



**Dual Credit & Student Success:
The Effect of High School Dual Credit on Educational
Outcomes at Kentucky Public Universities**

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Prepared by the Kentucky Council on Postsecondary Education



About the Council on Postsecondary Education

The Council on Postsecondary Education is Kentucky's higher education coordinating agency committed to strengthening our workforce, economy and quality of life. We do this by guiding the continuous improvement and efficient operation of a high-quality, diverse and accessible system of postsecondary education.

Key responsibilities include:

- developing and implementing a strategic agenda for postsecondary education that includes measures of progress.
- producing and submitting a biennial budget request for adequate public funding of postsecondary education.
- determining tuition rates and admission criteria at public postsecondary institutions.
- collecting and distributing data about postsecondary education performance.
- ensuring the coordination and connectivity of technology among public institutions.
- licensing non-public postsecondary institutions to operate in the Commonwealth.



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EXECUTIVE SUMMARY

Dual credit programs are collaborations between secondary and postsecondary institutions that enable high school students to enroll in college courses and receive simultaneous academic or technical credit that counts toward high school and college completion. Dual credit is distinct from Advanced Placement (AP) courses, which require students to pass an end-of-course examination to receive college credit.

Nationally and in Kentucky, dual credit participation is on the rise. The total number of high school students taking dual credit grew from 23,307 in 2014-15, to 40,821 students in 2019-20, an increase of 75.1%.

RESEARCH QUESTIONS

This study investigates whether dual credit positively affects the probability of persisting to a second year of college and earning a first-year GPA of 3.0 or higher. The dataset includes public and private Kentucky high school students who took dual credit courses and subsequently enrolled at an in-state, public four-year university after graduation. CPE is planning a second report to examine the effects of dual credit on postsecondary outcomes at KCTCS campuses. The research questions are:

- What are the effects of dual credit participation on students' postsecondary educational outcomes, as measured by their chance of persisting to a second year of college and earning a first-year GPA of 3.0 or higher?
- Do these effects vary by race, gender, income and college preparedness?

PARTICIPANT CHARACTERISTICS

Prior to any impact analysis, the differences in demographic characteristics and academic preparation between college students who had previously enrolled in dual credit (n=26,292; 50.6%) and those who had not (n=25,703; 49.4%) were explored. Findings include:

- Dual credit students were more likely to be female and white or Asian, and less likely to be part of an underrepresented minority (URM) group. Gaps in participation may reflect a lack of access to dual credit opportunities for many students of color.
- Surprisingly, low-income students were slightly more likely to enroll in dual credit courses. This was not true of students who were both low-income and minority.
- Dual credit students were more likely to be "college ready" than non-participants. College readiness is determined by minimum scores on the ACT, SAT or other assessments approved by the Council on Postsecondary Education, as set forth in the statewide college readiness standards.
- Starting in fall 2016, the percentage of Kentucky college students with dual credit was higher than the percentage without. This may be influenced by the implementation of CPE's dual credit policy and the creation of dual credit scholarships in Kentucky.

DUAL CREDIT EFFECTS

- Dual credit participants were more likely to persist to a second year of college than students who did not participate in dual credit.
- Dual credit participants were more likely to obtain a first-year GPA of 3.0 or higher (on a 4.0 scale) than students who did not participate in dual credit.
- Participation in dual credit had a stronger effect on the grades of students with lower first-year GPAs than those with higher GPAs.

EFFECTS ON SUBGROUPS

Likelihood of Persisting to a Second Year of College

- Dual credit had a greater effect on the second-year persistence of females than of males.
- Prepared dual credit participants were more likely to persist to a second year of college than prepared non-participants. Dual credit's effect on underprepared students was not statistically significant.
- The effect of dual credit on second-year persistence was twice as high for low-income participants than for higher income participants.
- Dual credit had a slightly greater effect on the second-year persistence of URM students than of white and Asian students.
- Dual credit had the greatest effect on non-minority, low-income students, raising their likelihood of persisting to a second year of college by 9.3 percentage points.

Likelihood of Earning a First-Year GPA of 3.0 or Higher

- Dual credit had a greater effect on the first-year GPA of male students than of female students.
- Prepared dual credit participants were more likely to earn a first-year GPA of 3.0 or higher than prepared non-participants. Dual credit's effect on underprepared students was not statistically significant.
- Dual credit's effect on the likelihood of earning a first-year GPA of 3.0 or higher was greater for low-income students than for higher income students.
- Dual credit's effect on the likelihood of earning a first-year GPA of 3.0 or higher was greater for white and Asian students than for underrepresented minority students.
- Dual credit had the greatest effect on the first-year GPA of non-minority, low-income students, raising their likelihood of earning a 3.0 or higher by 11.1 percentage points.



INTRODUCTION

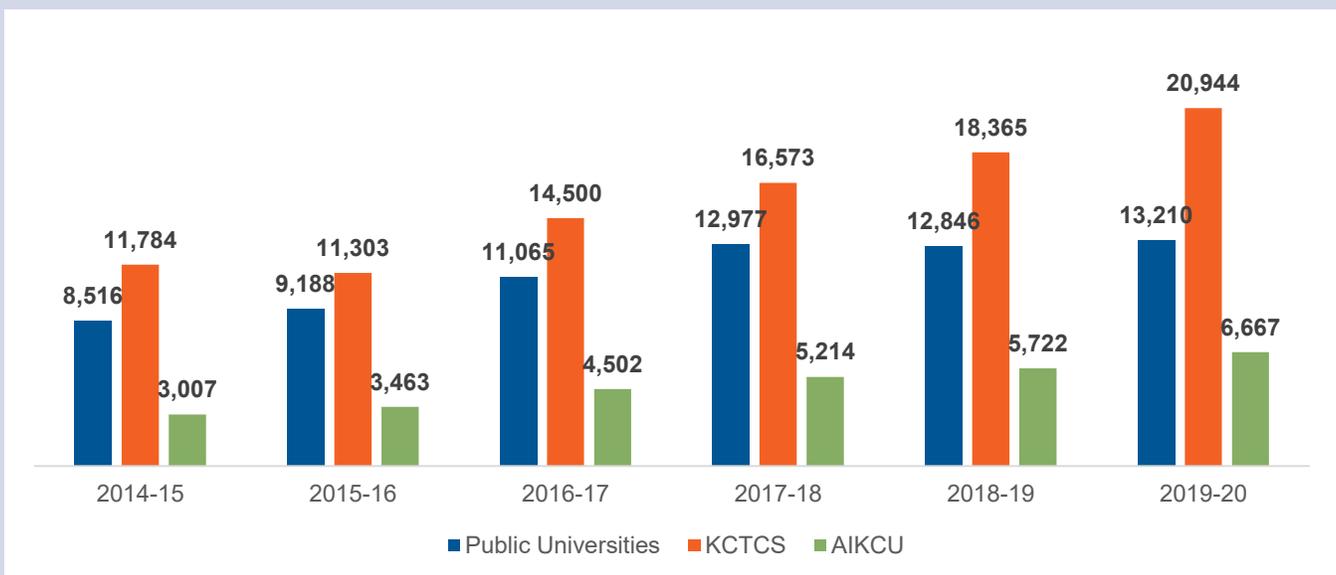
Dual credit programs are collaborations between secondary and postsecondary institutions that enable high school students to enroll in college courses (either at their high school, nearby college or online) and receive simultaneous academic or technical credit that counts toward high school and college completion. Dual credit is distinct from Advanced Placement (AP) courses, which require students to pass an end-of-course examination to receive college credit.

