIVE SUMMARY

In September 2013, the U.S. Department of Labor (DOL) Trade Adjustment Assistance Community College and Career Training (TAACCCT) program awarded a four-year $24.5M grant for Leveraging, Integrating, Networking, Coordinating Supplies (LINCS) in Supply Chain Management (SCM) to a Consortium led by Broward College. This award funded the Consortium to develop and create college-level certification track courses and certifications in eight cornerstone areas of SCM identified by the Council of Supply Chain Management Professionals (CSCMP). The goal was to increase the supply of appropriately skilled entry- and mid-level workers for SCM jobs.

LINCS certification areas

1. Supply Chain Management Principles
2. Customer Service Operations
3. Transportation Operations
4. Warehousing Operations
5. Demand Planning
6. Inventory Management
7. Manufacturing and Service Operations
8. Supply Management and Procurement

As a condition of the grant, DOL required TAACCCT grantees to commission an independent evaluation with two components: a study of program implementation and a study of participant outcomes or impacts. As the Consortium's lead, Broward College contracted with Mathematica Policy Research to serve as the external evaluator that would meet this requirement. Mathematica completed the first component of this evaluation, the implementation study, in August 2017 (Bruch et al. 2017) and this report comprises the second component, the outcomes and impact study. This study uses student-level data from five of the nine Consortium colleges (see the box to the left, which has the five colleges in red and italics) to examine students' employment and earnings after completing a certification track course in calendar year 2015. To examine the program's impact—that is, its effectiveness—the study compares outcomes for students who completed a certification track course at Broward College to those for students who took an SCM course at the college in 2014 but did not participate in LINCS.

Consortium colleges

- ***Broward College***
- ***Columbus State Community College***
- Essex County College
- ***Florida State College at Jacksonville***
- ***Harper College***
- Long Beach City College
- San Jacinto Community College
- ***St. Petersburg College***

Key findings from the outcomes and impact study

More than four-fifths (82 percent) of students in five LINCS Consortium colleges in 2015 were employed within the three calendar quarters after completing their first certification track course. They had average quarterly earnings of nearly $7,400, which corresponds to an annual salary of $29,600. For the 150 students at Broward College, these outcomes represented a 3.3 percent increase in employment and 5.2 percent increase in earnings since the time they first enrolled in a LINCS course. Although both increases were statistically significant, they cannot be attributed to the LINCS program, because the estimated impacts were not statistically significant. Still, LINCS surpassed its targets for program completion (Bruch et al. 2017), exceeding the goal of its proposal: to prepare students for SCM positions. Due to time limitations, this study is not able to assess increases in employment and earnings in the longer term.

I. INTRODUCTION

In September 2013, a Consortium of nine colleges and three universities received a $24.5 million Trade Adjustment Assistance Community College and Career Training (TAACCCT) grant from the U.S. Department of Labor (DOL) to develop and implement the Leveraging, Integrating, Networking, Coordinating Supplies (LINCS) program in supply chain management (SCM). The TAACCCT grant program was designed to provide funding and resources to enhance each college's ability to deliver education and career training programs that (1) could be completed in two years or less and (2) prepared participants for high-wage, high-skill occupations. Its intent was for colleges to help adults improve their employment prospects while also meeting employers' needs for skilled workers.

Consortium colleges

- Broward College (Florida)
- Columbus State Community College (Ohio)
- Essex County College (New Jersey)
- Florida State College at Jacksonville (Florida)
- Harper College (Illinois)
- Long Beach City College (California)
- San Jacinto Community College (Texas)
- St. Petersburg College (Florida)
- Union County College (New Jersey)

University partners

- Georgia Institute of Technology
- Northwestern University (Illinois)
- Rutgers, The State University of New

As a condition of the grant, DOL required TAACCCT grantees to commission an independent evaluation of their funded programs. DOL specified that evaluations focus on both program implementation and participant outcomes or impacts. As the LINCS Consortium's lead, Broward College contracted with Mathematica Policy Research to serve as the external evaluator for the LINCS program. The program implementation component of the evaluation is described in an earlier report (Bruch et al. 2017). The outcomes and impact study is the focus of this report. Together the two reports meet the DOL evaluation requirement.

This chapter provides an overview of the LINCS program (Section A), a description of the outcomes and impact study (Section B), a discussion of the limitations of the study (Section C), and a roadmap of the rest of the report (Section D).

Cornerstone areas of SCM

1. Supply Chain Management Principles
2. Customer Service Operations
3. Transportation Operations
4. Warehousing Operations
5. Demand Planning
6. Inventory Management
7. Manufacturing and Service Operations
8. Supply Management and Procurement

A. The LINCS program

The LINCS program was designed to address skill shortages in SCM by enhancing training and career pathway opportunities for individuals seeking entry- and mid-level SCM employment.[1] It focused efforts on building skills in each of the eight cornerstone areas of SCM identified by the Council of Supply Chain Management Professionals (CSCMP) before the grant application was submitted. These areas were verified by CSCMP during the proposal period and by employers through interviews conducted by Broward College after receipt of the grant.

[1] This summary is based on the findings described in the implementation evaluation report (Bruch et al. 2017).

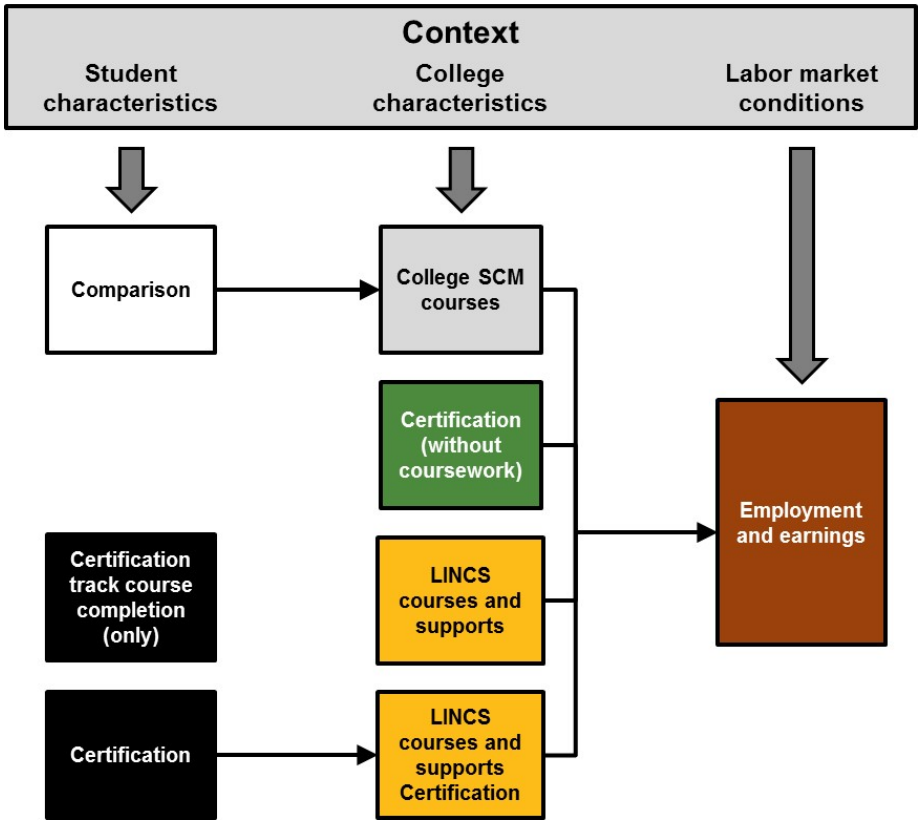
To address skill shortages, LINCS created certification track courses to align with CSCMP certification exams; student supports; and enhanced recruiting efforts, all of which were designed to boost the number of workers with in-demand SCM knowledge and skills. Courses and exams in eight areas were rolled out in 2015.

- **Certification track courses.** The LINCS Consortium developed content, and Consortium colleges offered courses integrating that content, allowing students to acquire subject matter knowledge and hands-on experience in each of the cornerstone areas in SCM. After completing a certification track course, students could take an examination in the area to earn that specific CSCMP certification.
- **Certification exams.** CSCMP created eight proprietary certification exams, SCPro™ Fundamentals. Passing one of the exams and thereby gaining a certification could provide a signal to employers that an individual had mastered the SCM content and skills in that particular area. The certifications complemented an existing platform of certifications, CSCMP's SCPro™ Certification, allowing students to continue to demonstrate higher levels of skills if they continued their education and passed higher-level exams.
- **Student support services.** About half of the Consortium colleges developed LINCS-specific academic support, career guidance, and job placement activities for students who pursued the certification track courses. Among other support services were life skills training, childcare and housing assistance, and case management.
- **Enhanced recruiting efforts.** All nine colleges expanded recruiting efforts beyond those traditionally used to recruit students into SCM programs and courses. The Consortium encouraged these efforts by contracting with the National Urban League to have its local affiliates work with colleges to recruit and support students in the LINCS program. Individual colleges also engaged in enhanced recruitment efforts through development of meaningful employer relationships, job fairs, networking through local CSCMP roundtables, online media campaigns, and email blasts (for example).

Figure I.1 shows how the first three components could help students improve employment and earnings. LINCS students fell into one of two categories, as the yellow boxes show. They could complete one or more certification track courses, which provided access to support services, without passing a certification exam and becoming certified (top yellow box). Because certification track courses are aligned with cornerstone areas of SCM, these students could have gains in employment and earnings (brown box at far right) compared with students with SCM courses that were not so aligned (white box at left). Other LINCS students might complete certification track courses *and* become certified in one or more areas (bottom yellow box). Because certification could signal SCM knowledge and skills in addition to the benefits of certification track course completion, these students might have additional increases in employment and earnings.[2]

[2] The evaluation does not include students who passed a certification exam without completing any certification track courses (green box) because they have not experienced a key component of the LINCS program.

Figure I.1. LINCS and potential improvement in employment and earnings



The expectation of increased employment and earnings is consistent with the trend in higher education toward developing credentials such as certificates and certification programs to provide students with in-demand skills in less time than it takes to complete traditional degrees (Gallagher 2016). Tying these credentials directly to labor market needs allows students to gain in-demand knowledge and skills quickly and to see greater employment and earnings than those without the credentials.

Such credentials have increased dramatically in recent years. Certificates with courses that bear credit, for example, have increased from about 6 percent of the credentials awarded by colleges and universities in 1980 to 22 percent in 2010 (Carnevale et al. 2012). These certificates, which are awarded for life after individuals demonstrate knowledge and skills through coursework and examinations, are very similar to the certifications developed by CSCMP, with curriculum offered by LINCS.[3] Existing evidence shows certificates can lead to earning gains of about $2,000 to $3,000 per year (Belfield and Baily 2017), with some people increasing employment rates by finding a job in a different sector (Xu and Trimble 2014).

[3] See CSCMP descriptions of the SCPro™ Fundamentals Certifications, which focus on courses and examinations, and of the different levels of SCPro™ Certifications, which focus on examinations and renewal.

B. LINCS outcomes and impact investigations

The outcomes and impact study addresses three research questions:

1. What are employment and earnings outcomes for students after (a) completing a certification track course and (b) becoming certified?
2. How does (a) completing a certification track course and (b) becoming certified increase students' employment and earnings relative to students who completed SCM courses that are not part of a certification track?
3. How do the outcomes vary with certain student characteristics: gender, youth, and incumbent worker status?

These questions are answered with an outcomes investigation and a distinct impact investigation. Together the two study components describe the potential for the LINCS program to build students' employment and earnings. The outcomes investigation is more expansive. It includes five colleges and enough students to enable examination of different subgroups of students. However, it describes employment and earnings only of students who participated in LINCS; it did not and cannot determine whether those outcomes would have been lower without LINCS participation. The impact investigation examines the possibility that LINCS increased employment and earnings by comparing these outcomes for LINCS students to those of students who did not participate in LINCS. However, it includes only one college and too few students to allow examination of impacts for different subgroups. Appendix B provides details on each investigation, which is summarized in the text below and in Table I.1.

The outcomes investigation addresses the first and third research questions. It documents employment and earnings for students after they complete their first certification track course and describes the associations between employment and earnings and particular aspects of LINCS participation: both number of certification track courses completed and certification. Analysis of outcomes after completion (called post-only analysis) is undertaken collectively for all five colleges, as well as separately for subgroups of males, females, youth (aged 18 to 24), adults (aged 25 and over), incumbent workers, and nonincumbent workers at these colleges, and for students at Broward College. If the post-only analysis shows outcomes for Broward College students to be similar to those for students at all colleges, results from the impact investigation might also apply to the other colleges. In addition, the outcomes investigation includes a pre-post analysis of Broward College students that shows changes in employment and earnings before and after completion of a certification track course.

The impact investigation addresses the first two research questions. It adds rigor to the study with a quasi-experimental design, or QED. It compares short-term employment and earnings of students who completed certification track courses to those of students who completed SCM courses without the LINCS augmentation (Appendix C provides details). The data requirements for this investigation restrict analysis to one college: Broward College.

Table I.1. Key features of outcomes and impact investigations

	Outcomes investigation	Impact investigation
Strengths	Greater number of colleges Allows for subgroup analysis	Adds rigor by comparing outcomes for students in LINCS to outcomes for those not in LINCS
Research questions addressed	1 and 3	1 and 2
LINCS students included	Completed at least one certification track course in 2015	
Comparison students	None	Completed at least one supply chain management course in 2014
Outcomes examined	**Labor market:** Employment and earnings	**Labor market:** Employment and earnings
Timing of labor market outcomes	First three calendar quarters after completing first certification track course (or supply chain management course for comparison group in impact investigation)	
Colleges included	Broward College Columbus State Community College Florida State College at Jacksonville Harper College St. Petersburg College	Broward College
Sample size	830	150 treatment, 103 comparison
Subgroups examined	Males, females Youth, adults Incumbent workers, nonincumbent workers Broward College students	None
Analyses	Descriptive Post-only Pre-post	Descriptive Quasi-experimentally designed impact

Analyses in both investigations share the same general structure and approach (see Appendix D for details). Each begins with statistics that describe students' background, environment in which they attended college or lived, LINCS participation, and outcomes before enrollment in the first certification track or SCM course. Each investigation uses regression analysis to estimate the association between LINCS participation and outcomes or impacts, controlling for factors in student background and environment that might be associated with outcomes.

C. Study limitations

Results of the study must be interpreted in light of its limitations. We highlight key design limitations here; more detailed explanations are in the appendices.

- **The study period was short.** The study followed students for three calendar quarters, which provides insights into short-term outcomes but does not capture how certification track courses or SCPro™ Fundamentals certifications might improve employment or earnings over time.

- **LINCS was in its early stages during the study period.** When students participated in LINCS (calendar year 2015), the program had been in place for less than a year. Thus, the associations estimated in this study reflect the outcomes and impacts of the LINCS program in its early stages, which may be understated relative to those that might be observed when the program is more mature.
- **Results are specific to the colleges and the time period used in analysis.** Results cannot be used to describe SCM courses or certification processes for colleges outside the study or in other time periods. Other programs and certification processes, whether in SCM or not, may differ from those developed by the LINCS grant, making their outcomes and impacts differ from those estimated in this study. In particular, the results do not necessarily apply to the Consortium colleges not included in the investigations. The outcomes investigation is heavily influenced by outcomes at Florida State College at Jacksonville; although the colleges' students comprised 27 percent of those who had participated in at least one certification track course by July 31, 2016, they comprised about 45 percent of those analyzed in the outcomes investigation. The impact investigation results are specific to Broward College.
- **Research does not show causality.** Because we could not use an experimental research design—that is, random assignment—or show that our treatment and comparison groups in the impact investigation had the same characteristics, the estimated impacts of the LINCS program could reflect underlying differences between the treatment and comparison groups.