Nationally, dual credit programs are on the rise. According to the National Center for Education Statistics, the number of students taking dual enrollment courses increased 80% to 1.2 million between 2002-03 and 2010-11.¹ Whereas dual credit was once targeted primarily at high-achieving students, today’s programs include a variety of general education and career and technical options and are seen as a way to prepare students at all levels for both two-year and four-year institutions.²

Dual credit programs are attractive to students and parents for a variety of reasons—they can reduce college costs by decreasing time-to-degree and increase college persistence and completion.³ Moreover, dual credit can provide more academic rigor and additional course options that are not otherwise available through a high school’s curriculum.

Following the national trend, Kentucky has experienced a dramatic rise in dual credit in recent years. The total number of high school students taking dual credit grew from 23,307 in 2014-15, to 40,821 students in 2019-20., an increase of 75.1% (Figure 1).

Figure 1. Dual Credit Participation Across Institutions and Academic Years



Source: Kentucky Postsecondary Education Data System. This graph shows the number of high school students who were enrolled in dual credit courses at public universities, KCTCS or private institutions by academic year.



DUAL CREDIT INITIATIVES

Two initiatives have propelled dual credit participation in Kentucky. First, CPE approved a dual credit policy in June 2015, which took effect in fall 2016. The policy advises that high school students should have access to a minimum of three general education and three career or technical dual credit courses over the course of their high school career. The policy also provides guiding principles and evidence-based practices to support and maintain the accessibility, quality, transferability and affordability of dual credit programs.

The second initiative is a dual credit scholarship established in June 2016, supported by Kentucky Lottery proceeds. This program allows high school juniors or seniors the chance to earn credit for two college courses at no cost. The Work Ready Kentucky Dual Credit Scholarship, established in 2018, expanded this benefit to include two Career and Technical Education (CTE) dual credit courses per year. Both initiatives aim to drive significant increases in dual credit hours taken and reduce barriers posed by tuition and fees.



DUAL CREDIT BENEFITS

Numerous policymakers, educators and researchers have found that dual credit leads to positive educational outcomes for students at all levels. The following benefits emerged from a national literature review:

- **Providing rigor and relevance.** Dual credit courses often are viewed as more rigorous than general high school courses.⁴ They may increase the relevance of schoolwork by enabling students to access courses related to their career goals and interests, like engineering, business or marketing.⁵
- **Increasing college enrollment.** Participation in dual credit programs has been found to increase the probability of enrolling in college by 16.8 percentage points.⁶ One study found that dual credit participants were more than twice as likely to enroll in college.⁷
- **Reducing college attrition and increasing degree completion.** Numerous studies have shown that college students with prior dual credit were more likely to persist to a second year of college and eventually complete a degree. A 2013 study found that dual credit participants were 8 percentage points more likely to complete any college credential and 7 percentage points more likely to complete a bachelor's degree.⁸
- **Strengthening academic performance in college.** Exposure to college-level courses better prepares high school students for the academic demands of college. Studies have shown that dual credit participants have higher college GPAs than non-participants.⁹
- **Reducing tuition costs.** Dual credit can reduce tuition costs by shortening time to degree.¹⁰ One study reported a savings of \$5,000 to \$24,000 in tuition when students accumulated up to a year of college credit.¹¹
- **Enhanced effects for less advantaged groups.** Studies have shown that underrepresented minority (URM) and low-income students benefit more from dual credit than higher-income, white students.¹² Dual credit also has been shown to increase career and college readiness for URM students.¹³



RESEARCH METHODOLOGY

The Dataset

This study examines if dual credit students at Kentucky public universities experience similar benefits as students nationwide, focusing on the likelihood of earning a first-year GPA of 3.0 or higher and returning for a second year of college. The study uses a longitudinal dataset compiled from CPE's Kentucky Postsecondary Education Data System (KPEDS), which includes nearly 52,000 students who graduated from a Kentucky high school and enrolled full-time at an in-state, four-year public institution for the first time during the fall of 2014, 2015, 2016 and 2017.

This longitudinal dataset includes a rich array of high school and postsecondary variables, allowing us to follow students as they transition from high school to a Kentucky public university. The independent variable being examined is dual credit participation. The outcome variables are probable persistence and first-year GPA. Gender, income, race, academic preparation, institution and cohort year also were evaluated. For a more detailed description of the measures and variables used, see Appendix A.

Analytic Strategies

This study uses regression analysis to examine the effects of dual credit participation on postsecondary educational outcomes. Regression analysis adjusts for the observed confounding variables in the models. Five sets of interaction terms were tested through five separate binary logistic regression models. The interaction terms were: 1) dual credit and gender; 2) dual credit and college readiness; 3) dual credit and low-income status; 4) dual credit and underrepresented minority (URM) status; and 5) dual credit and low-income, URM status.

In an ideal experimental setting, high school students would be randomly assigned to enroll or to not enroll in a dual credit course. The unbiased treatment effects of dual credit on students' postsecondary achievements would then be compared to the control group. However, in Kentucky, dual credit is not randomly assigned but self-selected. In other words, dual credit participation depends on the active choices of students and their parents and is influenced by academic performance, motivation, the family's financial situation and available opportunities at the high school. If dual credit students achieve higher grades than non-participants, it could be a function of higher motivation, better family support or other potentially unobserved differences between the two groups, not a function of the dual credit itself. In order to mitigate this selection bias, the study employed Propensity Score Matching (PSM) as a quasi-experimental approach to obtain better treatment effects.

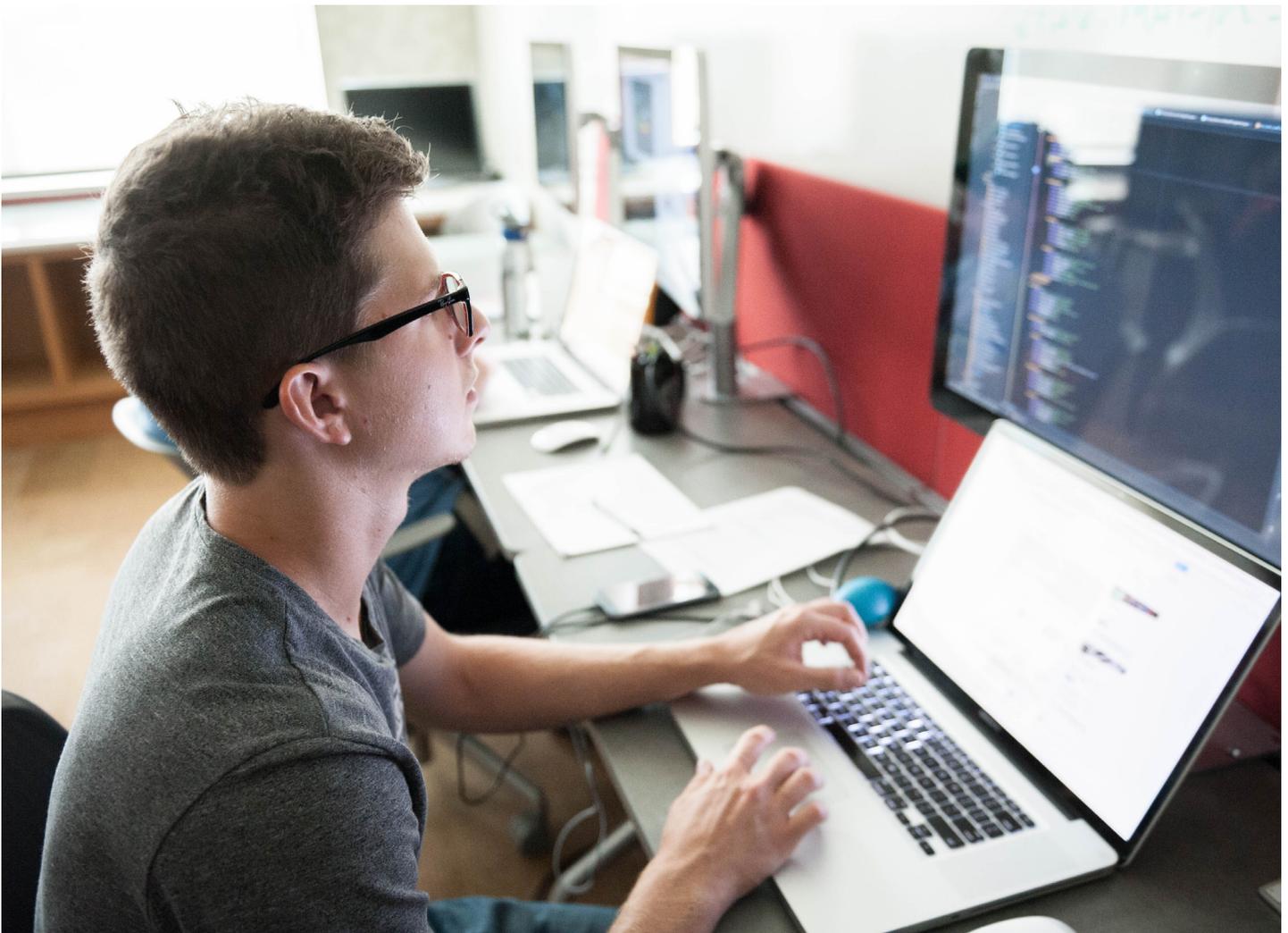
Once the high school cohorts transitioned to a four-year university, there were other potential variations that could account for differences in academic outcomes, like institutional support and selectivity and student-faculty ratio. There also were variations by cohort. In order to mitigate these, institution fixed effects and cohort fixed effects were included. A more detailed description of these analytic strategies is included in Appendix B.



RESEARCH QUESTIONS

As growth in dual credit accelerates, there is a need to provide empirical evidence of its effectiveness. This study investigates whether dual credit in Kentucky positively affects second-year persistence and first-year GPA at four-year public universities. The study sets out to answer the following questions:

- **What are the effects of dual credit participation on students' postsecondary educational outcomes, as measured by their chance of persisting to a second year of college and earning a first-year GPA of 3.0 or higher?**
- **Do these effects vary by race, gender, income and college preparedness?**





DUAL CREDIT PARTICIPATION

Prior to any impact analysis, the differences in demographic characteristics and academic outcomes between students who enrolled in dual credit (n=26,292; 50.6%) and students who did not (n=25,703; 49.4%) were explored. Findings include:

- Dual credit students were more likely to be female and white or Asian, and less likely to be part of an underrepresented minority (URM) group. Gaps in participation may reflect a lack of access to dual credit opportunities for many students of color.
- Surprisingly, low-income students were slightly more likely to enroll in dual credit courses. This was not true of students who were both low-income and minority.
- Dual credit students were more likely to be “college ready” than non-participants. College readiness is determined by minimum scores on the ACT, SAT and other assessments approved by the Council on Postsecondary Education, as set forth in the statewide college readiness standards.¹⁴
- Starting in fall 2016, the percentage of college students with dual credit was higher than the percentage without. This may be influenced by CPE's implementation of the dual credit policy and the creation of dual credit scholarships in Kentucky.



Figure 2. Characteristics of Dual Credit Participants and Non-Participants in the Study (N=51,995)

Variables	All Students (N=51,995)	Participants (N=26,292)	Non-Participants (N=25,703)
GENDER			
Male	44.4%	39.5%	49%
Female	55.6%	60.5%	51%
URM			
Yes	15.1%	11.4%	18.9%
No	84.9%	88.6%	81.1%
UNDERPREPARED			
Yes	12%	7.2%	16.8%
No	88%	92.8%	83.2%
LOW-INCOME			
Yes	38.7%	38.8%	38.6%
No	61.3%	61.2%	61.4%
LOW-INCOME & URM			
Yes & Yes	9.1%	6.8%	11.5%
Yes & No	29.5%	32%	27%
No & Yes	6%	4.7%	7.4%
No & No	55.3%	56.5%	54.1%
SECOND-YEAR PERSISTENCE			
Yes	83.1%	87.6%	79.9%
No	16.2%	12.4%	20.1%
FIRST-YEAR GPA			
<3.0	44.4%	38.4%	50.3%
≥3.0	55.6%	61.6%	49.7%
COHORT YEAR			
Fall 2014	25.2%	23.1%	27.3%
Fall 2015	25.6%	24.5%	26.7%
Fall 2016	24.9%	25.4%	24.4%
Fall 2017	24.4%	27%	21.6%

Dual credit students are all individuals who enrolled in at least one dual credit course in high school.



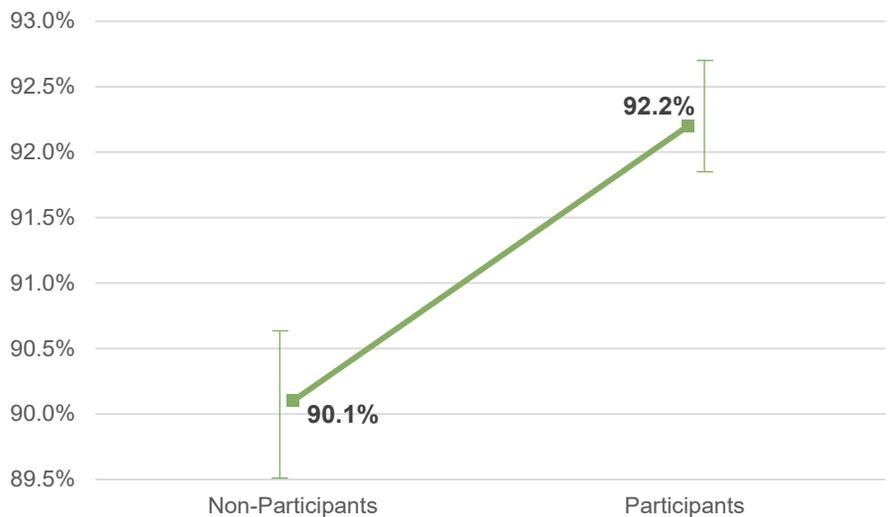
EFFECTS OF DUAL CREDIT

Using rigorous quantitative methods, this study provides empirical evidence of the effectiveness of dual credit as a general strategy for increasing the likelihood of persisting to a second year of college. Unlike retention, persistence measures whether a student returns to any Kentucky postsecondary institution for a second year, not only to their native institution. Key findings include:

■ Dual credit participants were more likely to persist to the second year of college than students who did not participate in dual credit.

The study predicted the average probability of persisting to a second year for dual credit participants and non-participants. The probability of dual credit students persisting to a second year of college was 92.2%, compared to 90.1% for non-participants, a difference of 2.1 percentage points. For a more detailed explanation of analytic strategies used to obtain this result, see Appendix C.