D. Report overview

The rest of the report is structured as follows: Chapter II presents the findings from the study and Chapter III discusses some of the possible explanations for the findings. The body of the report is followed by a reference section and five appendices: Appendix A provides definitions of terms used in the report; Appendix B describes samples used in each investigation, as well as the data used and the variables constructed; Appendix C describes the impact investigation design; Appendix D describes analytic methods; and Appendix E contains the tables showing the analysis results that underlie the discussion of outcomes and impacts in this report.

II. ESTIMATED OUTCOMES AND IMPACTS

The aim of this study is to learn how students fared, primarily in terms of their employment and earnings, after completing a certification track course or gaining a certification. This chapter presents the findings from the analyses in each investigation. We first look at results observed in the outcomes investigation: What employment and earnings did students obtain after completing their first certification track course, and how did those outcomes differ across various types of students and for students who participated in different ways? To what extent did those outcomes represent an improvement for participants? Next, we assess the causal contribution of the LINCS program through the impact investigation: To what extent did the LINCS program contribute to those improvements?

In both investigations, we examine two labor market outcomes: (1) whether a student was employed and (2) average quarterly earnings. Students are considered employed if they had any employment during the first quarter and during the first three quarters after completing the first certification track course. Earnings are averaged across all individuals—including those who are not employed, to avoid mixing employment and earnings outcomes—and across three quarters after completing the first certification track course.

The remainder of the chapter discusses results from the outcomes investigation (Section A) and the impact investigation (Section B).

Key findings

1. **Nearly all LINCS students found employment.** More than 82 percent of students were employed within the three quarters after completing the first certification track course. Average quarterly earnings corresponded to an annual salary of $29,600.

2. **Employment and earnings increased.** For students at Broward College, employment increased from 81 to 83 percent, or 3.3 percent, in the three quarters following completion of the first certification track course, and average quarterly earnings increased from $6,400 to $6,700, or 5.2 percent. If the growth in earnings persisted, annual earnings would have increased from about $25,600 to $26,900.

3. **Increases cannot necessarily be attributed to the LINCS program.** The impact investigation analyses did not show statistically significant impacts of LINCS on employment or earnings.

A. Outcomes investigation

The outcomes investigation focuses on students who participated in LINCS in 2015 by completing at least one certification track course and examines their labor market outcomes. It includes three analyses, which are discussed in detail in Appendix D.

1. **A descriptive analysis** builds an understanding of the students in the five colleges in the investigation, in terms of their demographic, education, and other background characteristics.
2. **A post-only analysis** describes employment and earnings after students completed their first certification track course at one of the five colleges. As part of this analysis, we examine whether the level of student involvement in LINCS—including the number of certification track courses completed and whether students attained any certification—is related to the outcomes experienced.
3. **A pre-post analysis** assesses how employment and earnings changed for students at Broward College after completing a certification track course (employment information prior to LINCS enrollment was not consistently available for all five Consortium colleges in the outcomes investigation).

To better understand how employment and earnings differ among students who completed certification track courses, we examine outcomes for student subgroups of interest, including males and females, youth and adults, and those employed (incumbent workers) and not employed when they enrolled in a certification track course. We also examine how findings at Broward College differ from those at the other colleges, as Broward College is the subject of the impact investigation described in the next section of this chapter.

Although the outcomes investigation indicates what happened after completing a certification track course for a broad range of students, it is purely descriptive—it cannot indicate the extent to which the LINCS program caused these outcomes. This caveat is especially important in interpreting the subgroup analyses. Comparisons across subgroups implicitly assume that characteristics and outcomes before LINCS participation are the same across groups (males/females, youth/adults, incumbent/nonincumbent workers), but they may not be. For example, higher employment for one group of participants relative to another might reflect the fact that the former group had higher rates of employment before their participation in LINCS.

1. Environment: Student characteristics, labor markets, and LINCS participation

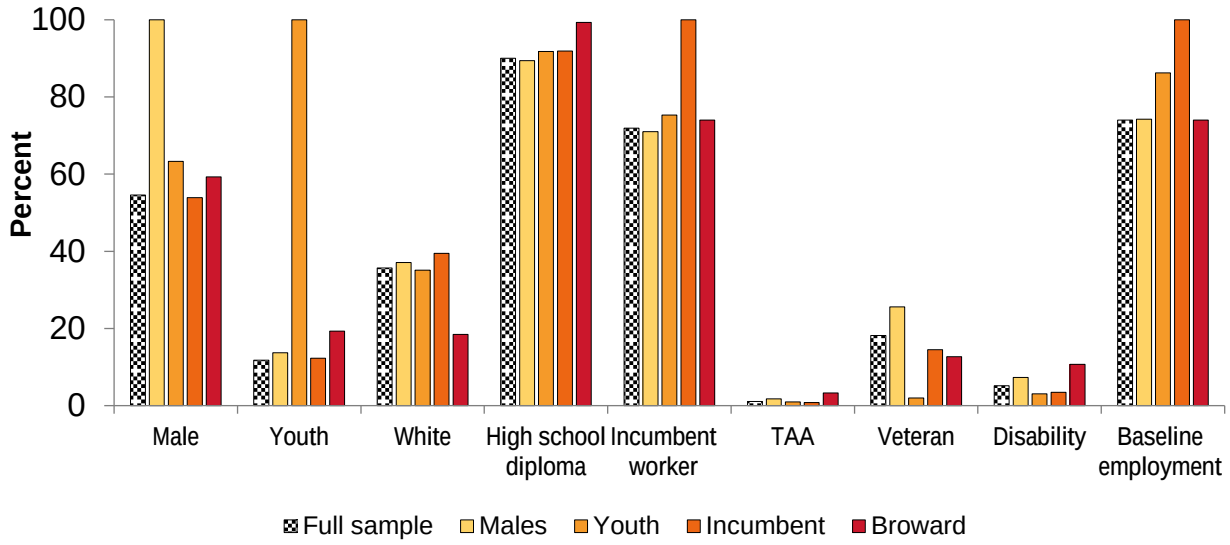
The context in which students participate in LINCS affects both the outcomes that can be achieved and the interpretation of those outcomes, as the logic model in Figure I.1 showed. In examining employment and earnings, we consider students' backgrounds and local labor markets in addition to their participation in LINCS (Appendix E, Table E.1). The characteristics of students (for example, education and age) help illustrate their employment and earnings potential, whereas the local labor market plays a critical role in determining whether that potential is realized. Courses completed and certifications attained indicate the extent of a student's participation in LINCS, and perhaps their interest and achievement in the field of SCM.

The characteristics of students in the outcomes investigation highlight their diversity (Figure II.1 and Appendix E, Table E.1). Note that in this figure—and in all remaining figures—the

black textured bar shows the values for the overall sample and the red bar indicates students at Broward College. Although comparisons between subgroups are not explicitly made in figures that follow, these comparisons can be inferred by comparing the subgroup shown to the overall average. If the bar showing the percentage of males (for example) that are youth is higher than the average—as represented by the black textured total bar—then the percentage of females that are youth must be below average.

On average, students are approximately 39 years old and more than half are male (55 percent). The group is racially diverse: 43 percent of the students are black or African American, 36 percent are white, and 18 percent are Hispanic. Nearly all have a high school diploma or GED, but only a small proportion have an associate's degree (3 percent) or bachelor's degree (5 percent). Almost one fifth are veterans and small proportions have a disability or are eligible for Trade Adjustment Assistance (TAA) benefits. The majority were already employed (74 percent) when they enrolled in the first certification track course. The average student at Broward College has a similar profile, but is slightly younger, more likely to be male, and less likely to have a bachelor's degree; a higher percent of Broward students are Hispanic (46 percent). Only modest differences exist in the profile of each subgroup. Notably, women and nonincumbent workers tend to be older; adults are more likely to have earned a degree; and men, adults, and nonincumbent workers are more likely to be veterans.

Figure II.1. Characteristics of students in the outcomes investigation



Source: Appendix E, Table E.1.

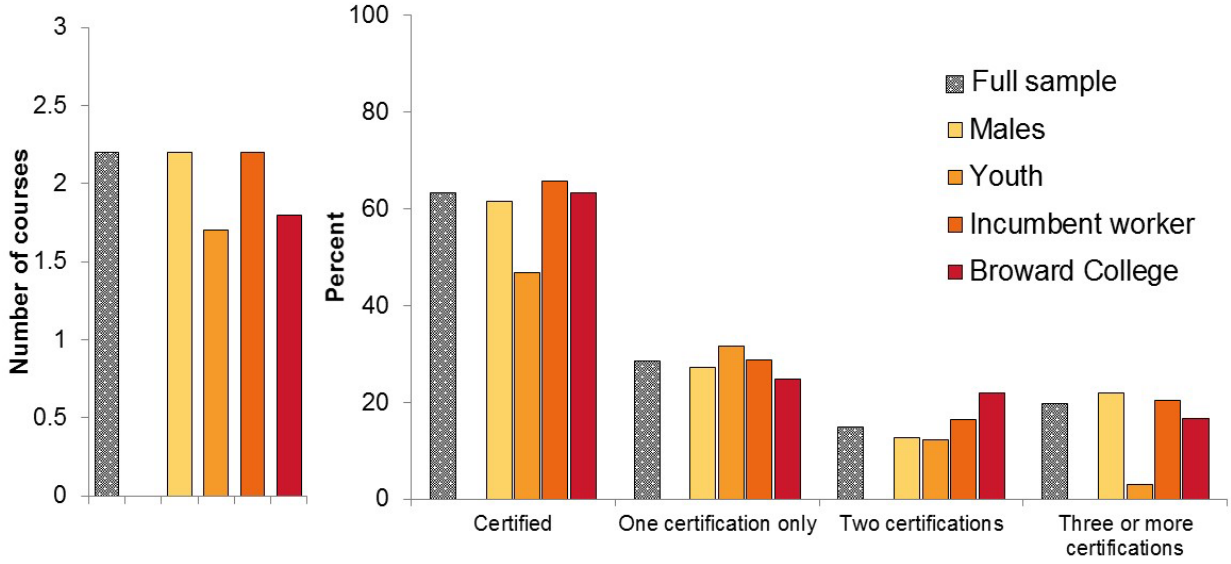
Note: The black textured bar shows the values for the overall sample and the red bar indicates students at Broward College. Although comparisons between subgroups are not explicitly shown, they can be inferred by comparing a subgroup's percentage to the overall average. If the bar showing the percentage of males (for example) that are youth is higher than the average—as represented by the black textured total bar—then the percentage of females that are youth must be below average. Note that males (for example) are shown to be 100 percent of the "male" descriptor because females represent 0 percent of that descriptor.

Nearly half (45 percent) of the students in the outcomes investigation are from Florida State College at Jacksonville (375 students), about 18 percent are from Broward College (150 students), 17 percent are from St. Petersburg College (139 students), 12 percent are from

Columbus State Community College (97 students), and 8 percent are from Harper College (69 students). Considerable geographic variation existed in labor markets across the five colleges (Bruch et al. 2017). Average local area unemployment rates in 2016 ranged from 3.9 percent in Columbus, Ohio, to 5.4 percent in the Chicago area, the metropolitan area that includes Harper College. Composition of jobs in the local areas also changed. Employment in trade, transportation, and utilities near the Florida colleges increased more than 2 percent from 2015 to 2016, but decreased in Columbus and increased only slightly in Chicago.

The nature of students' participation in LINCS is reflected in their course-taking and certification attainment (Figure II.2). Students completed about two certification track courses on average (including the first course) within one academic term of completing their first course. That total increases slightly within two academic terms. Most go on to take and pass a certification exam: 61 percent attain a certification within one academic term, and 63 percent within two academic terms. Almost 29 percent of students attain a single certification within two terms, 15 percent earn two certifications, and 20 percent earn three or more. LINCS participation varies somewhat across student subgroups. Youth complete slightly fewer certification track courses than adults. Women, adults, and incumbent workers are more likely to attain a certification than men, youth, or nonincumbent workers.

Figure II.2. LINCS participation within two terms after completing first certification track course



Source: Appendix E, Table E.1.

Note: The black textured bar shows the values for the overall sample and the red bar indicates students at Broward College. Although comparisons between subgroups are not explicitly shown, they can be inferred by comparing a subgroup's percentage to the overall average. If the bar showing the percentage of males (for example) that are youth is higher than the average—as represented by the black textured total bar—then the percentage of females that are youth must be below average.

2. Employment and earnings after course completion

The post-only analysis estimates regression-adjusted average employment and earnings outcomes, controlling for student demographics, education, and other characteristics and

unemployment in the local labor market (Appendix E, Table E.2). In addition to presenting outcomes for all students and subgroups, we explore sources of variation in outcomes—student background characteristics and program components. We also examine how outcomes change after participation for Broward College students.

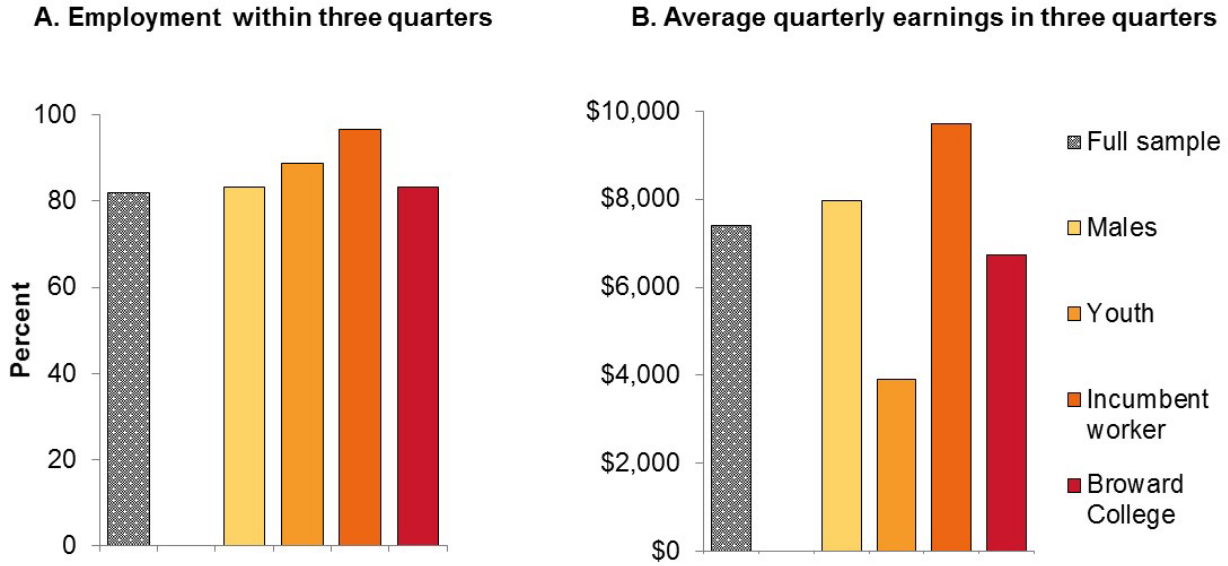
a. Post-only outcomes analysis

About three-quarters of the students who completed a certification track course in the five LINCS Consortium colleges in 2015 were employed within one quarter after completing the first course, with that proportion rising to more than four-fifths (82 percent) of students within three quarters. Average quarterly earnings during the three quarters were nearly $7,400, corresponding to an annual salary of $29,600.