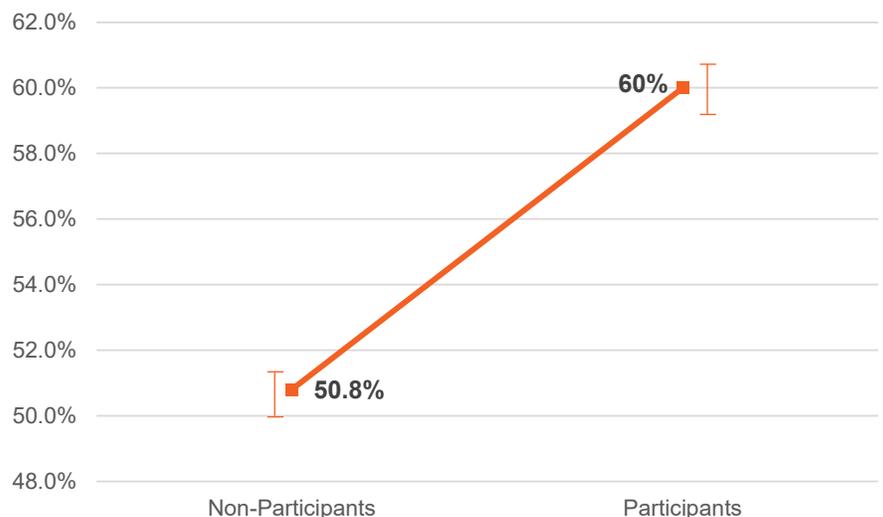
Vertical lines represent 95% confidence intervals. Values: Non-participants (89.5%-90.6%) and participants (91.8%-92.7%).



■ Dual credit participants were more likely to obtain a first-year GPA of 3.0 or higher (on a 4.0 scale) than students who did not participate in dual credit.

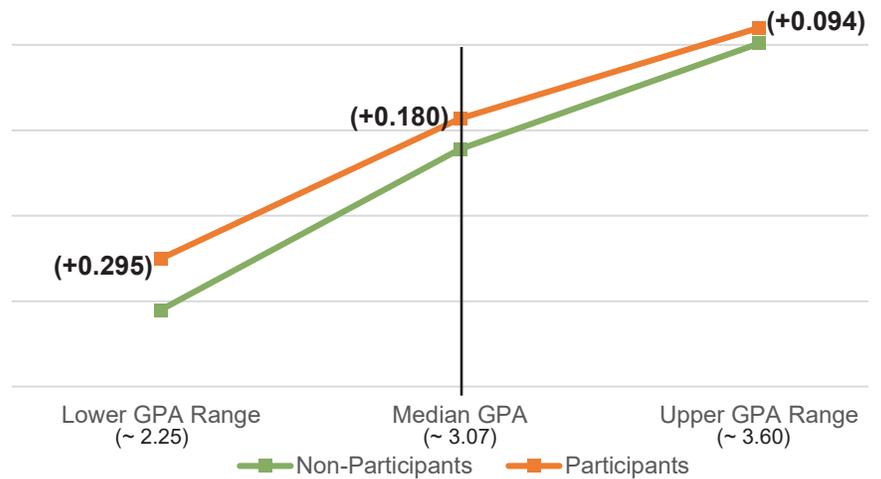
The study predicted the average probability of achieving a first-year college GPA of 3.0 or higher for dual credit participants and non-participants. The probability of dual credit students earning a 3.0 GPA or higher in their first year was 60%, compared to 50.8% for non-participants, a difference of 9.2 percentage points. For a more detailed analysis, see Appendix D.

Vertical lines represent 95% confidence intervals. Values: Non-participants (50%-51.7%) and participants (59.2%-60.9%).



■ Participation in dual credit had a stronger effect on the grades of students with lower first-year GPAs than those with higher GPAs.

At the lower end of the GPA range (approximately 2.25), dual credit participants averaged 0.295 points higher than non-participants. At the median GPA (3.07), dual credit participants averaged 0.180 points higher than non-participants. At the upper end of the range (approximately 3.6), dual participants averaged 0.094 points higher than non-participants. For more detail about the quantile regression analysis used to obtain this result, see Appendix E.





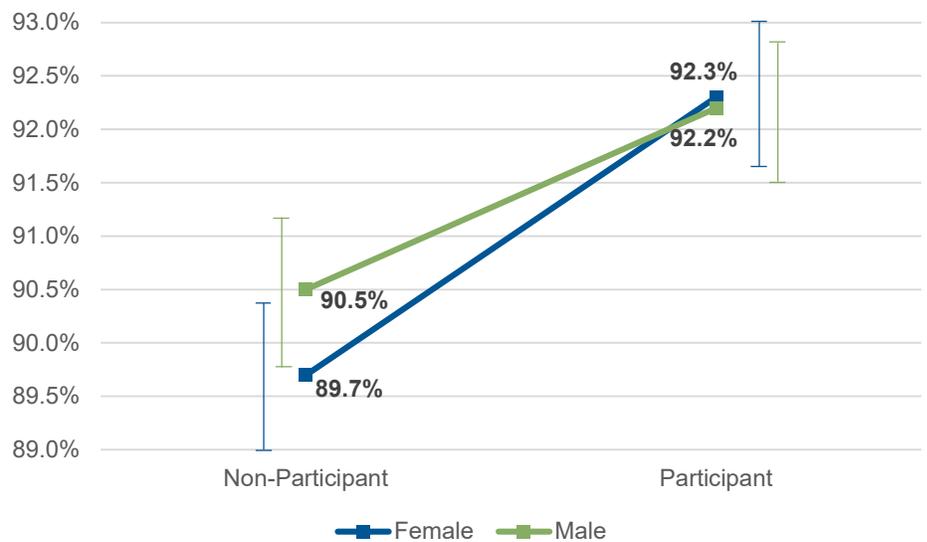
EFFECTS ON SUBGROUPS

Dual credit participation had positive effects on second-year persistence for all of the subgroups observed, with the exception of underprepared students. These results were calculated using interactions of the student subgroup (i.e., gender, college readiness, income, race) with the dual credit indicator in the analysis models. Five sets of interaction terms were tested through five separate binary logistic regression models for each assessment outcome (see Appendix F). Key findings are as follow:

■ Dual credit had a greater effect on the second-year persistence of females than of males.

Female dual credit participants were 2.6 percentage points more likely to persist to a second year of college than female non-participants. Dual credit also had a positive effect on male students, increasing their likelihood of persisting to a second year by 1.7 percentage points.

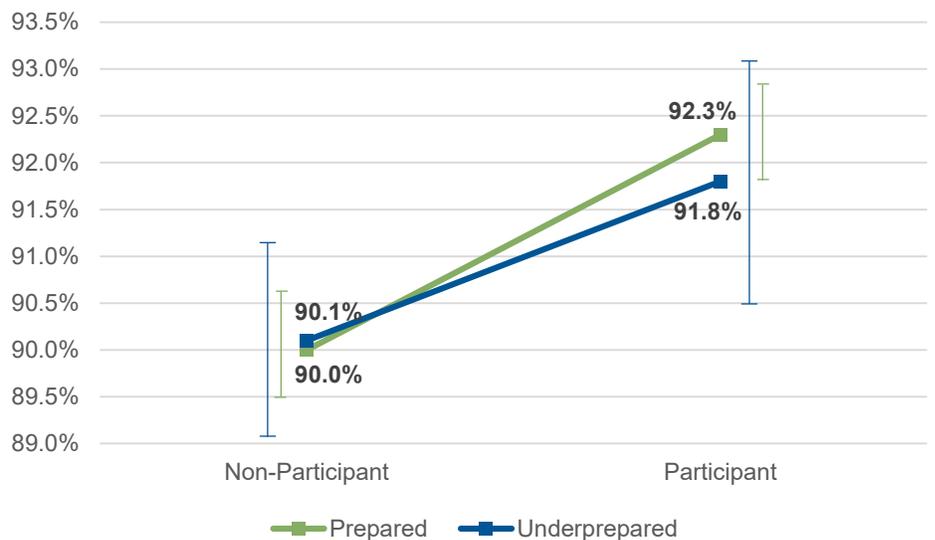
Vertical lines represent 95% confidence intervals. Values: Female non-participants (89%-90.4%) and female participants (91.7%-93%). Male non-participants (89.8%-91.2%) and male participants (91.5%-92.8%).



■ Prepared dual credit participants were more likely to persist to a second year of college than prepared non-participants. Dual credit's effect on underprepared students was not statistically significant.