Findings for all students mask differences across student subgroups that cannot be seen when looking at the overall findings for students (Figure II.3). Specifically, after completion of a certification track course:

- Men are slightly more likely to be employed and have higher average earnings than women.
- Youth are more likely to be employed, but adults have higher average earnings.
- Incumbent workers are more likely to be employed and have higher earnings than nonincumbent workers. About 5 percent of incumbent workers were no longer employed within three quarters after completion of a certification track course. Of those workers who did not have a job before completing a certification course, over 40 percent found employment within three quarters after finishing the course.

Figure II.3. Employment and earnings after first certification course



Source: Appendix E, Table E.2.

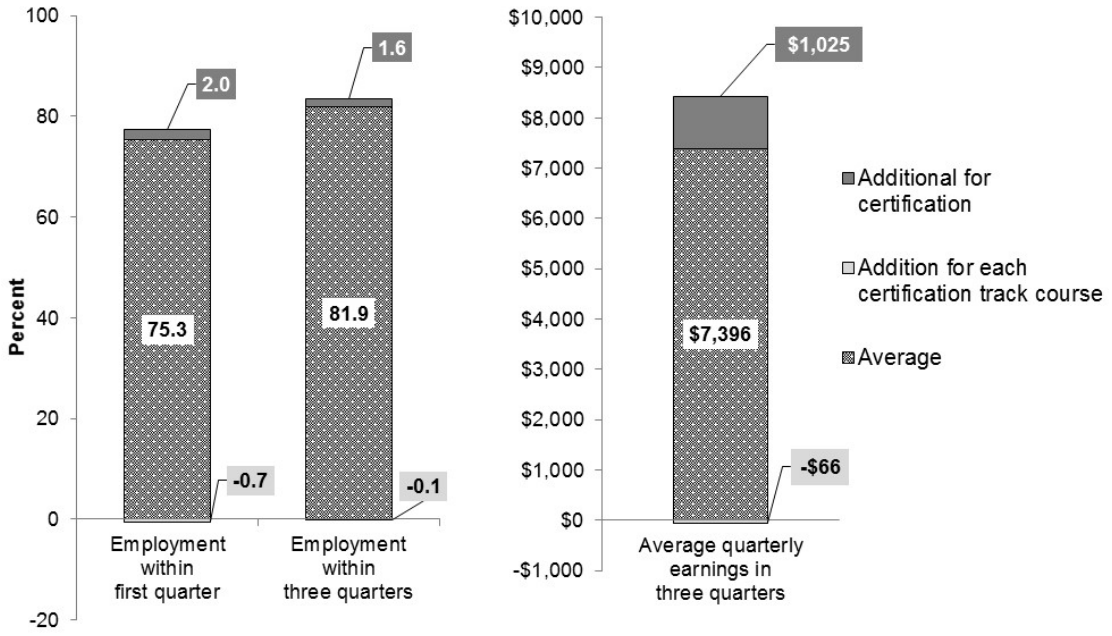
Note: The black textured bar shows the values for the overall sample and the red bar indicates students at Broward College. Although comparisons between subgroups are not explicitly shown, they can be inferred by comparing a subgroup's percentage to the overall average. If the bar showing the percentage of males (for example) that are youth is higher than the average—as represented by the black textured total bar—then the percentage of females that are youth must be below average.

These subgroup findings may stem from differing levels of LINCS participation or differing benefits from the same participation, but a descriptive analysis such as this one cannot answer such causal questions. We therefore do not compute or discuss the statistical significance of differences between subgroups, and we urge readers to view the subgroup findings judiciously.

b. Associations between levels of LINCS participation and outcomes

As Figure II.2 shows, students who complete a certification track course differ in their involvement with LINCS, and those differing levels of involvement may be observed and rewarded differently in the labor market. For example, employers might take note of certifications on a student's resume, but fail to observe courses completed or understand the difference between SCM courses with and without LINCS content. Still, completion of additional courses may increase knowledge and skills in SCM, improving a student's chance of interviewing successfully for a job or advancing in a position. We use regression analysis to examine the association between employment and earnings and two indicators of LINCS participation: (1) the number of certification track courses completed within two academic terms of completing the first certification track course and (2) attainment of certification within those two terms. Figure II.4 shows these associations by showing the average outcome (large textured bar), the change in the average associated with each additional certification track course (light solid line), and the *additional* change associated with certification (dark solid line).

Figure II.4. Employment and earnings and LINCS participation



Source: Appendix E, Table E.3.

Note: The figure shows the average value of the outcome and the association with LINCS certification track courses or certification. A negative value indicates that additional courses or certification was associated with a reduced average and a positive value indicates that it was associated with an increased average. Of note, none of the estimated increases or decreases is statistically significant.

As Figure II.4 shows, the number of certification track courses completed has small and statistically insignificant associations with employment and earnings in the aggregate (that is, for

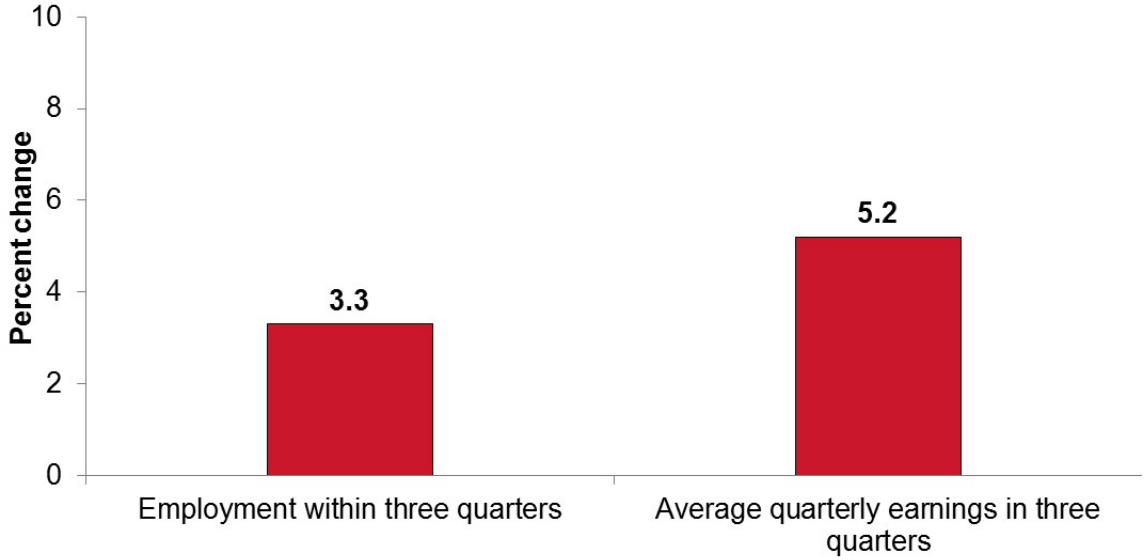
all students in the five colleges). Results are similarly small and insignificant and in mixed directions for the subgroups (Appendix E, Table E.3). Although two findings are significant, readers are cautioned not to attach too much importance to these findings. When examining a large number of estimates of an effect, the likelihood of finding at least one to be statistically significant, even when there is no true effect, becomes substantial. According to this well-known statistical concept of multiple comparisons, when examining the 42 subgroup association estimates in Appendix E, Table E.3 (six effects for seven subgroups), we would expect approximately two falsely significant findings. This does not imply that the two significant associations observed are not real, but it does suggest that further support would be needed to have confidence in the results.

c. Pre-post analysis for Broward College

We next turn to an analysis of the change in outcomes. Comparing outcomes to a baseline measured before enrolling in a certification track course sheds light on whether the outcome represents a gain or a loss. Outcomes after LINCS participation—relatively high rates of employment or earnings, for example—can be difficult to interpret unless we also know their levels before LINCS participation. Although comparing outcomes before and after LINCS participation does not indicate causality, the comparison allows us to assess findings as increases or decreases. We conduct a pre-post analysis of the change in outcomes, controlling for student demographics, education, and other characteristics and for unemployment in the local labor market (Appendix E, Table E.4). This analysis focuses on students at Broward College, for whom baseline data were available.

Both the likelihood of employment and average earnings increase significantly for students who completed certification track courses at Broward College (Figure II.5). Employment rates increased from 74 to 78 percent (a 5.4 percent change) in the first quarter after course completion, and from 81 to 83 percent (a 3.3 percent change) in the three quarters following course completion. Average quarterly earnings within three quarters after course completion increased by $331 (from about $6,400 to $6,700), or 5.2 percent. If this increase were sustained, it would result in about $1,300 more per year in annual salary (from $25,600 to $26,900).

Figure II.5. Percent change in outcomes at Broward College: Pre-post analysis



Source: Appendix E, Table 4.

Note: Increases were statistically significant.

Students who attained certifications experienced similar increases in employment and earnings. The changes in their outcomes were not significantly different from the changes in the outcomes of students who did not attain certifications. Likewise, outcomes did not differ for students who completed more or fewer certification track courses.

B. Impact investigation

The impact investigation aims to determine the causal effect of LINCS on employment and earnings. The analysis is based on a QED, which compares outcomes of a treatment group of students who completed a certification track course in 2015 with the outcomes of a comparison group of students who completed an SCM course before the LINCS program rolled out. The comparison group's experiences represent what might have happened to the students in the treatment group had they not participated in LINCS. This design increases the rigor of the analysis over that in the outcomes investigation. As long as both the treatment and comparison group students are the same with respect to observable and unobservable characteristics—including employment and earnings before enrollment in a certification track or SCM course—with the exception of their participation in LINCS, the analysis can estimate the impact of the LINCS program on outcomes.

The impact investigation focuses only on students at Broward College, the only college to satisfy the conditions for inclusion in a QED impact analysis (Appendix B). Students at Broward College who were part of the outcomes investigation (represented by a red bar in the figures) were compared with students who completed at least one of four selected for-credit, non-certification track SCM courses at the college in the previous year. This comparison group shared the same geographic area and educational environment as the treatment group, and took courses in the same academic field of SCM. However, because the two groups were not randomly selected, other differences between them could affect their outcomes. Some

differences between the groups, such as the higher rate of baseline employment and earnings and lower local unemployment rates for members of the treatment group after completion of their first certification track course, mean that causal inferences drawn from the impact investigation are necessarily limited.

This section presents findings from the two analyses that make up the impact investigation. A **descriptive analysis** builds an understanding of the impact investigation's sample of students at Broward College in terms of their demographic, education, and other background characteristics. A **QED impact analysis** compares the employment and earnings of the treatment group who participated in LINCS with that of the comparison group, who did not.

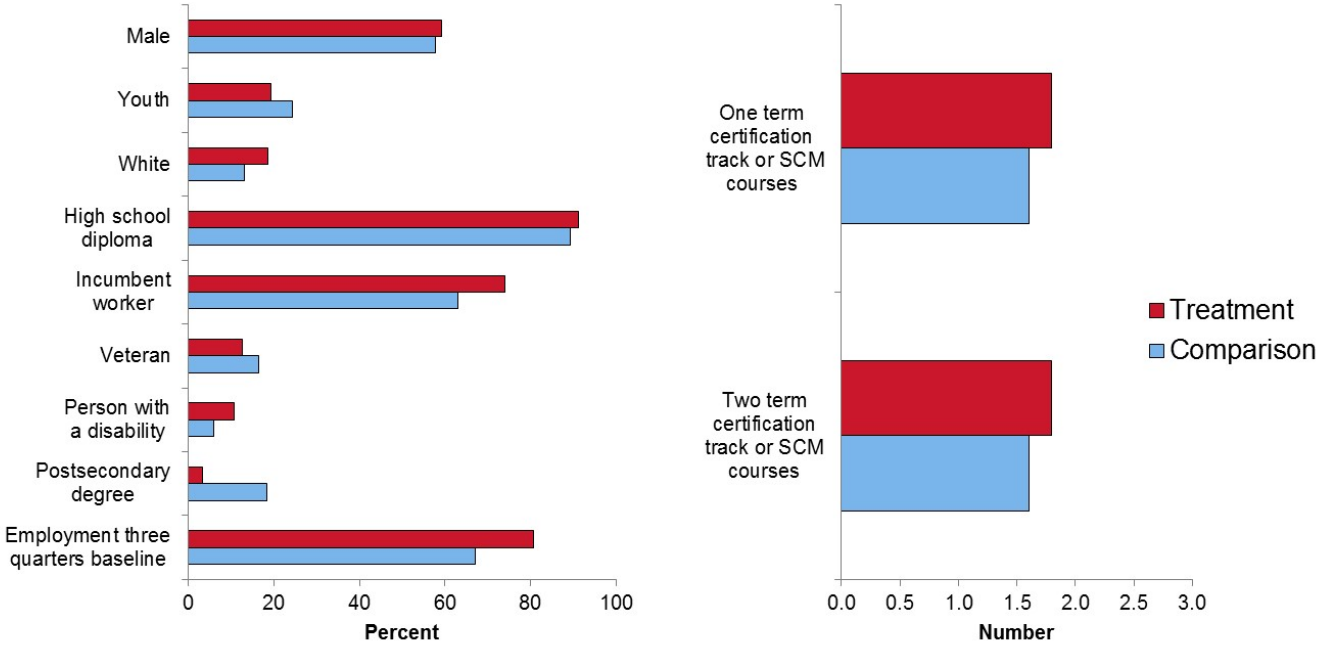
1. Environment at Broward College: Student characteristics, labor markets, and SCM courses

Understanding the potential of the LINCS program to produce impacts, and interpreting those impacts, depends heavily on the nature and similarity of the contexts in which students in the treatment group and comparison group are observed. We compare the groups in terms of their background, local environment around Broward College, and participation in SCM courses.

In general, characteristics of the treatment and comparison groups differed, which suggests that the students were different before they enrolled in a LINCS or SCM course (Figure II.6; Appendix C, Table C.4) and calls into question the ability of the investigation to estimate the impact of LINCS. Specifically, students in the treatment group differed from members of the comparison group in a number of ways, many of which might result from the way the samples were drawn (see Appendix C). Students in the treatment group:

- Were more likely to be white, a group that tends to have higher rates of employment and earnings than other race and ethnic groups (U.S. Bureau of Labor Statistics 2015).
- Were more likely to have a disability, which tends to be associated with lower rates of employment and earnings.
- Had completed a greater number of SCM courses (when comparing certification track courses among the treatment group to SCM courses among the comparison group), which may have bolstered the skills needed for an SCM job.
- Faced lower unemployment rates in the local labor market, were more likely to be incumbent workers and employed in the quarters prior to course enrollment, and had substantially higher average quarterly earnings in the three quarters before enrollment. All of these factors tend to improve rates of employment and earnings after completion.