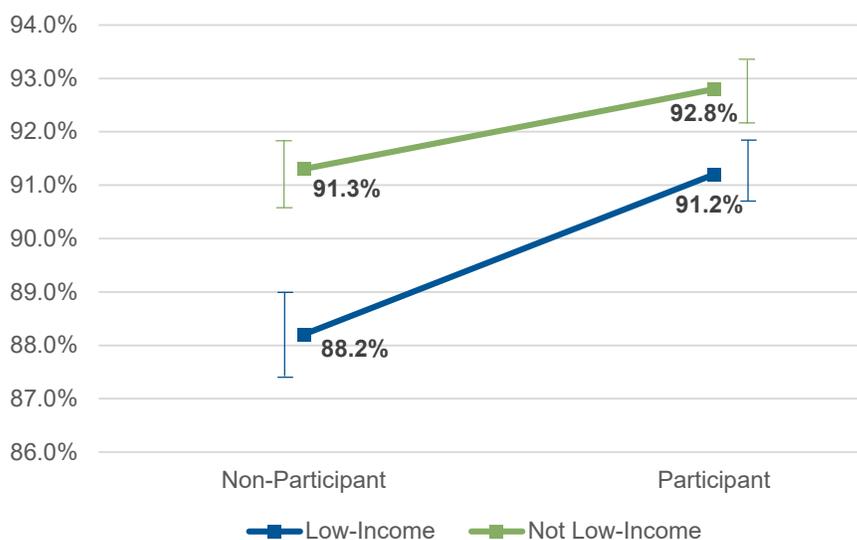
For prepared students, dual credit participation increased their likelihood of persisting to a second year by 2.3 percentage points. Without dual credit, students shared a similar chance of persisting, regardless of academic preparation. The increase in the probability of persisting to a second year for underprepared students was not statistically significant.

Vertical lines represent 95% confidence intervals. Values: Prepared non-participants (89.5%-90.6%) and prepared participants (91.8%-92.8%). Underprepared non-participants (89.1%-91.2%) and underprepared participants (90.5%-93.1%).



■ **The effect of dual credit on second-year persistence was twice as high for low-income participants than for higher income participants.**

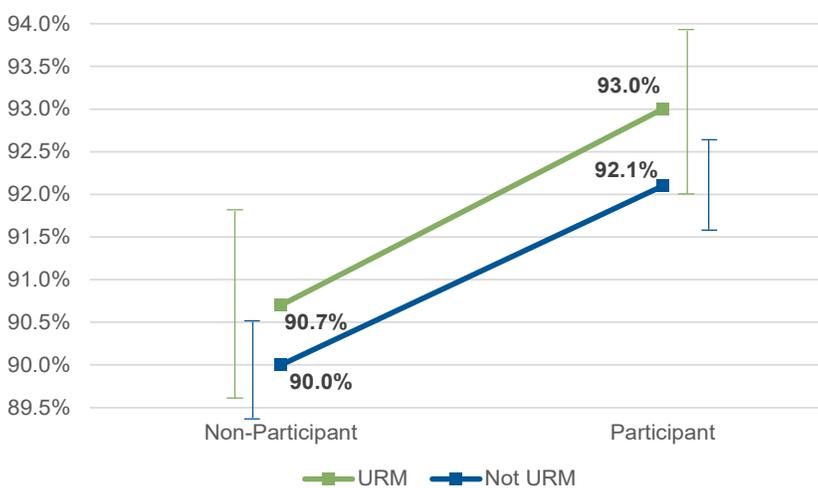
On average, low-income dual credit participants were 3 percentage points more likely to persist to a second year of college than low-income non-participants. The effect on higher income participants was 1.5 percentage points greater than for higher income non-participants. With or without dual credit, higher-income students had a better chance of persisting to a second year. However, dual credit narrowed the gap between these subgroups from 3.1 percentage points to 1.6 percentage points.



Vertical lines represent 95% confidence intervals. Values: low-income non-participants (87.4%-89%) and low-income participants (90.7%-91.9%). Non low-income non-participants (90.6%-91.9%) and non low-income participants (92.2%-93.4%).

■ **Dual credit had a slightly greater effect on the second-year persistence of underrepresented minority students than of white and Asian students.**

On average, URM participants were 2.3 percentage points more likely to persist to a second year of college than URM non-participants; white and Asian participants were 2.1 percentage points more likely to persist to a second year of college. Dual credit slightly widened the gap between these two groups, to the benefit of URM students.



Vertical lines represent 95% confidence intervals. Values: URM non-participants (89.6%-91.8%) and URM participants (92%-93.9%). Non-URM non-participants (89.4%-90.5%) and non-URM participants (91.6%-92.6%).

■ **Dual credit had the greatest effect on non-minority, low-income students, raising their likelihood of persisting to a second year of college by 9.3 percentage points.**

Non-minority, low-income students benefited the most from dual credit participation, followed by URM, low-income students. Interestingly, higher income students, regardless of race, did not benefit as much from dual credit participation in terms of their persistence to a second year of college, suggesting that dual credit access for at-risk students should become a greater priority. See the table on page 32 (Appendix F) for more detail.



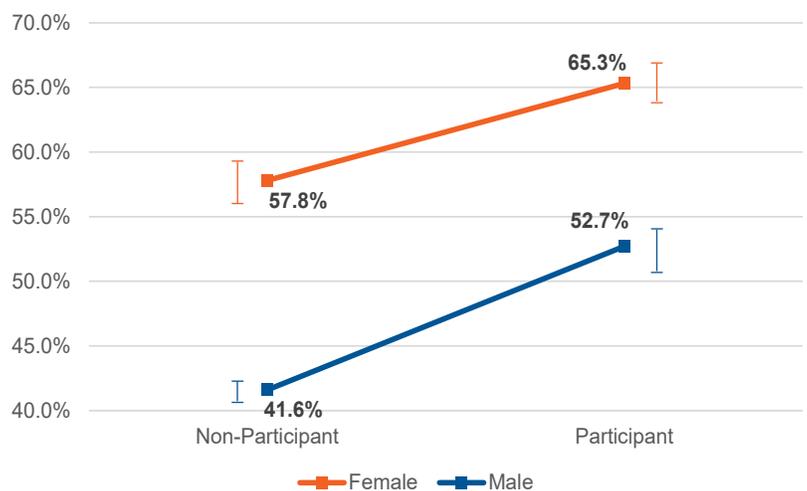
EFFECTS ON SUBGROUPS

Dual credit participation had positive effects on first-year GPA for all of subgroups observed, with the exception of underprepared students and higher-income, URM students. These results were calculated using interactions of the student subgroup (i.e., gender, college readiness, income and race) with the dual credit indicator in the analysis models. Five sets of interaction terms were tested through five separate binary logistic regression models for each assessment outcome (see Appendix G). Key findings include:

■ Dual credit had a greater effect on the first-year GPA of male students than of female students.

Male dual credit participants were 11.1 percentage points more likely to earn a 3.0 or higher in their first year than male non-participants, while female participants were 7.5 points more likely. With or without dual credit, females had a much better chance of earning a 3.0 or higher, but dual credit significantly narrowed the gap between male and female students (from 16.2 percentage points to 12.6 percentage points).

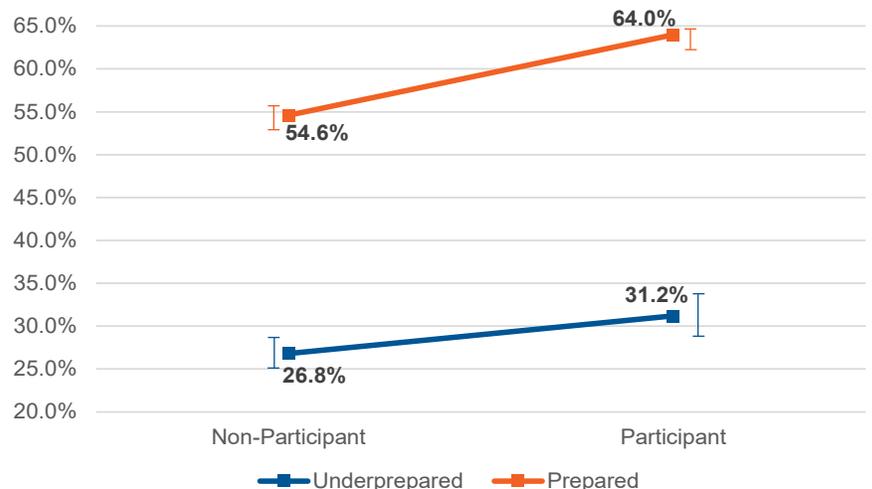
Vertical lines represent 95% confidence intervals.
Values: Male non-participants (40.4%-42.9%) and male participants (51.4%-53.9%). Female non-participants (56.7%-58.9%) and female participants (64.2%-66.3%).



■ Prepared dual credit participants were more likely to earn a 3.0 or higher than prepared non-participants. Dual credit's effect on underprepared students was not statistically significant.

Overall, college-ready students were much more likely to earn a first-year GPA of 3.0 or higher than students failing to meet college readiness benchmarks, regardless of dual credit participation. For academically prepared students, dual credit participation increased this likelihood by 9.4 percentage points. Dual credit's effect on the first-year GPA of underprepared students was not statistically significant.

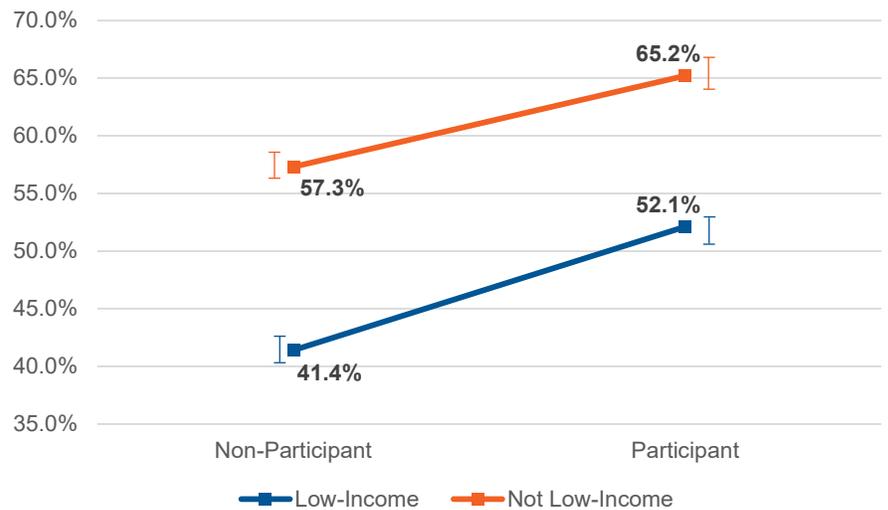
Vertical lines represent 95% confidence intervals.
Values: Underprepared non-participants (25%-28.6%) and underprepared participants (28.3%-34.1%). Prepared non-participants (53.7%-55.5%) and prepared participants (63.1%-64.8%).



■ Dual credit's effect on the likelihood of earning a first-year GPA of 3.0 or higher was greater for low-income students than for higher income students.

Dual credit increased the likelihood of earning a first-year GPA of 3.0 or higher by 10.7 percentage points for low-income students and 7.9 percentage points for higher-income students. With or without dual credit, higher-income students had a better chance of earning at least a 3.0 GPA. However, dual credit narrowed the gap between these two groups from 15.9 percentage points to 13.1 percentage points.

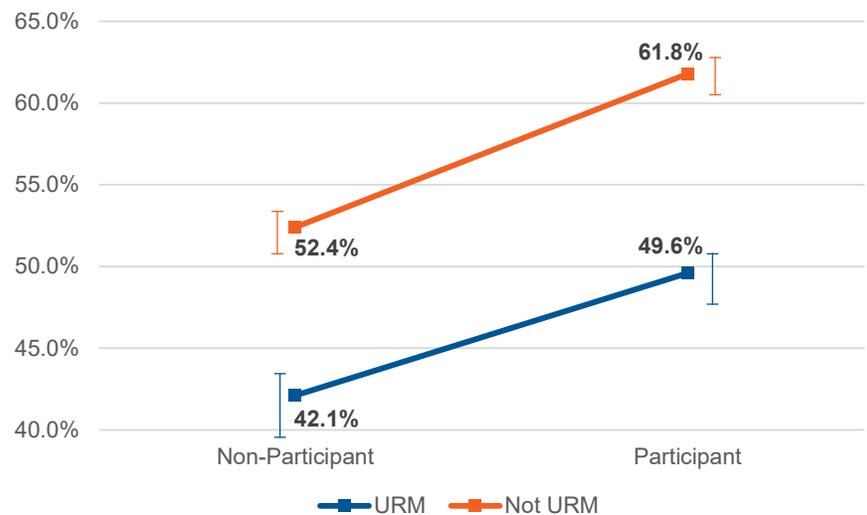
Vertical lines represent 95% confidence intervals. Values: Low-income non-participants (40.1%-42.8%) and low-income participants (50.8%-53.3%). Non low-income non-participants (56.2%-58.4%) and non low-income participants (64.2%-66.2%).



■ Dual credit's effect on the likelihood of earning a first-year GPA of 3.0 or higher was greater for white and Asian students than for underrepresented minority students.

On average, dual credit increased the likelihood of earning a first-year GPA of 3.0 or higher by 9.4 percentage points for non-minority students and 7.5 percentage points for URM students. Dual credit participation slightly widened the gap between these subgroups, from 10.3 points without dual credit to 12.2 points with dual credit.

Vertical lines represent 95% confidence intervals. Values: URM non-participants (39.9%-44.3%) and URM participants (47.5%-51.8%). Non-URM non-participants (51.5%-53.3%) and non-URM participants (61%-62.7%).



■ Dual credit had the greatest effect on the first-year GPA of non-minority, low-income students, raising their likelihood of earning a 3.0 or higher by 11.1 percentage points.

In terms of the probability of earning at least a 3.0 GPA in the first year, non-minority, low-income students benefited the most from dual credit, followed by URM, low-income students. Interestingly, higher income students, regardless of race, did not benefit as much from dual credit participation in terms of their likelihood of earning at least a 3.0 as freshmen, suggesting that dual credit access for at-risk students should become a greater priority. For more detail, see the table on page 35 (Appendix G).



RECOMMENDATIONS

Based on these findings, Kentucky would do well to increase access to dual credit opportunities. Local K-12 districts should explore differences in dual credit participation, particularly among underrepresented minority students, to determine their underlying causes. While dual credit increases outcomes for nearly all participant groups, the effects are magnified for underrepresented minority and low-income students. Thus, increasing dual credit participation could be an effective strategy for narrowing academic achievement gaps.

CPE's "Dual Credit Policy for Kentucky Public and Participating Postsecondary Institutions and Secondary Schools" outlines best practices for administering dual credit courses. Additionally, this study suggests Kentucky could benefit from the following actions:

- **Improving outreach and advising for middle and high school students, particularly those who are low-income and minority, to educate them about the availability and benefits of dual credit courses.**

Although Kentucky has increased participation in dual credit since 2016, courses still may not reach the students who could benefit from them the most. With the assistance of state education agencies and counseling professionals, an even stronger message could be tailored and disseminated to at-risk high school students in K-12 districts across the state. CPE and KDE should facilitate closer collaboration among high schools and colleges to better advise students who are unaware of the benefits of dual credit in terms of increasing college readiness and reducing college costs.