Figure II.6. Characteristics of treatment and comparison group students

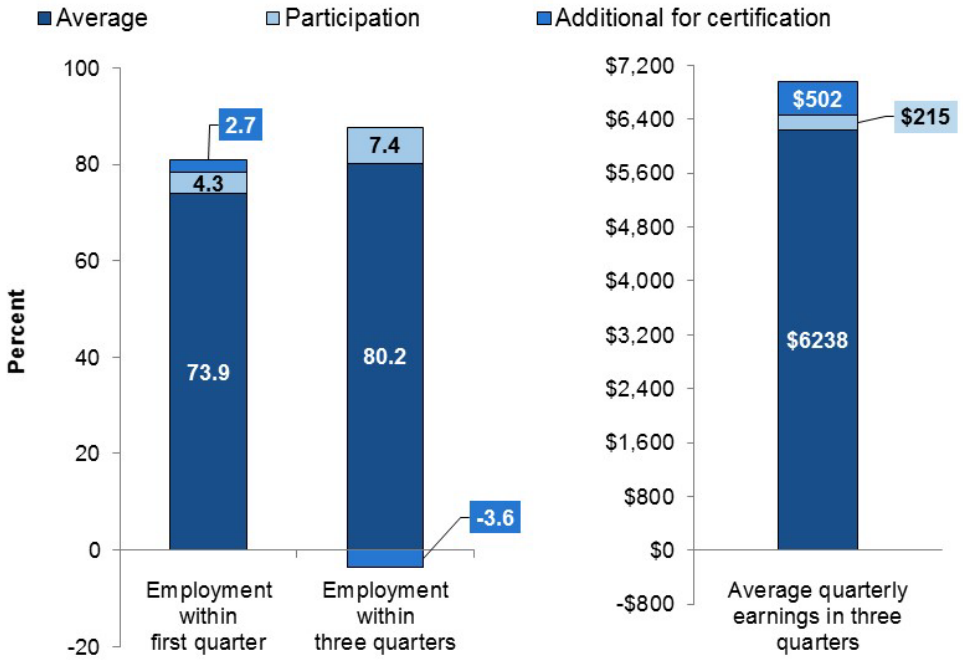


Source: Appendix E, Table E.5.

2. Impacts of LINCS on employment, and earnings

The QED impact analysis estimates impacts using a regression analysis that compares treatment and comparison group students while controlling for their demographics, education, and other characteristics and unemployment in the local labor market (Appendix E, Table E.6). It also estimates the impact of having a certification, which should be interpreted as an additional effect beyond the impact of completing a certification track course. Participation in LINCS did not appear to have an impact on employment and earnings. Figure II.7 presents the results by showing the average outcome (large blue bar), the change in that average associated with participation in LINCS (light blue line), and the *additional* change associated with certification (dark blue line). As this figure shows, neither completion of a certification track course nor gaining a certification had a large or statistically significant impact on employment and earnings.

Figure II.7. Impact of LINCS on employment, and earnings



Source: Appendix E, Table E.6.

Note: The figure shows the average value of the outcome and the association with participating in LINCS or certification. A negative value indicates that participation or certification was associated with a reduced average and a positive value indicates that it was associated with an increased average. Of note, none of the estimated increases or decreases is statistically significant.

III. INTERPRETATION OF FINDINGS

The outcomes and impact study of the LINCS evaluation was structured to address three research questions:

1. What are employment and earnings outcomes for students after (a) completing a certification track course and (b) becoming certified?
2. How does (a) completing a certification track course and (b) becoming certified increase students' employment relative to students who completed SCM courses that are not part of a certification track?
3. How do the outcomes vary with certain student characteristics: gender, youth, and incumbent worker status?

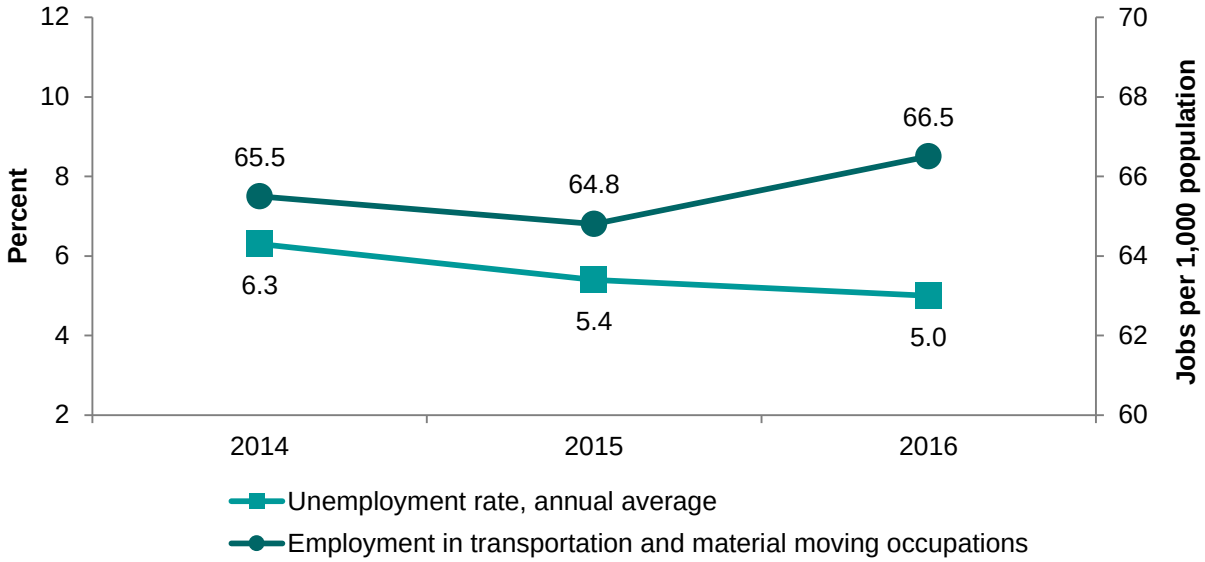
Although our analyses suggest that students generally found employment after completing a certification track course, we cannot attribute these labor market outcomes to the LINCS program because the estimated impacts were not statistically significant. We discuss five potential explanations for the absence of impacts on employment and earnings below.

One possibility is that the LINCS program shifted workers into SCM jobs from other sectors. Incumbent workers might have stayed in or moved into SCM, and new workers might have taken SCM jobs instead of other jobs. Under such a scenario, students would not see increased employment and earnings, but the SCM jobs would have an increased supply of trained workers, which was the intent of the grant. This scenario is consistent with design features of the program and findings about program implementation that suggest the LINCS content was valuable to employers and mastered by students, and that LINCS students received additional job placement support (Bruch et al. 2017). Survey input from employers and industry groups provided both before and during content development suggests that the LINCS content was aligned with their needs. The high pass rates on the industry-created certification exams indicate that students assimilated the LINCS content. Finally, as proposed in its grant project, Broward College hired dedicated staff to help students find employment in SCM jobs.

Another possible explanation for the absence of impacts might be that treatment and comparison group students faced differing labor market conditions when they completed certification track or SCM courses. Such differences could contribute to any observed impacts on employment and earnings, in addition to any impacts of LINCS. With an improved labor market in the Miami-Fort Lauderdale-West Palm Beach metropolitan area in which Broward College is located, the treatment group faced better conditions after completing their first certification track course in late 2015 or 2016 than the comparison group did roughly a year earlier (Figure III.1). The seasonally adjusted local area unemployment rate trended downward throughout the period, falling from 6.1 to 5.6 between September 2014 and March 2015, and from 5.3 to 5.1 between September 2015 and March 2016. Concurrently, employment in the transportation and material moving occupations decreased relative to the size of the population aged 25 and older during the period in which the comparison group likely entered the labor market, and increased during the period in which the treatment group likely entered it. These changes would tend to produce results opposite to what we find; however, they would have led to artificially high labor market outcomes for LINCS students completing certification track courses, and thus to artificially high

impacts. Although other labor market factors that were not captured in this study—like an increasing supply of labor market entrants as a falling unemployment rate brings discouraged workers back into the labor market, or increasing demand for skills—might have had a dampening effect on the employment and earnings of the treatment group, it seems unlikely that labor market changes are responsible for the insignificant impact of the LINCS program given improvements in the labor market.

Figure III.1. Miami–Fort Lauderdale–West Palm Beach labor market



Source: Bureau of Labor Statistics, Local Area Unemployment Statistics (https://www.bls.gov/lau/malrgrank14.htm, /malrgrank15.htm, and /malrgrank16.htm) and Occupational Employment Statistics (https://www.bls.gov/oes/tables.htm).

A third possibility is that recruiting shifts changed the average employability of students taking SCM courses during 2015. Two changes occurred. First, intensive recruiting for LINCS targeted both existing SCM students as well as those who may not have attempted SCM courses without encouragement (Bruch et al. 2017). Specifically, the project staff at Broward College recruited by promoting the program to for-credit SCM students, discussing it at the CSCMP South Florida roundtable and with local veteran-affiliated organizations, and sending email blasts to CSCMP local members and affiliates. The college's local Urban League affiliate also promoted the program on its website and engaged in direct recruitment efforts. Second, Broward College started SCM Express, a cohort-based accelerated bachelor's degree program. It increased recruiting efforts for this complementary program in 2015 (see Appendix C for discussion). Both of these recruiting changes might have produced a different group of students in the treatment group relative to the comparison group, and in fact, our analysis does show differences in the characteristics of the two groups. Some of the differences suggest that treatment group students had characteristics that would make them more likely to succeed in the labor market than the comparison group students (particularly higher employment and earnings coming before enrolling in certification track courses). This would tend to produce results opposite to what we find: artificially high labor market outcomes for LINCS students completing certification track courses, and artificially high impacts. Thus, it is unlikely that the changing composition of students is responsible for the insignificant impact of the LINCS program.

A fourth possibility is that the treatment group differed from the population of people taking LINCS certification programs in ways that affected the analysis of employment and earnings. As Appendix B discusses, and Figure B.1 in that Appendix shows, only 150 of the 3,295 students who had participated in at least one certification track course by July 31, 2016 were included in the impact investigation. Because the criteria for including individuals in the impact investigation systematically excluded groups with different characteristics from those included (for example, students at eight of the nine colleges and all noncredit participants), results might have differed if a more representative group of students were subject to analysis.

A final possibility is that study design limitations precluded us from accurately estimating the LINCS program impacts. In particular, limitations may exist in the following areas.

- **Early stages of implementation.** Because we observed students participating in LINCS during the program's earlier stages of implementation, we could only observe outcomes associated with four areas of certification (SCM principles, customer service, warehousing operations, and transportation operations). Students in the study might not have received the full benefits of the LINCS program in these areas and impacts may have been stronger in other areas. This design limitation explanation seems unlikely to account for the absence of impacts on employment and earnings, however. Broward College had fully implemented certification track courses in the first four areas (Appendix C, Table C.2), CSCMP had implemented certification examinations in the areas, and neither were expected to change substantially. Further, the areas in which these courses and examinations were implemented were those in which students were most likely enroll even in later terms and those most valued by employers (Bruch et al. 2017).

- **Students still enrolled.** Because some students were enrolled in the program when the study stopped, they might have depressed employment and earnings. Even though we include controls for enrollment in our estimations, those currently enrolled might have more labor market potential (which we cannot control for), thus producing artificially low levels of employment and earnings. This explanation also seems implausible, however, because members of the treatment and comparison groups were still enrolled in college at similar rates (65.3 and 62.1 percent, respectively). Their similar levels of enrollment suggests that our estimations might have captured this dampening effect on employment and earnings for both groups.

- **Impacts estimated only at Broward College.** The impact investigation was conducted only for students at Broward College enrolled in academic programs. If associations between LINCS participation and employment and earnings for Broward College were different from the associations for other colleges, the study could show no estimated impacts of LINCS at Broward College, even if LINCS had an impact for Consortium colleges as a whole. However, results of the outcomes investigation suggest that student characteristics and LINCS participation at Broward College were similar to those at other colleges, as were the associations of student characteristics and LINCS participation with outcomes following LINCS participation. Thus, this explanation also seems unlikely to account for the lack of impacts on employment and earnings.

The seeming implausibility of the labor market, intensive recruiting, and study design limitations as reasons for the LINCS program's insignificant impacts on employment and earnings leaves two potential explanations: the shifting of workers into SCM jobs and the selected sample analyzed. We note that the explanation of shifting workers into SCM jobs is consistent with the goal of the LINCS program to increase the number of workers with the knowledge and skills needed to fill entry- and mid-level positions in SCM jobs. The program was not necessarily established as a program to improve participants' labor market outcomes, although that outcome was certainly a possibility, given the need for appropriately skilled workers in SCM positions. LINCS surpassed its enrollment targets for program completion (Bruch et al. 2017), demonstrating program success in the short term. Whether it also increases participants' employment and earnings in the longer term is a question that this study cannot address.

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APPENDIX A. DEFINITIONS OF TERMS

This appendix provides a centralized resource for readers to look up the definitions of key terms used in the report, eliminating the need to define terms repeatedly and thereby improving the exposition of the text. In Table A.1, we present an alphabetical list of terms.

Table A.1. Definition of terms

Term	Definition
Baseline equivalence	The similarity between two groups before program services begin (for example, the similarity between members of a treatment group and a comparison group).
Comparison group	A group of people similar to those in the treatment group except that they did not participate in the program. The group's outcome represents an approximation of what would have happened to members of the treatment group without the program.
Descriptive statistics, including regression adjustments	Measures that describe characteristics or outcomes. They include measures of central tendency (for example, mean and median) and measures of variation or dispersion (for example, standard deviation and minimum and maximum values). Statistics may be regression-adjusted, meaning that the average or percent (for example) accounts for differences in characteristics across individuals by using regression analysis.
Impact	An estimate of the difference between the average outcome following program participation and the average outcome that would have occurred had the individuals not participated in the program. Impacts are estimated by comparing the outcomes of members of the treatment group with those of members of a comparison group.
Post-only design	An approach that measures the average outcome after participants complete a program (for example, employment after completing the first certification track course).
Pre-post design	An approach that measures the average change that occurred between the time participants started a program and after participants completed it (for example, between employment before enrolling in the first certification track course and employment after completing the course).
Quasi-experimental design	An approach that compares the outcomes of a group of program participants (treatment group) with those of a similar group that did not participate in the program (comparison group). The rigor of the design is determined by the baseline equivalence of the two groups because participants were not randomly assigned to the treatment and comparison groups and because researchers cannot control for other conditions that may affect outcomes for the groups.
Regression analysis	A statistical technique for estimating the relationships between variables. It focuses on estimating changes in the average value of the outcome or dependent variable (for example, earnings) associated with changes in any one of the explanatory or independent variables (for example, attaining a certification) while other explanatory variables (for example, demographic characteristics) remain fixed. The variables that remain fixed are called statistical controls (see definition below).
Statistical controls	Variables included in regression analysis to help isolate the relationship between an outcome or dependent variable and a key explanatory variable. For example, a regression analysis that estimates the relationship between employment and LINCS participation would include statistical controls for other factors that might also affect employment, such as demographic characteristics and the local area unemployment rate.
Statistical significance	Statistical significance is the probability that a statistical test will indicate a false positive relationship or type I error. A false positive means that the analysis indicates a relationship when in fact none exists. By convention, we define a statistically significant result as one with a probability less than or equal to 5 percent of a false positive occurring (often written as $p \leq 0.05$).
Treatment group	A group of people who participated in the program. Their outcomes are compared to those of members of a comparison group to estimate the program's impact.