- **Ensuring dual credit courses are accessible at local high schools during the school day to the greatest extent possible.**

Currently, dual credit is comprised of multiple options: some courses are taught by high school teachers, some take place at a KCTCS campus or university, some are online, and some occur outside of the regular school day. While all of these options are valid, increasing the number of dual credit courses offered on the high school campus during the regular school day would reduce barriers associated with transportation, scheduling and other costs. Doing so may require districts to incentivize more teachers to obtain the necessary qualifications to teach dual credit, since dual credit teachers must meet the college's minimum qualifications for instruction (in most cases, 18 hours of master's degree credit in the subject being taught). Schools also should examine whether unnecessary prerequisites are required for dual credit participation and if so, consider their removal or amendment.

- **Providing additional financial assistance for low-income students to expand dual credit opportunities and help cover associated costs.**

Given the positive effects of dual credit on postsecondary outcomes, Kentucky should explore whether more funding is available to help low-income students cover additional dual credit coursework and associated indirect costs.



FOR FUTURE STUDY

While the findings presented in this study provide evidence that dual credit can help students succeed in college, additional research is needed to address some of its limitations and expand its depth and breadth.

- **Include additional demographic characteristics and variables.** Given restrictions in the longitudinal dataset of this study, we were only able to include some demographic characteristics in the matching model to predict the likelihood of enrolling in a dual credit course. Because prior academic performance and motivation are key predictors of dual credit enrollment, additional research would match students within each high school using eighth-grade GPA or other characteristics as a measure of academic motivation. A next step is to merge CPE's dataset with KDE's dataset to obtain better estimates of the causal relationship between high school dual credit and postsecondary achievement. Furthermore, the current dataset did not include information about the intensity of dual credit enrollment, such as total dual credit hours taken and the types of dual credit courses. Exploring how variations in dual credit participation affect academic outcomes is critical. Further research also is needed to assess dual credit's impact on other postsecondary outcomes, like college completion and employment.
- **Examine outcomes for dual credit participants who attend KCTCS.** CPE is planning a second report to explore the effects of dual credit participation on student outcomes at KCTCS campuses. This report also will include information about the intensity of dual credit enrollment to explore how this variation affects academic outcomes at KCTCS.
- **Survey dual credit students, teachers and other stakeholders.** It would be helpful to better understand the perceptions and experiences of stakeholders who are involved in dual credit, such as students, instructors, advisors and school administrators. To facilitate this, surveys could be designed and administered, and focus groups and individual interviews could be conducted.

In conclusion, additional qualitative research would help us gain further insights into the accessibility, transferability, affordability and quality of dual credit programs and their effects on academic achievement. Through these approaches, CPE would gain a more complete picture of Kentucky dual credit programs and participants.



APPENDICES





APPENDIX A

MEASURES

Independent Variable:

Dual credit. This variable indicates whether students enrolled in a course for which they received both high school and college credit.

Outcome Variables:

Second-year persistence. This variable indicates whether or not students returned to any higher education institution within Kentucky in the fall semester following their first year of college.

First-year GPA. This variable indicates the average GPA of all courses that students took during their first year of college, excluding grades from remedial courses. We used GPA as both a continuous and categorical variable for this study. For the continuous variable, the points range from 0.0 to 4.0. The categorical variable is classified into two categories: $GPA < 3.0$ and $3.0 \geq GPA$. (Note: We included first-year GPA as one of the confounding variables to predict second-year persistence.)

Confounding Variables:

Underrepresented minority (URM). This variable indicates whether students categorized themselves as (a) Hispanic or Latinx, (b) American Indian or Alaska Native, (c) Black or African American, (d) Native Hawaiian or Other Pacific Islander, or (e) Two or more Races.

Low-income. This variable indicates whether or not students received any Pell Grant at entry or during specific semesters (varies depending on the specific metric).

Gender. This variable indicates whether students categorized themselves as (a) female or (b) male.

College underpreparedness. This variable indicates whether or not students are underprepared for college based on CPE college readiness standards (<http://www.cpe.ky.gov/policies/collegereadiness.html>).

First-year GPA. This variable is one of the outcome variables. We included it in the models as one of the confounding variables to predict the second-year persistence.

Cohort year. This variable indicates the cohort year when students first enrolled in a public university in Kentucky, including fall 2014, 2015, 2016 and 2017.

Institution name. This variable indicates the four-year public institution in Kentucky where students enrolled during the cohort years of fall 2014, 2015, 2016 and 2017. They include: (a) Eastern Kentucky University, (b) Kentucky State University, (c) Morehead State University, (d) Murray State University, (e) Northern Kentucky University, (f) University of Kentucky, (g) University of Louisville, and (h) Western Kentucky University.

ATTRIBUTES OF THE VARIABLES

Variable Name	Type	Categories
Independent Variable		
Dual Credit	Binary	(a) Yes (b) No
Outcome Variables		
Second-Year Persistence	Binary	(a) Yes (b) No
First-Year GPA	Binary	(a) GPA < 3.0 (b) GPA ≥ 3.0
	Continuous	Points Range on a 4.0 scale
Confounding Variables		
Underrepresented Minority	Binary	(a) Yes (b) No
Gender	Binary	(a) Yes (b) No
Underprepared for College	Binary	(a) Yes (b) No
Cohort Year	Categorical	Fall 2014 Fall 2015 Fall 2016 Fall 2017
Institution	Categorical	Eastern Kentucky University Kentucky State University Morehead State University Murray State University Northern Kentucky University University of Kentucky University of Louisville Western Kentucky University



APPENDIX B

ANALYTIC STRATEGIES

Descriptive analyses examined the differences in preexisting demographic characteristics (URM, low-income, gender), academic outcomes (college underpreparedness, first-year GPA, second-year persistence), and cohort year participation (fall 2014, 2015, 2016 and 2017) between students who enrolled in dual credit and those who did not.

This study used regression analysis to examine the effects of dual enrollment on postsecondary educational outcomes, as measured by students' second-year persistence and first-year GPA. Regression analysis adjusts for the observed confounding variables in the models. The confounding variables included in this study were found to be associated with the interested outcome variables suggested by both theories and previous empirical studies. Binary logistic regression models were used for the dichotomous outcome variable: second-year persistence.

For the second outcome variable, first-year GPA, the underlying assumptions were tested to determine whether to use an Ordinary Least Squares (OLS) regression model for the continuous GPA variable. A violation of one of the assumptions was found, showing that the error term was not normally distributed. Additionally, the distribution of the continuous GPA was highly left skewed. OLS regression can be misleading, as it relies on the mean as a measure of centrality for a normal distribution. Thus, the original continuous GPA variable was placed into two categories: $GPA < 3$ and $3 \geq GPA$. A binary logistic regression was conducted using this new categorized GPA variable. Furthermore, quantile regression was used to determine if dual credit affects GPA differently at various quantiles of the conditional test score distribution.

This dataset includes full-time freshman students from eight different four-year public institutions in Kentucky across four cohorts, regardless of whether a student had a dual credit experience or in which sector the dual credit experience took place. However, there are variations in second-year persistence and first-year GPA across universities, due to the differences in each university's institutional support, selectivity, student-faculty ratio, etc. In addition, there are variations by cohort. Without accounting for the differences between institutions and cohorts, the estimate of the effect of dual credit on second-year persistence and first-year GPA might be biased. In order to mitigate the potential bias, institution fixed effects and cohort fixed effects were included to account for the variations across institutions and by cohort.