APPENDIX B. SAMPLES AND DATA

The outcomes and impact study involves two distinct investigations. The outcomes investigation examines labor market outcomes among a group of students who completed a LINCS certification track course. The impact investigation uses a quasi-experimental design (QED) to compare employment and earnings for a group of students who completed a LINCS certification track course with those of similar students who complete an SCM course without LINCS augmentation (Appendix C provides details). In this appendix, we describe the colleges and students included in the study (Section A) and the data used in analysis (Section B).

A. Colleges and students in the study

To be included in the outcomes and impact study, colleges had to provide data on outcomes. The labor market outcomes examined in the study—employment and earnings—came from unemployment insurance (UI) wage record data. Only five of the nine colleges could provide UI data for students at their college: Broward College, Columbus State Community College, Florida State College at Jacksonville (FSCJ), Harper College, and St. Petersburg College. At the other four colleges, program leads were unable to obtain state workforce agency contracts for UI data and administered surveys to students to obtain information on employment and earnings. Given that the surveys did not request information comparable to that in the UI wage records, we could not use the survey-based information in the outcomes and impact study.[4] UI data for students enrolled in LINCS through self-study outside the Consortium colleges were not available.

For colleges that could supply UI data, Mathematica placed three restrictions on students for inclusion in the study:

1. **Completed certification track course.** Mathematica restricted inclusion to students who completed a course in supply chain management (SCM) with content developed by the LINCS Consortium; we called such a course a certification track course. This restriction excluded students who enrolled in but did not complete such courses, thereby ensuring that students had some exposure to the LINCS content and did not (for example) enroll in the course and never attend a class. We defined completion as passing a course with a grade D or higher or a Pass designation.
2. **Course completion during calendar year 2015.** Because September 2016 was the last month for which UI data could be obtained, analyzed, and reported within the grant funding period, students must have completed a certification track course in calendar year 2015. This

[4] In addition, survey data are missing for more than 40 percent of students at each college and are not comparable across colleges because of the use of different survey methods and instruments. These colleges used a number of approaches and data collection instruments to obtain self-reported employment data from participants to address a variety of difficulties in obtaining UI wage data. Union County College used a combination of online data collection surveys and forms and follow-up phone calls because they were unable to obtain UI wage data in time for the report. San Jacinto Community College used Survey Monkey, individual emails, meetings and phone calls because the State of Texas would not provide the requested wage data. Essex County College used an online survey at enrollment, individual emails, and phone calls because they were unable to obtain UI wage data in time for the report. Long Beach City College used a combination of emailed online surveys and follow-up phone calls to obtain employment and wage data as they were unable to access individual-level data from the State of California.

timing has implications for which certification tracks students completed. Although all content developed for the certification tracks was released to colleges during 2015, different tracks were released at different times of the year. The first wave was released from January to May 2015 and the second wave from July to August 2015. Because more students had an opportunity to take courses in the tracks released in the first wave, the outcomes investigation best reflects students who completed certification track courses in supply chain management principles, transportation operations, warehousing operations, and customer service operations and the impact investigation includes only students who completed these tracks (Appendix C).

Two waves of development

Wave 1: January–May 2015

- Supply Chain Management Principles
- Transportation Operations
- Warehousing Operations
- Customer Service Operations

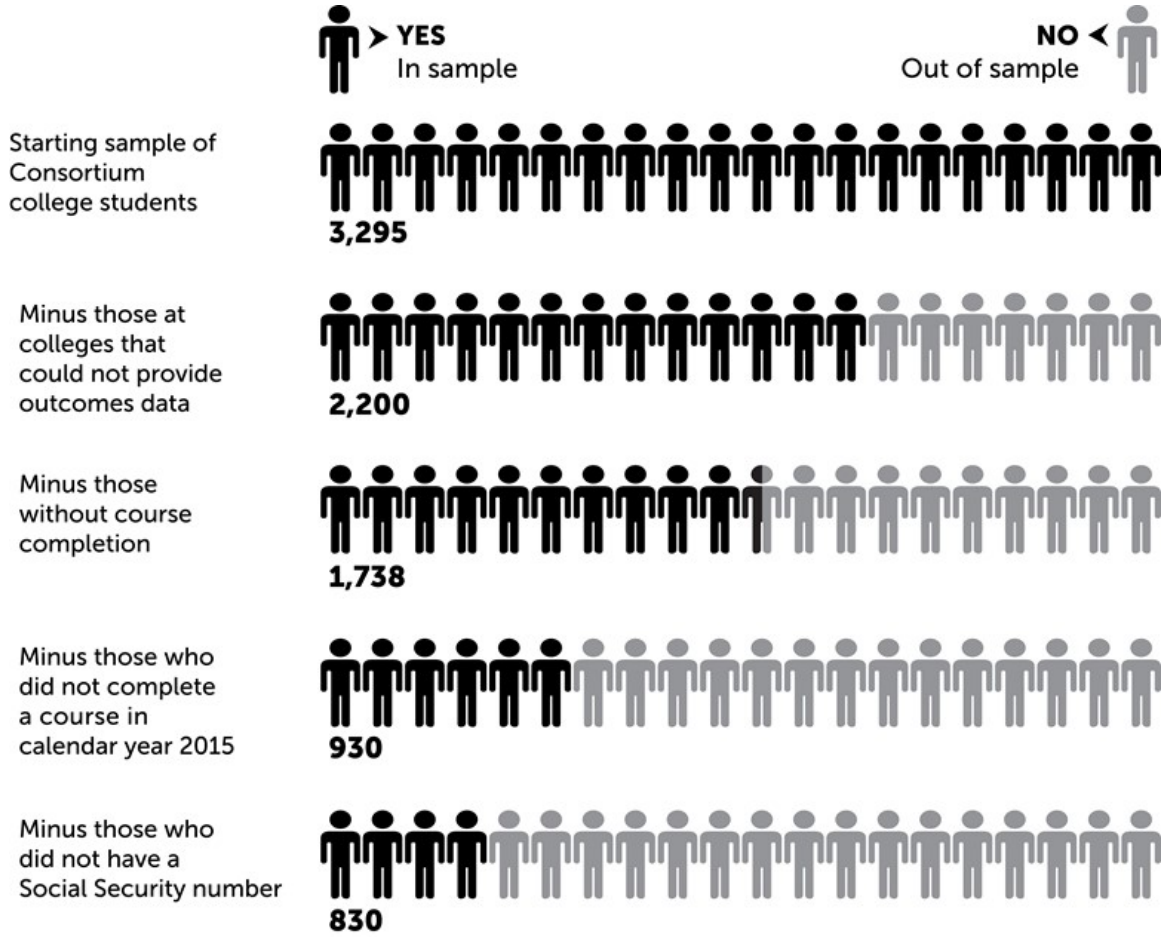
Wave 2: July–August 2015

- Demand Planning
- Inventory Management
- Manufacturing and Service Operations
- Supply management and Procurement

3. **Valid Social Security number.** If colleges did not have a valid Social Security number for a student, UI wage record data could not be obtained.

As a result of these restrictions, the outcomes investigation includes 830 of the 3,295 students at the nine Consortium colleges who began participating in LINCS before August 1, 2016. In Figure B.1, we show how students were excluded.

Figure B.1. Identifying students in the outcomes investigation



Note: The *Starting sample of Consortium college students* row shows the 3,295 students across the nine Consortium colleges who began participating in LINCS before August 1, 2016. It does not include the 121 students from the LINCS Central database (Bruch et al. 2017, Appendix B). The next row excludes those students who were enrolled at the Essex County College, Long Beach City College, San Jacinto Community College or Union County College, none of which could access unemployment insurance (UI) wage records in their state. The row *Minus those without course completion* excludes students who did not have courses or had failing or missing grades in their certification track course. Most of these students excluded (345 of 462) had some indication of participation (for example, they had an access date in the Consortium's learning management system or a supplemental application) but did not have course data. The *Minus those who did not complete a course in calendar year 2015* row excludes those students who completed a certification track course in calendar year 2014 or 2016, and the *Minus those who did not have a Social Security number* row excludes students for whom the college could not access their UI wage record data because they did not have a valid Social Security number on file.

The impact investigation placed two additional restrictions on college inclusion. To examine program impacts, one can compare outcomes for people who participated in a program to outcomes for those who continued with "business as usual" (called the counterfactual). For the LINCS evaluation, the impact investigation compared outcomes for students who participated in LINCS (called the **treatment group**) to similar students who did not participate in LINCS (called the **comparison group**), requiring colleges to provide equivalent information for members of both the treatment and comparison groups. The following two conditions had to be satisfied to ensure the provision of equivalent information:

1. **The existence of a counterfactual condition in which students might take part in the absence of LINCS.** The ideal comparison would examine students who completed LINCS certification track courses in 2015 (in the outcomes investigation) versus students who completed existing SCM courses that did not include LINCS content during the same period. Unfortunately, no college continued to offer comparable SCM courses without LINCS content. The evaluation team, in agreement with the National Program Office, decided to use 2014 as the period for the counterfactual SCM courses because LINCS had not yet altered SCM courses. Columbus State Community College was removed from the impact investigation because it offered one-credit courses with LINCS content, rather than incorporating LINCS content into existing three-credit courses. The requirement also eliminated Florida State College at Jacksonville, which did not embed LINCS content into its existing academic courses.
2. **Availability of outcomes and course record information for the comparison group.** All five colleges that were able to provide UI outcomes data were potentially eligible for inclusion in the impact investigation. Columbus State could not provide UI wage record data for students before they started a certification track course; these data were needed in the impact investigation to establish baseline equivalence (see Appendix C). As a result, Columbus State could not be included in the impact investigation. Two additional colleges could not provide UI wage record data for a comparison group of students. Harper College did not collect Social Security numbers for students in SCM courses in 2014, and St. Petersburg College offered only noncredit SCM classes in 2014 and, as a result, did not have full school record data on the potential comparison students.

These two additional restrictions for the impact investigation left only Broward College in the impact investigation.

B. Data

Mathematica specified needed data elements for each college, and the colleges compiled the data from a variety of sources (Table B.1), including college administrative records, certification examination records provided to the colleges by the Council of Supply Chain Management Professionals (CSCMP), and UI wage records. In addition, Mathematica obtained information on local area unemployment rates from data published by the Bureau of Labor Statistics.

Table B.1. Sources of data

Type of student data	Data source(s)
Student background	
Demographic and background characteristics	• College student record systems • Program intake forms/supplemental applications
Education	• College student record systems • Student course records
Environment	
Unemployment rate	• Bureau of Labor Statistics Local Area Unemployment Statistics (http://www.bls.gov/lau/lamtrk15.htm; see also /lamtrk14 and /lamtrk16)
LINCS participation	
Course-taking data	• College student record systems
Certification examination data	• Council of Supply Chain Management Professionals
Outcomes (baseline and following completion)	
Employment and earnings	• Unemployment insurance wage records

Mathematica ensured accuracy in data collection and consistency across colleges in the construction of variables for use in the analysis by:

- **Developing a data dictionary** for each college, which defined each data element requested
- **Holding several rounds of calls** with college program leaders and staff in research offices to review the data dictionary, discuss any data gaps or challenges, and establish processes for data collection and submission
- **Providing a customized data request memorandum and conducting presentations** to review the data requested, including specific college sources for data elements and issues with collecting them, and the instructions for submitting data through Mathematica's secure file transfer site
- **Providing ad hoc guidance and other technical assistance** tailored to the needs and capacities of each college

Mathematica prepared the submitted data in three steps. First, we conducted diagnostic checks to address immediate issues, such as failure to include all students, or requested data elements. We asked colleges to provide replacement or supplemental files as needed. Second, we cleaned and standardized data across colleges and conducted another round of diagnostic checks, following up with colleges as needed. Third, we constructed and conducted final quality assurance checks on the file created for analysis and made corrections as needed.

1. Variables

The data analyzed for the study included information on (1) student background characteristics, (2) environment, (3) LINCS participation, (4) outcomes at baseline (that is, before the start of a LINCS certification track or SCM course), (5) outcomes after completing the first LINCS certification track or SCM course, and (6) control variables. In Table B.2, we define the variables used in analyses, using italics to reference a variable name.

Table B.2. Variable definitions

Variable name	Definition
Student background characteristics	
Demographics	
Male	A 0, 1 variable with 1 indicating a male and 0 indicating a female.
Age	The student's age at the time of enrolling in the first certification track or SCM course. Age was set to the mean for students at St. Petersburg who did not have age information reported.
Youth	A 0, 1 variable with 1 indicating a student whose *age* is less than 25 and 0 indicating a student who is at least 25 (that is, adult).
Race/ethnicity	
Hispanic	A 0, 1 variable with 1 indicating self-identification as Hispanic and 0 indicating someone who did not indicate Hispanic ethnicity.
Asian	A 0, 1 variable with 1 indicating self-identification as an Asian or Pacific Islander and not Hispanic and 0 indicating someone who did not indicate an *Asian* race or *Hispanic* ethnicity.
Black	A 0, 1 variable with 1 indicating self-identification as a black or African American and not Hispanic and 0 indicating someone who did not indicate a *Black* race or *Hispanic* ethnicity.
White	A 0, 1 variable with 1 indicating self-identification as white and not Hispanic and 0 indicating someone who did not indicate a *White* race or *Hispanic* ethnicity.
Other race	A 0, 1 variable with 1 indicating self-identification as a race or ethnicity other than *Hispanic, Asian, black*, or *white* or indicating several races and 0 indicating someone who identified one of the race/ethnicity categories or who had missing race/ethnicity information.
Education	
No diploma	A 0, 1 variable with 1 indicating the highest level of education attained not including a high school diploma or GED and 0 indicating a high school diploma or GED.
High school diploma	A 0, 1 variable with 1 indicating that the highest level of education was a high school diploma or GED and 0 indicating all other attainment levels. In the impact investigation, 1 indicates that the highest level of education was a high school diploma, and 0 indicates *no diploma* or that the highest level of education was an *associate's* degree or bachelor's degree.
Associate's degree	A 0, 1 variable with 1 indicating the highest level of education was an associate's degree and 0 indicating all other attainment levels.
Bachelor's degree	A 0, 1 variable with 1 indicating the highest level of education attained was a bachelor's or post-baccalaureate degree and 0 indicating all other education attainment levels.
Other characteristics	
Incumbent worker	A 0, 1 variable with 1 indicating employment in the quarter before enrolling in the first certification track or SCM course and 0 indicating no employment indicated at that time. Employment is indicated by non-zero earnings in UI wage data for all colleges except Columbus State, for which employment was indicated by data provided by the college's LINCS program lead.
TAA-eligible	A 0, 1 variable with 1 indicating receipt of Trade Adjustment Assistance benefits during enrollment in certification track or SCM courses and 0 indicating no TAA benefit receipt.
Veteran	A 0, 1 variable with 1 indicating a veteran and 0 indicating not a veteran.
Person with a disability	A 0, 1 variable with 1 indicating a self-reported disability during enrollment in certification track or SCM courses and 0 indicating no reported disability.
Environment	
Unemployment rate	A continuous variable for the prevailing unemployment rate in the metropolitan statistical area of the college in the month following completion of the first certification track course.
College	
Broward	A 0, 1 variable with 1 indicating enrollment in a certification track course at Broward College and 0 indicating enrollment at a different college.
Columbus State	A 0, 1 variable with 1 indicating enrollment in a certification track course at Columbus State Community College and 0 indicating enrollment at a different college.
FSCJ	A 0, 1 variable with 1 indicating enrollment in a certification track course at Florida State College at Jacksonville and 0 indicating enrollment at a different college.
Harper	A 0, 1 variable with 1 indicating enrollment in a certification track course at Harper College and indicating enrollment at a different college.
St. Petersburg	A 0, 1 variable with 1 indicating enrollment in a certification track course at St. Petersburg College and 0 indicating enrollment at a different college.

Variable name	Definition
LINCS participation	
Number of certification track courses completed	
Courses one academic term	A continuous variable measuring the number of certification track courses a participant completed by one academic term after completion of first certification track course.
Courses two academic terms	A continuous variable measuring the number of certification track courses a participant completed by two academic terms after completion of first certification track course.
SCPro™ Fundamentals certification	
Certified one academic term	A 0, 1 variable with 1 indicating attainment of a SCPro™ Fundamentals certification (certifications) within one academic term after completing the first certification track course and 0 indicating no certifications in that period.
Certified two academic terms	A 0, 1 variable with 1 indicating attainment of a certification within two academic terms of completing the first certification track course and 0 indicating no certifications in that period.
One certification	A 0, 1 variable with 1 indicating attainment of one certification within two academic terms of completing the first certification track course and 0 indicating no certification or more than one certification in that period.
Two certifications	A 0, 1 variable with 1 indicating attainment of two certifications within two academic terms of completing the first certification track course and 0 indicating no certification, one certification, or more than two certifications in that period.
Three or more certifications	A 0, 1 variable with 1 indicating attainment of three or more certifications within two academic terms of completing the first certification track course and 0 indicating fewer than three certifications in that period.
Outcomes at baseline	
Employment first previous quarter	A 0, 1 variable with 1 indicating employment in the quarter before enrolling in the first certification track or SCM course and 0 indicating no employment during that quarter.
Employment three previous quarters	A 0, 1 variable with 1 indicating employment in the three quarters before enrolling in the first certification track or SCM course and 0 indicating no employment during those quarters.
Average three-quarter previous earnings	The average quarterly earnings, in 2016 dollars, in the three quarters before enrolling in the first certification track or SCM course. In UI data, we assume 0 if no employment was reported.
Outcomes following course completion	
Employment first quarter	A 0, 1 variable with 1 indicating employment in the first quarter after completing the first certification track or SCM course and 0 indicating no employment during that quarter.
Employment three quarters	A 0, 1 variable with 1 indicating employment in the three quarters after completing the first certification track or SCM course and 0 indicating no employment during those quarters.
Average three-quarter earnings	The average quarterly earnings, in 2016 dollars, in the three quarters after completing the first certification track or SCM course. We assume 0 if no earnings were reported.
Control variables	
Missing value indicators	A set of 0, 1 variables corresponding to each student background variable with 1 indicating that the corresponding age, race, and incumbent worker is missing and 0 indicating that it is not missing.
Continuing enrollment	
Enrolled first term	A 0, 1 variable with 1 indicating enrollment at the college one academic term after completing the first certification track or SCM course and 0 indicating no enrollment during that term.
Enrolled second term	A 0, 1 variable with 1 indicating enrollment at the college two academic terms after completing the first certification track or SCM course and 0 indicating no enrollment during that term.

Student background characteristics variables. Individual-level student background characteristics, including demographics, education, and other characteristics, are measured at the time students enrolled in the first certification track or SCM course that they completed. When data were missing at that time, Mathematica used information from subsequent periods to indicate that a student ever had the status while enrolled in certification track or SCM courses.

Of note, we captured data for some variables (high school diploma, veteran, person with a disability, prior degree) only as "yes" and blank for the comparison group (that is, we were unable to distinguish between "no" and missing data). Although we could distinguish between a "no" response and missing data for the treatment group, we had to capture the variables in the same way for the treatment and comparison groups to eliminate measurement bias. As a result, we sometimes had to define variables differently in the outcomes and impact investigations. In addition, TAA eligibility is not available for the comparison group and therefore not used in the impact investigation.

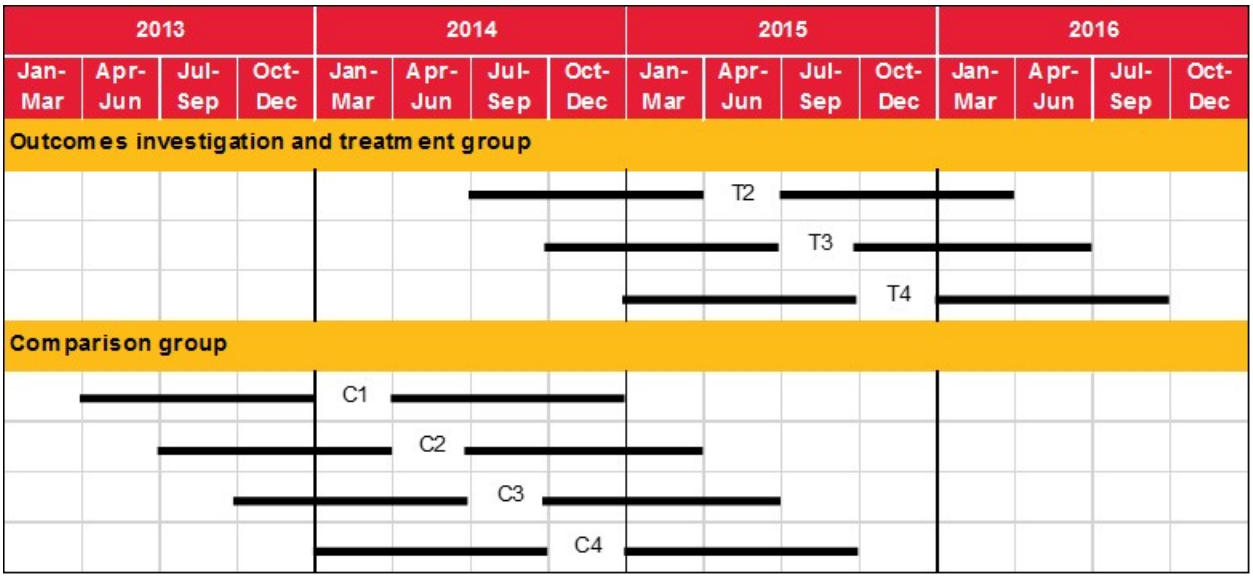
Environment variables. The outcomes and impact study contains two types of variables capturing environmental factors. The unemployment rate captures the availability of jobs in the local labor market, as defined by the metropolitan statistical area of the college in the quarter after completing the first certification track or SCM course. The college in which a student completed courses captures the educational environment in which the certification track courses were completed and accounts for any other factors varying at the college level.

LINCS participation variables. LINCS participation variables indicate the number of certification track courses completed and SCPro™ Fundamentals certifications attained. Both are captured within one and two academic terms after the term in which the first certification track course was completed.

Outcomes at baseline variables. Because **s**tudents have different knowledge, skills, and abilities when they enroll in SCM courses and these characteristics—and not SCM coursework—might influence employment and earnings, we developed measures for them in order to statistically control for them in our multivariate analysis. These measures include employment and earnings during the three quarters before a student enrolled in an SCM course.

Outcomes following course completion variables. The outcomes and impact study follows students for as long as possible given data availability. UI wage data provide information on quarterly employment and earnings through the third calendar quarter of 2016 (given the six- to nine-month lag in data availability). This period allows us to capture labor market outcomes for up to three quarters after completion of the first certification track or SCM course for all students completing a certification track course in 2015 or selected SCM course in 2014. In Figure B.2, we show the periods in which we followed outcomes for students in the outcomes investigation and the treatment group in the impact investigation (T) and for students in the comparison group in the impact investigation (C). The numbers in the figure designate the quarter of the calendar year in which students completed a certification track course (for those in T) or an SCM course (for those in C) and present a starting point for the timing of data collection. For example, for comparison group students completing a course in the first quarter of the calendar year, we have captured outcomes from April to December of that same year and baseline data (discussed above) from April to December of the previous year.

Figure B.2. Timing for employment and earnings outcomes



Note: T2 through T4 and C1 through C4 designate the quarter in which students in the outcomes investigation or treatment group (T) completed a certification track course or students in the comparison group (C) completed a supply chain management course. (T1 was not possible because the program was not yet implemented). Horizontal lines to the right of the T or C indicate the quarters for which we captured outcomes, and those to the left of T or C indicate the quarters for which we captured baseline measures.

Other control variables. When using multivariate estimation techniques, it is important to control statistically for factors that might affect outcomes or that allow us to maintain our sample sizes (Appendix D). In these estimations, we control for two such conditions. First, we control for whether a student is still enrolled in college after completing the first certification track or SCM course; outcomes may be lower because the student is still in school. Second, we include students in the analysis even if they have missing data (discussed in the next section) by assigning them either a zero or the average value of the variable (for age and youth) and including a missing value indicator for the variable in the estimation.

2. Missing data

In Table B.4, we show rates of missing data for all colleges and for each college in the outcomes investigation, and for the treatment and comparison groups in the impact investigation. We do not include data on education, TAA eligibility, veteran status, person with a disability, environmental variables, LINCS participation variables, other control variables, outcomes at baseline, or outcomes following completion because they were not missing. At the same time, some types of information (for example, Pell Grant receipt, Pell Grant eligibility) are not included in the table or in the study because of high rates of missing data. Of note, rates of missing data differ between the outcomes and impact investigations because of the different construction of variables (Table B.1). In general, rates of missing data are generally under 5 percent, although rates are relatively high for St. Petersburg College and, to a lesser extent, for race/ethnicity at Columbus State.

Table B.3. Missing data (percent, unless specified)

	Outcomes						Impact		
	All five colleges	Broward	Columbus State	FSCJ	Harper	St. Petersburg	All	Treatment	Comparison
Demographics									
Male	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.0
Age (and youth)	3.0	0.0	0.0	0.0	0.0	18.0	0.0	0.0	0.0
Race/ethnicity									
Hispanic	5.9	2.7	7.2	1.3	1.4	23.0	2.8	2.7	2.9
Asian	5.9	2.7	7.2	1.3	1.4	23.0	2.8	2.7	2.9
Black	5.9	2.7	7.2	1.3	1.4	23.0	2.8	2.7	2.9
White	5.9	2.7	7.2	1.3	1.4	23.0	2.8	2.7	2.9
Other race	5.9	2.7	7.2	1.3	1.4	23.0	2.8	2.7	2.9
Other characteristics									
Incumbent worker	0.4	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0
Sample size	830	150	97	375	69	139	253	150	103

3. Data limitations

Although the data provided by the colleges were the most accurate data available, they have limitations that should be noted when interpreting findings:

- **Outcomes captured within a short period.** The study follows students for three calendar quarters after completing the first certification track or SCM course. This time frame provides insights into short-term outcomes but does not provide information about how participation in LINCS through certification track courses or SCPro™ Fundamentals certifications might improve outcomes over a longer period as, for example, employers come to recognize certifications.
- **LINCS was in its early stages during the study period.** Because UI wage data have a six- to nine-month lag in availability, completion of certification track courses must have occurred in calendar year 2015 for the study to capture employment and earnings outcomes in the three quarters following completion. However, LINCS was still undergoing development during that period (for example, content for certification track courses was rolled out from January to August 2015). As a result, estimated associations may understate those that might have occurred when the program was more mature.
- **Lack of generalizability.** Results of the outcomes and impact study are time- and place-specific. The outcomes investigation is based on students at five Consortium colleges, and the impact investigation is based on students at Broward College; results may not be generalizable to other colleges or to other time periods.

In addition, although the UI wage data are a relatively cost-effective way for colleges and researchers to track students' employment outcomes, they contain some well-known limitations (Feldbaum and Harmon 2012). In particular, they:

- **May undercount employment because they do not include:**
  - *All people in the labor force.* They exclude agricultural, military, and federal civilian and railroad employees and the self-employed.
  - *Individuals in the underground economy.* With the data based on employers' payments into the UI system, they do not include information on individuals who work outside the legal channels for reporting wages.
  - *Those employed out of the state.* Because each state maintains their own UI wage record databases, data do not include earnings for individuals who work out of state.

- **Cannot precisely capture earnings because they do not include:**
  - *Direct information on employment and jobs.* The absence of earnings is not the same as not being employed but must be interpreted as such because the UI wage record data do not contain information on employment. They also do not include the exact date an employee starts a job, making it impossible to determine if low quarterly earnings result from employment obtained at the end of the quarter or from a low hourly wage. It is also not possible to determine if employment was in the SCM sector because SCM jobs span many industries, and UI wage record data do not have information about the occupation or job that was the source of earnings.
  - *Hours worked.* Although some states require employers to report employee hours worked during each quarter, most do not. As a result, it is not possible to compute accurate measures of hourly wage rates consistently across states. Without data on hours, a worker employed full-time throughout a quarter will appear to have been paid at a much higher rate than a worker employed part-time throughout the quarter. For this reason, we cannot analyze hourly wage rate as an outcome.

APPENDIX C. IMPACT INVESTIGATION DESIGN

The quasi-experimental design (QED) impact investigation compared the outcomes of a treatment group of students who completed a LINCS certification track course in 2015 with those of a comparison group of students who completed an SCM course in 2014 without LINCS content. We selected the comparison group to provide an estimate of the counterfactual condition—what would have happened to the treatment group in the absence of LINCS. Because it was not feasible to randomly assign students into treatment and comparison groups, which is necessary for a randomized controlled trial, Mathematica adopted a QED approach.

Three key conditions must be present for a QED impact analysis to estimate a causal impact:

1. A **distinctive counterfactual** must exist such that the treatment and the counterfactual conditions differ. In the impact investigation, the treatment condition is the LINCS program, and the counterfactual condition is composed of the SCM courses at Broward College before LINCS content was included.
2. The treatment and comparison groups must exhibit **baseline equivalence**. In other words, the treatment group must be identical to the comparison group before they complete a certification track or SCM course.
3. There must be **no confounding factors** that affect outcomes for all students in the treatment group or all students in the comparison group other than the LINCS program. In the impact investigation, a changing labor market or education environment (for example) could produce confounding factors.

Here, we describe the strength of the design of the impact investigation with respect to the following conditions: a clear counterfactual (Section A), baseline equivalence (Section B), and confounding factors (Section C). In the final section (Section D), we discuss the limitations of the investigation.

A. Distinctive counterfactual

In 2014 and 2015, Broward College offered a range of SCM courses that were part of three SCM credential programs: (1) a Logistics and Transportation Specialist Technical certificate, (2) an Associate of Science degree in SCM Operations, and a (3) Bachelor of Applied Science degree in SCM. LINCS introduced three changes to courses in these SCM programs in 2015. As shown in column 1 of Table C.1, the college enhanced recruitment practices for certification track courses, developed new career support services for students enrolled in the courses, and embedded certification track content into course offerings. These changes might have influenced the impact investigation in several ways. Changes in recruiting students might have changed the characteristics of students enrolling in the courses (for example, they may have more education) and thus created differences in outcomes due to differences in characteristics and not LINCS. Changes in support services and the integration of LINCS content into SCM courses were both designed to improve student outcomes and potentially produce program impacts.

Table C.1. Overview of comparison and intervention conditions at Broward

	Treatment condition	Comparison condition
Recruitment activities	- General recruitment activities - Outreach to CSCMP roundtable, CSCMP local members and affiliates, local veteran-affiliated organizations - Promotion of LINCS program on local Urban League affiliate website	- General recruitment activities
Support services available	- College student support and job placement services - Two grant-funded job placement specialists for students in certification track courses	- College student support and job placement services
SCM courses offered	- 13 SCM courses - Four courses with LINCS content	- 12 SCM courses - No course with LINCS content

Source: Broward College course catalogues (http://www.broward.edu/catalog/Pages/default.aspx) and Broward College LINCS program lead.

Note: Table shows the recruitment activities, support services, and SCM courses offered in calendar years 2015 (treatment condition) and 2014 (comparison condition).

CSCMP = Council of Supply Chain Management Professionals

- **Recruitment practices.** Beyond the typical recruitment activities used for SCM programs before the grant period, Broward College used external organizations to promote LINCS. Project staff discussed the program at the Council of Supply Chain Management Professionals (CSCMP) South Florida roundtable and with local veteran-affiliated organizations and sent email blasts to CSCMP local members and affiliates. The college's local Urban League affiliate also promoted the program on its website and in other outreach activities.
- **Student supports.** Broward College used grant funds to hire two full-time job placement specialists who served only students enrolled in LINCS certification track courses. The specialists helped students write resumes and develop nonacademic professional skills and sought to set up internships and job interviews with local employers. Students enrolled in certification track courses also had access to support from professors and through the college's academic success center and career services office; similar services were available to students in the comparison group in 2014.
- **Certification track changes.** When the Consortium released the content for the first four certification tracks in January to May 2015, Broward College embedded the tracks into existing courses and created a new course (Table C.2). The LINCS program lead identified four SCM courses as similar to the certification track courses in 2014. Because the courses covered similar topics and were part of similar credential programs, Mathematica used them to identify students in the comparison group. Three of the four comparison courses underwent modification in 2015 to include LINCS content (the other was altered in 2016). In addition to content changes, three of the four certification track courses were offered fully online, as well as in the blended (in person and online) mode offered in 2014. Other aspects of the (blended) courses remained relatively stable between 2014 and 2015.[5]

[5] For example, in the spring and fall terms in both years, courses were offered for three hours per week in class and three hours per week online, over eight weeks. Summer courses were offered for three to four hours per week in

Table C.2. Defining comparison and treatment groups: SCM-track courses

	SCM course aligned with certification track	Course used to identify		Course mode of instruction	
		Treatment group?	Comparison group?	Treatment condition	Counterfactual condition
Certification tracks offered for credit in 2015					
Customer service operations	Seminar/special topics	Yes	Yes	Blended and fully online	Blended
Supply chain management principles	Supply chain management	Yes	Yes	Blended and fully online	Blended
Transportation operations	Introduction to transportation and logistics	Yes	Yes	Blended and fully online	Blended
Warehousing operations	Warehouse operations	Yes	No, created in 2015	Blended	n.a.
Certification tracks offered not for credit in 2015					
Demand planning	None	No, self-study in 2015	No	n.a.	n.a.
Inventory management	None	No, self-study in 2015	No	n.a.	n.a.
Manufacturing and service operations	None	No, self-study in 2015	No	n.a.	n.a.

Source: Broward College LINCS program lead.

Note: We used the given courses offered in 2015 to identify the treatment group and the courses offered in 2014 to identify the comparison group. Blended indicates that the instruction involved both in person and online components.

n.a. = not applicable

Given that all SCM courses could potentially improve employment and earnings, and considering that we found students in the treatment group took more SCM courses than students in the comparison group (Appendix E, Table E.5), we recognized that the improved labor market outcomes might have resulted from the greater SCM coursework and not from LINCS. In the top panel of Table C.3, we show the percent of the treatment and comparison students who completed SCM courses in certification track course areas. We demonstrate that students in the treatment group were more likely to complete courses related to SCM principles and warehousing while students in the comparison group were more likely to complete courses in customer service. In the bottom panel of Table C.3, we show that treatment students were somewhat less likely to complete SCM courses in topic areas outside those covered in certification track courses, which is consistent with comparison group students being enrolled in degree programs.

Of note, overlap exists between course enrollment for students in the treatment and comparison groups. Specifically, 22 students in the treatment group completed one or more of the four SCM courses designated for identifying the comparison group in 2014, and 22 students in the comparison group completed a certification track course in 2016. Thirteen of the comparison group students who enrolled in certification track courses and one additional student earned a

class and four to five hours per week online, over six weeks. The same three faculty members taught all courses, in addition to three adjunct faculty members hired under the grant.

certification after the third quarter of 2015. Their participation in LINCS could not have affected our impact investigation because the coursework occurred after we measured outcomes.

Table C.3. Supply chain management course completion for students in the treatment and comparison groups (percent, unless noted)

	Treatment group	Comparison group
SCM courses used to identify treatment and comparison groups		
Customer service operations	16.0#	24.3
Supply chain management principles	88.0#	66.0
Supply management and procurement	10.0	7.8
Transportation operations	83.3	77.7
Warehousing operations	30.0#	0.0
Other SCM courses at Broward College offered during study period		
Seminar in global trade and logistics	6.0#	14.6
Supply chain management II	18.7	25.2
Supply chain quality management	10.7	7.8
Applied production/operations management	9.3#	20.4
Global operations management[a]	0.7#	13.6
Global logistics/import and export	7.3	7.8
Directed independent research in supply	4.7#	11.7
Supply chain management internship or practicum	3.3#	11.7
Supply chain modeling	3.3	0.0
Sample size	150	103

Note: The table shows the percent of treatment and comparison group members who completed each course by the end of the second academic term after enrollment in the first certification track or SCM course. In Table C.2, we present the certification track courses and equivalent SCM courses.

#Difference between students in the treatment and comparison groups is greater than 0.25 based on the Cox index or Hedge's *g* (given that the Cox index cannot be computed when one group has a mean of 0, we used the Hedge's *g* as appropriate).

[a]Global operations management was not offered in calendar year 2015, the year in which the treatment group completed its first certification track course, but it was offered in 2013–2014 when some treatment group students completed it.

B. Baseline equivalence

To attribute differences in outcomes between students in the treatment and comparison groups to LINCS, the students in both groups must be equivalent in all ways except for participation in LINCS. We assessed their similarities in terms of characteristics captured by the data used in the study and by Hedge's *g* and the Cox index to assess the extent of differences in continuous and dichotomous measures, respectively. Values greater than 0.25 standard deviations are considered substantively important. It is possible that the groups may also differ in terms of unobservable characteristics such as motivation or SCM work experience, but we cannot assess the extent of such differences.

As Table C.4 shows, we observed substantively important differences between students in the treatment and comparison groups on variables in all categories examined. Notably, the treatment group contained a higher proportion of students identifying as white, who tend to have higher rates of employment and earnings than other race and ethnic groups (U.S. Bureau of Labor Statistics 2015). Students in the treatment group also faced lower unemployment rates

(discussed below), including a higher proportion of incumbent workers and individuals employed in quarters before enrollment. In addition, students in the treatment group had substantially higher average three-quarter earnings before the quarter in which they completed a certification track or SCM course. All of these factors tend to improve rates of employment and earnings. Still, the treatment group also contained a higher percentage of people with a disability, which tends to be associated with lower rates of employment and earnings. Because students in the treatment group differ from those in the comparison group, we cannot say for certain that estimated impacts are caused by LINCS and not characteristic differences.

Table C.4. Characteristics of treatment and comparison group students (percent, unless noted)

	Treatment group	Comparison group
Student background		
Demographics		
Male	59.3	57.8
Age		
Average age, in years	34.0	33.9
Youth	19.3	24.3
Race/ethnicity		
Hispanic	45.9	50.0
Asian	2.7	2.0
Black	31.5	33.0
White	18.5#	13.0
Other race	1.4	2.0
Education		
High school diploma	91.3	89.3
Other characteristics		
Incumbent worker	74.0#	63.1
Veteran	12.7	16.5
Person with a disability	10.7#	5.8
Environment		
Unemployment rate	5.2#	6.2
Outcomes at baseline		
Employment in first quarter	74.0#	63.1
Employment in three quarters	80.7#	67.0
Average three-quarter earnings (in 2016 dollars)	6,395#	4,253
Other control variables		
Continuing enrollment	65.3	62.1
Sample size	150	103

Note: Item-specific nonresponse varies in each cell. Percent is calculated using nonmissing data for each variable.

#Difference between students in the treatment and comparison groups is greater than 0.25 based on the Cox index or Hedge's *g* (given that the Cox index cannot be computed when one group has a mean of 0, we used the Hedge's *g* as appropriate).

C. No confounding factors

The impact investigation can attribute improved outcomes to LINCS if other environmental conditions that could affect outcomes did not change. If conditions at Broward College changed between 2014 and 2015 when students in the comparison and treatment groups were in college, or the local labor market changed between 2015 and 2016 when outcomes were measured, students in each group would have experienced different conditions, and those conditions could

have affected outcomes in ways that were unrelated to LINCS. Impact estimates would likely reflect these effects as well as any effects of LINCS.

1. **College environment.** The college offered three SCM programs throughout the period that the treatment and comparison group students were enrolled. Both program and course descriptions were largely unchanged during this period.[6] However, early in the LINCS program, Broward College implemented *Supply Chain Management (SCM) Express*, an innovative weekend cohort bachelor's degree program. Additional recruitment efforts for this program included local print media articles and advertisements and information sessions. The cohort schedule was viewed as a recruitment tool to attract students to a faster-paced degree program with a known schedule of courses. LINCS coursework was included in the appropriate classes for those students. The availability of the SCM Express program may have influenced the mix of students who enrolled in LINCS certification track courses, leading to differences in the characteristics of the treatment and comparison groups.
2. **Local labor market.** As Chapter III discusses, the labor market in the Miami-Fort Lauderdale-West Palm Beach metropolitan area, in which Broward College is located, improved significantly between 2014 and 2106. As such, students in the treatment group faced a labor market with lower levels of unemployment (Table C.4) and, as a result, may have been more likely than those in the comparison group to find or advance in a job after completing certification track or SCM courses.

D. Limitations of the impact investigation design

Although the QED structure of the impact investigation could permit causal inference of the impact of LINCS on employment and earnings, it is limited in several important ways:

1. **Historical comparison group.** Although an historical comparison group ensures that comparison students were not exposed to LINCS program components, one major disadvantage is that students in the treatment group experienced a better labor market and a somewhat different educational environment. The multivariate regression analysis adjusts for some of these influences by including local area unemployment rates in the estimations (Appendix D), but does not capture other important changes in the labor market (for example, changes in SCM jobs) or changes in the Broward College SCM offerings.
2. **Substantial differences in baseline characteristics.** Large differences exist between the characteristics of students in the treatment and comparison groups, and differences in outcomes between the two groups may be partly a function of these differences.

These limitations mean that while the analysis of impacts will provide interesting insights into the experiences of SCM students who enroll in certification track courses and take certification examinations, we cannot rely on the analysis to make causal inferences about the impact of the LINCS program. It is likely that the data used in the impact investigation do not capture all the factors that might underlie the relationships between student and program characteristics and program outcomes.

[6] The only changes noted in the Broward College course catalogues from these years were one new course required for the technical certificate, two new courses required for the associates' degree program, and two new courses required for the bachelor's of applied science degree program.

APPENDIX D. ANALYTIC METHODS

The analyses in this report are designed to answer the following three research questions:

1. What are the employment outcomes for students after (a) completing a certification track course and (b) attaining a certification?
2. How does (a) completing a certification track course or (b) attaining a certification increase students' employment and earnings relative to students enrolled in SCM courses that are not part of a certification track?
3. How do the outcomes vary with certain student characteristics: gender, youth, and incumbent worker status?

The questions were answered with an outcomes investigation and an impact investigation. Appendix B describes the samples and data used in these investigations and Appendix C provides details of the design of the impact investigation. This appendix describes the methods used to analyze the data (Section A) and their limitations (Section B). To help readers interpret the symbols used in the equations in this appendix, Table D.1 shows which variables are associated for each symbol used in each equation.

Table D.1. Variables included in multivariate regressions

Analysis	Outcomes		Impact	
Equation	(1)	(2)	(3)	(4)
Student background (included in *X* in equations)				
Demographics				
Male	✓	✓	✓	✓
Age	✓	✓	✓	✓
Race/ethnicity (white is the category to which others are compared)	✓	✓	✓	✓
Education				
Degree	✓	✓	✓	✓
Other characteristics				
Incumbent worker	✓	✓	✓	✓
TAA-eligible (not available for comparison group)	✓	✓	✓	
Veteran	✓	✓	✓	✓
Person with a disability	✓	✓	✓	✓
Environment				
Unemployment rate (included in *u* in equations)	✓	✓	✓	✓
College (Broward College is the college to which others are compared)	✓	✓		
LINCS participation (included in *L* in equations)				
LINCS participant (in treatment group)				✓
Number of courses (certification or SCM)		✓	✓	✓
Any certification		✓	✓	✓
Outcomes at baseline (included in *X* in equations)				
Employment or earnings			✓	✓
(Other) Control variables (included in *X* in equations)				
Continuing enrollment in first or second term		✓	✓	✓
Missing value indicators (for age, race/ethnicity, and incumbent worker)	✓	✓	✓	✓

A. Analytic approaches

Analyses for both the outcomes and impact investigations shared the same general structure and approach. Each began with descriptive statistics summarizing characteristics of students included in the investigation and then, to improve the precision of estimates, estimated multivariate regressions of outcomes or impacts that control for student background, environment, and other factors likely associated with outcomes.

1. Outcomes investigation analysis

The outcomes investigation has three components: the descriptive analysis; the post-only analysis; and the pre-post analysis, which uses only the subsample of 150 students at Broward College.

Descriptive analysis. The outcomes investigation first conducted a purely descriptive analysis of the employment and earnings of students after they completed their first LINCS certification track course. This analysis documented how students fare in the labor market after completing a certification track course and provided information on a broad group of students across several Consortium colleges. Descriptive statistics summarize the average student background, environment, LINCS participation, and employment and earnings prior to completion of the first certification track course. The descriptive analysis also included subgroup analyses, in addition to analyses for all the students, allowing for an examination of whether outcomes associated with LINCS differed for males, females, youth, adults, incumbent workers, and nonincumbent workers. Mathematica chose these subgroups because (1) SCM is traditionally a male-dominated field (O'Marah 2016), potentially making LINCS participation more beneficial for men than for women; (2) unemployment tends to be higher for youth than for adults (Bureau of Labor Statistics 2016), and many of the affected jobs (such as those in warehousing) involve physical exertion, which might make LINCS participation more beneficial for youth than for adults; and (3) LINCS participation helps individuals move up in or find a job, making it of interest to examine incumbent and nonincumbent workers separately.

Post-only analysis of outcomes. The post-only analysis involved two separate analyses: a regression-adjusted descriptive analysis of outcomes and an analysis of the association between outcomes and certification track courses. The regression-adjusted descriptive analysis estimated average employment and earnings for LINCS participants, controlling for the effects of individual demographic, education, and other background characteristics and for the effects of local labor market characteristics. We estimated the regression-adjusted means by ordinary least squares (OLS) analysis of the following model:[7]

$$(1)\quad Y_i = \alpha + \theta_1 X_i + \theta_2 u_{ci} + \sum_{c=1}^{4} \rho^c D_{ci}^c + \varepsilon_i,$$

where Y is the outcome of interest for student i, X is a vector of individual-level control variables, u is the unemployment rate prevailing in the area of the college c after the student completes his or her first certification track course, D^c is a set of college indicator variables, and

[7] Results were similar using probit estimation.

ε is the error term. The regression adjusted mean $\bar{Y}_i$ is the predicted value of the outcome evaluated at the mean values of *X*, *u*, and D^c using the estimated regression parameters.

In addition, we investigated how completing several certification track courses and attaining a certification were associated with the likelihood of employment and the level of earnings by controlling for a vector *L* of LINCS experience variables (equation 2), where *L* includes the number of certification track courses completed and an indicator of whether any certifications were attained.[8] Positive and significant estimates of the coefficients on *L* ($p \leq 0.05$) would indicate that the LINCS experience is positively associated with the outcomes.

(2) $Y_i = \alpha + \theta_1 X_i + \theta_2 u_{ci} + \sum_{c=1}^{4} \rho^c D_{ci}^c + \pi L_i + \varepsilon_i$

Pre-post analysis. The post-only analysis provided insights into labor market outcomes following a certification track course, but the more interesting question pertained to the change in labor market outcomes: Did employment and earnings improve after completion of LINCS? Unfortunately, not all colleges in the post-only analysis could provide information about employment and earnings before certification track course completion; therefore, we focused the pre-post analysis on students at Broward College by using students in the treatment group.[9] We estimated the average changes in employment and earnings, controlling for baseline outcomes as well as for the effects of individual demographic, education, and other background characteristics; local labor market characteristics; LINCS experience; and continuing education. We estimated these regression-adjusted means by OLS analysis of the following model:

(3) $(Y - Y^{pre})_i = \alpha + \theta_1 X_i + \theta_2 u_{ci} + \pi L_i + \varepsilon_i,$

where Y^{pre} represents the value of the outcome before enrollment in the first certification track course, measured over the same time period. For example, when analyzing the outcome of employment during the first quarter following certification track course completion, we controlled for employment during the first quarter before first course enrollment. We performed a two-tailed *t*-test of the hypothesis positing that the adjusted change in outcomes equals zero.

2. Impact investigation analysis

We expected the pre-post analysis to overstate the influence of LINCS on employment and earnings if students had improved labor market outcomes without it. The QED impact analysis, however, provided for a more rigorous estimate of influences than the pre-post analysis because it used a comparison group to account for factors that influenced both treatment and comparison group members. The investigation involved two components:

[8] We conducted sensitivity analyses for *L*, in this and all other estimations, by exploring the number of certifications, categories for different numbers of certifications, and a set of indicators for each individual certification (for example, customer service operations, demand planning). Results did not change substantively. For simplicity, we chose to use the indicator of whether any certifications were attained,

[9] Columbus State Community College could not provide information on outcomes at baseline and could not be included in this analysis. For simplicity, we used students in the treatment group of the impact investigation rather than perform analysis on a different group of students (that is, students at the four Consortium colleges).

Descriptive analysis. We first conducted a descriptive analysis to understand more fully the characteristics of treatment group and comparison group students included in the impact investigation and to assess baseline equivalence (Appendix C).

QED impact analysis. We estimated the impacts of the LINCS program on employment, and earnings based on the regression model (4) below.

(4) $Y_i = \alpha + \theta_1 X_i' + \theta_2 u_{ci} + \gamma Y_i^{pre} + \beta_1 L_i + \varepsilon_i$

Model (4) controls for the baseline outcome before enrollment in certification track courses; individual demographic, education, and other background characteristics; local labor market characteristics; and continuing education.[10] The set of individual characteristics included in model (4) differed slightly from those used above and so is denoted *X′*.

B. Methodological limitations

In addition to the data limitations described in Appendices B and C, it is important to note that the small sample sizes affected the ability of the statistical analysis to pick up outcome differences between the treatment and comparison groups. Analyses require sufficient sample sizes to have the statistical power to estimate differences of an expected magnitude. The evaluation's work plan estimated that the impact analysis could detect a minimum impact of five to eight percentage points on employment with 721 students in the analysis, a sample size larger than the 253 that we ultimately obtained. With a smaller-than-projected sample size, the impact analysis was constrained in its ability to detect statistically significant impacts that might have been possible to detect with a larger sample.

[10] The baseline education outcome is whether a student had attained a bachelor's degree or higher at baseline, a variable that is already included in *X'*, so there is no separate Y^{pre} term in that regression.

APPENDIX E. DATA TABLES

In this appendix, we provide tables with the results of the analysis in the outcomes and impact investigations. Appendix E is intended to be used in conjunction with Appendix B, which provides details on the samples, data, and definitions of variables used in the analyses. Appendix E is also intended to be used in conjunction with Appendix D, which provides details on the analytic methods, including the estimation equations referenced.

In Section A, we present tables showing results from analysis in the outcomes investigation:

- Table E.1: Descriptive statistics on students in all five colleges and the subgroups analyzed
- Table E. 2: Regression-adjusted averages for employment and earnings based on equation (1), Appendix D
- Table E.3: Associations between LINCS participation and employment and earnings, estimated by using equation (2), Appendix D
- Table E.4: Results of the pre-post analysis for Broward College students examining the associations between LINCS participation and changes in employment and earnings, estimated by using equation (3), Appendix D

In Section B, we present tables showing results from analysis in the impact investigation:

- Table E.5: Descriptive statistics for the treatment and comparison groups
- Table E.6: Estimates of the impact of the LINCS program on employment and earnings as estimated by using equation (4), Appendix D

For ease in reading and interpreting the tables, Mathematica consistently used the following guidelines when developing the tables in this appendix:

- Showing percent, except for earnings, which are reported in 2016 dollars, sample sizes, which are numbers, and as otherwise noted in a table.
- Using an asterisk (*) to indicate that the coefficient in multivariate estimations (Tables E.3, E.5, E.6) is statistically significant from 0 at $p < 0.05$, two-tailed *t*-test
- Including the size of the sample analyzed, although item-specific nonresponse reduced the size in some cells (Tables E.1 and E.4), with details on missing values in Appendix B
- Calculating a percent by using nonmissing data for each variable
- Using acronyms and symbols for the following:

FSCJ	Florida State College at Jacksonville
GED	General Education Development
LINCS	Leveraging, Integrating, Networking, and Coordinating Supplies in Supply Chain Management
SCM	Supply chain management
TAA	Trade Adjustment Assistance

A. Outcomes investigation

Table E.1. Characteristics of students in the outcomes investigation (descriptive analysis)

		Subgroups						
	All	Males	Females	Youth	Adult	Incumbent	Non-incumbent	Broward
Student background								
Demographics								
Male	54.6	100.0	0.0	63.3	52.6	53.9	56.5	59.3
Age								
Average age, in years	38.7	37.5	40.1	21.6	41.1	37.5	41.7	34.0
Youth	11.8	13.7	9.5	100.0	0.0	12.3	10.3	19.3
Race/ethnicity								
Hispanic	17.7	19.6	15.4	19.1	17.4	16.9	19.7	45.9
Asian	3.3	4.3	2.2	2.1	3.5	3.6	2.7	2.7
Black	42.5	37.8	47.9	41.5	42.5	39.3	50.7	31.5
White	35.7	37.1	34.2	35.1	36.0	39.5	26.0	18.5
Other race/ethnicity	0.8	1.2	0.3	2.1	0.6	0.7	0.9	1.4
Education								
High school diploma	90.0	89.4	90.7	91.8	89.5	91.9	85.8	99.3
Associate's degree	2.8	2.4	3.2	0.0	3.3	2.7	2.6	2.7
Bachelor's degree	5.1	5.7	4.2	1.0	5.8	5.2	4.7	0.7
Other characteristics								
Incumbent worker	71.9	71.0	73.1	75.3	70.9	100.0	0.0	74.0
TAA-eligible	1.1	1.8	0.3	1.0	1.0	0.8	1.7	3.3
Veteran	18.2	25.6	9.3	2.0	20.5	14.5	28.0	12.7
Person with a disability	5.2	7.3	2.7	3.1	5.7	3.5	9.5	10.7
Environment								
Unemployment rate	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.2
College								
Broward	18.1	19.6	16.2	29.6	17.1	18.7	16.8	100.0
Columbus State	11.7	11.7	11.7	8.2	12.6	14.1	4.3	0.0
FSCJ	45.2	41.7	49.3	20.4	50.2	41.0	56.5	0.0
Harper	8.3	9.3	7.2	14.3	7.8	9.4	5.6	0.0
St. Petersburg	16.7	17.7	15.6	27.6	12.3	16.8	16.8	0.0
LINCS participation								
Number certification track courses completed								
Courses one academic term	1.9	1.9	1.9	1.6	1.9	1.9	1.9	1.8
Courses two academic terms	2.2	2.2	2.2	1.7	2.3	2.2	2.2	1.8
Certified								
Certified one academic term	60.7	59.6	62.1	44.9	62.9	63.4	53.4	61.3
Certified two academic terms	63.3	61.6	65.3	46.9	65.6	65.7	56.5	63.3
One certification	28.6	27.2	30.2	31.6	28.7	28.7	27.2	24.7
Two certifications	14.9	12.6	17.8	12.2	15.6	16.5	11.2	22.0
Three or more certifications	19.8	21.9	17.2	3.1	21.4	20.5	18.1	16.7
Outcomes at baseline								
Employment first previous quarter	74.0	74.2	73.8	86.2	71.1	100.0	0.0	74.0
Employment three previous quarters	80.7	82.0	78.7	93.1	77.7	100.0	25.6	80.7
Average earnings	$5,987	$6,145	$5,798	$2,668	$6,313	$8,065	$736	$6,395
Control variables								
Enrolled first term	60.5	62.7	57.8	61.2	60.5	63.0	54.3	82.7
Enrolled second term	39.9	43.7	35.3	41.8	39.9	39.7	40.5	65.3
Sample size	830	453	377	98	707	595	232	150

Table E.2. Employment and earnings after completion of first certification track course (post-only regression-adjusted means)

		Subgroups						
	All	Males	Females	Youth	Adult	Incumbent	Non-incumbent	Broward
Employment								
First quarter	75.3	76.2	74.3	78.6	74.3	93.8	27.6	78.0
Three quarters	81.9	83.2	80.4	88.8	80.6	96.6	44.0	83.3
Average three-quarter earnings	$7,396	$7,968	$6,709	$3,900	$7,763	$9,701	$1,512	$6,726
Sample size	830	453	377	98	707	595	232	150

Table E.3. LINCS participation and employment and earnings for different groups (post-only analysis)

	All students			Broward		
	Employment		Average three-quarter earnings	Employment		Average three-quarter earnings
	In first quarter	In three quarters		In first quarter	In three quarters	
Unadjusted average, dependent variable (*100 for employment)	75.3	81.9	$7,396	78.0	83.3	$6,726
Regression coefficients						
Number certification track courses completed	-0.007	-0.001	-66	-0.012	-0.007	145
Certified	0.020	0.016	$1,025	0.009	-0.049	$779
Sample size	830	830	830	150	150	150
	Males			**Females**		
	Employment		Average three-quarter earnings	Employment		Average three-quarter earnings
	In first quarter	In three quarters		In first quarter	In three quarters	
Unadjusted average, dependent variable	76.2	83.2	$7,968	74.3	80.4	$6,709
Regression coefficients						
Number certification track courses completed	0.011	0.004	-126	-0.032	-0.008	-107
Certified	-0.001	-0.011	$1,662	0.059*	0.061	$281
Sample size	453	453	453	377	377	377
	Youth			**Adult**		
	Employment		Average three-quarter earnings	Employment		Average three-quarter earnings
	In first quarter	In three quarters		In first quarter	In three quarters	
Unadjusted average, dependent variable	78.6	88.8	$3,900	74.3	80.6	$7,763
Regression coefficients						
Number certification track courses completed	-0.049	-0.104	$70	-0.002	0.005	-12
Certified	0.050	-0.022	$303	0.013	0.024	$979
Sample size	98	98	98	707	707	707
	Incumbent			**Nonincumbent**		
	Employment		Average three-quarter earnings	Employment		Average three-quarter earnings
	In first quarter	In three quarters		In first quarter	In three quarters	
Unadjusted average, dependent variable	93.8	96.6	$9,701	27.6	44.0	$1,512
Regression coefficients						
Number certification track courses completed	-0.015*	-0.014	$50	0.006	0.020	$128
Certified	0.026	0.002	$1,192	0.036	0.085	$327
Sample size	595	595	595	232	232	232

Table E.4. LINCS participation and changes in employment and earnings at Broward College (pre-post analysis)

	Employment		Average three-quarter earnings
	In first quarter	In three quarters	
Averages (see Appendix D for how computed)			
Baseline average	74.0	80.7	$6,395
Post-LINCS average	78.0	83.3	$6,726
Pre-post difference	4.0*	2.7*	$331*
Regression coefficients			
Number certification track courses completed	-0.012	0.010	-33
Certified	0.017	-0.053	653
Sample size	150	150	150

B. Impact investigation

Table E.5. Characteristics of students in the impact investigation (descriptive analysis)

	All	Treatment	Comparison
Student background			
Demographics			
Male	58.7	59.3	57.8
Age			
Average age, in years	33.9	34.0	33.9
Youth	21.3	19.3	24.3
Race/ethnicity			
Hispanic	47.6	45.9	50.0
Asian	2.4	2.7	2.0
Black	32.1	31.5	33.0
White	16.3	18.5	13.0
Other race	1.6	1.4	2.0
Education			
High school diploma	90.5	91.3	89.3
Other characteristics			
Incumbent worker	69.6	74.0	63.1
Veteran	14.2	12.7	16.5
Person with a disability	8.7	10.7	5.8
Environment			
Unemployment rate	5.6	5.2	6.2
SCM participation			
Number SCM courses completed			
Course one academic term	1.7	1.8	1.6
Courses two academic terms	1.8	1.8	1.6
SCPro™ Fundamentals certification			
Certified one academic term	36.4	61.3	0.0
Certified two academic terms	37.5	63.3	0.0
Outcomes at baseline			
Employment first quarter	69.6	74.0	63.1
Employment three quarters	75.1	80.7	67.0
Average three-quarter earnings	$5,523	$6,395	$4,253
Outcomes after completion of first certification track course			
Employment first quarter	73.9	78.0	68.0
Employment three quarters	80.2	83.3	75.7
Average earnings	$6,238	$6,726	$5,527
Control variables (continuing enrollment)			
Enrolled first term	80.2	82.7	76.7
Enrolled second term	64.0	65.3	62.1
Sample size	253	150	103

Table E.6. Impacts of LINCS on employment and earnings

	Employment and earnings		
	Employment first quarter	Employment three quarters	Average three-quarter earnings
Averages			
Unadjusted average, dependent variable (*100 for degree and employment)	73.9	80.2	$6,238
Regression coefficients			
Treatment group	0.043	0.074	215
Certified	0.027	-0.036	502
Sample size	253	253	253

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