In order to explore whether the effects of dual credit vary across various subgroups of students, the analysis was disaggregated further by student race, gender, income and college readiness. These estimates were calculated by introducing interactions of the student subgroup with the dual credit indicator in the analysis models. Five sets of interaction terms were tested through five separate binary logistic regression models. The interaction terms are: (a) dual credit and gender, (b) dual credit and college underpreparedness, (c) dual credit and URM, (d) dual credit and low-income, (e) dual credit and URM and low-income.

In an ideal experimental setting to gauge the effects of dual credit, high school students would be randomly assigned either to enroll or to not enroll in a dual credit course. The unbiased treatment effects of dual credit on students' postsecondary achievements would then be calculated. However, in Kentucky, dual credit is not randomly assigned, but self-selected. Choosing to apply for a dual credit course depends on the active choices of students and their parents. These choices typically depend on student academic performance, motivation, family financial situation, and available dual credit opportunities in high schools. For example, if students with higher eighth-grade GPA or motivation apply for dual credit courses, then the postsecondary performances of these students might appear better than non-dual credit students because of potentially unobserved

background differences between two groups. In order to mitigate the selection bias, we employed Propensity Score Matching (PSM) as a quasi-experimental approach attempting to obtain better treatment effects.

Given the availability of the longitudinal data, student demographic characteristics for this study included gender, race, low-income, cohort year, and region in the matching model to predict student likelihood to enroll in a dual credit course. Ideally, students would be matched within each high school using their eighth-grade GPA and a measure of their motivation. Thus, due to this limitation, PSM was used as a trial on the preferred logistic regression models predicting second-year persistence and first-year GPA for this study.

For all logistic regression analysis results, both Odds Ratio (OR) and Marginal Effects at the Means (MEM) were calculated and recorded. Compared with the OR, the MEM present the differences in probabilities while holding other confounding variables at their means. Therefore, MEM can provide a clearer interpretation of the magnitude of the effect that dual credit had on second-year persistence and first-year GPA by isolating these outcomes variables without effect from the other factors. Adjusted Predictions at the Means (APM) were also computed and reported to present the average predicted probabilities while holding other confounding variables at their means.

All analyses were conducted using Stata SE/14.0 statistical software.



APPENDIX C

THE EFFECT OF DUAL CREDIT ON SECOND-YEAR PERSISTENCE

Overall, dual credit had a positive impact on students' second-year persistence across all the models, as shown in the table below. After controlling for the covariates and including the institution and cohort fixed effects in Model 4, the average predicted probability of being retained for a dual credit student was 2.0 percentage points higher than a non-dual credit student ($p < 0.001$). The result on the matched sample after PSM also indicates that dual credit students were more likely to persist to a second year. The effect size for this outcome even slightly increased by 0.1 percentage points after matching, compared with Model 4.

	Model 1	Model 2	Model 3	Model 4	Model 5 (PSM)
Dual Credit (Marginal Effects at the Means)	0.077*** (0.003)	0.021*** (0.003)	0.022*** (0.003)	0.020*** (0.003)	0.021*** (0.008)
Dual Credit (Odds Ratio)	1.782*** (0.043)	1.305*** (0.042)	1.314*** (0.042)	1.300*** (0.042)	1.305*** (0.052)
¹ Covariates	NO	YES	YES	YES	YES
Cohort Fixed Effects	NO	NO	YES	YES	YES
Institution Fixed Effects	NO	NO	NO	YES	YES
Observations	51,995	48,554	48,544	48,544	30,792
Pseudo R ²	0.013	0.342	0.342	0.348	0.347
Log-likelihood	-23022.128	-14087.754	-14079.213	-13963.874	-9006.964
AIC	48472.593	28189.508	28179.255	27961.794	18047.928
BIC	45490.311	28251.039	28267.157	28111.183	18189.624

Note. ¹Covariates included gender, URM, low-income, college underpreparedness, and first-year GPA. Robust standard errors are in parentheses.

* $P \leq .05$. ** $P \leq .01$. *** $P \leq .001$.

AVERAGE PREDICTED PROBABILITY OF PERSISTING TO A SECOND YEAR OF COLLEGE

The following table presents the average predicted probability of persisting to a second year of college for both dual and non-dual credit students after holding other confounding variables at their means. In Model 4, the predicted chance of second-year persistence for dual and non-dual credit students were 92.5% and 90.5% respectively, although the difference in Model 5 after matching was slightly increased. However, the chance of persisting to a second year for both groups was relatively smaller: 92.2% for dual credit students and 90.1% for non-dual credit students.

	Model 1	Model 2	Model 3	Model 4	Model 5 (PSM)
Dual Credit	0.876 (0.002)	0.924 (0.002)	0.924 (0.002)	0.925 (0.002)	0.922 (0.002)
95% Confidence Intervals	[0.872, 0.880]	[0.920, 0.927]	[0.921, 0.928]	[0.921, 0.929]	[0.918, 0.927]
Non-Dual Credit	0.799 (0.002)	0.903 (0.002)	0.902 (0.002)	0.905 (0.002)	0.901 (0.002)
95% Confidence Intervals	[0.794, 0.804]	[0.898, 0.907]	[0.898, 0.906]	[0.901, 0.909]	[0.895, 0.906]

*Note. 95% confidence Intervals were reported.
Robust standard errors are in parentheses.*



APPENDIX D

THE EFFECT OF DUAL CREDIT ON FIRST-YEAR GPA

Overall, dual credit had a positive impact on students' first-year GPA for all the models, as shown in the table below. After controlling for the covariates and including the institution and cohort fixed effects in Model 4, the average predicted probability of earning a first-year GPA equal to or greater than 3.0 on a 4.0 scale for a dual credit student was 8.2 percentage points higher than for a non-dual credit student ($p < 0.001$). The result on the matched sample after PSM also indicates that dual credit students were more likely to earn a first-year GPA equal to or greater than 3.0 during their freshmen year. The effect size slightly increased by 1.0 percentage point after matching compared with model 5.

	Model 1	Model 2	Model 3	Model 4	Model 5 (PSM)
Dual Credit (Marginal Effects at the Means)	0.119*** (0.004)	0.079*** (0.005)	0.075*** (0.005)	0.082*** (0.005)	0.092*** (0.006)
Dual Credit (Odds Ratio)	1.623*** (0.030)	1.378*** (0.027)	1.356*** (0.027)	1.400*** (0.028)	1.453*** (0.036)
¹ Covariates	NO	YES	YES	YES	YES
Cohort Fixed Effects	NO	NO	YES	YES	YES
Institution Fixed Effects	NO	NO	NO	YES	YES
Observations	48,693	48,544	48,544	48,544	30,792
Pseudo R ²	0.010	0.078	0.080	0.086	0.085
Log-likelihood	-33100.468	-30768.623	-30689.704	-30476.934	-19373.641
AIC	66204.936	61549.247	61397.408	60985.868	38779.282
BIC	66222.522	61601.988	61476.520	61126.511	38912.643

Note. ¹Covariates included gender, URM, low-income, college underpreparedness. Robust standard errors are in parentheses.

* $P \leq .05$. ** $P \leq .01$. *** $P \leq .001$.

**AVERAGE PREDICTED PROBABILITY OF OBTAINING A FIRST-YEAR GPA
EQUAL TO OR GREATER THAN 3.0**

The following table presents the average predicted probability of obtaining a first-year GPA that is either equal to or greater than 3.0 for both dual and non-dual credit students after holding other confounding variables at their means. In model 4, the predicted chance of obtaining a first-year GPA that is either equal to or greater than 3.0 for dual and non-dual credit students was 59.8% and 51.6%, respectively. In Model 5, after matching, the gap widened - it was 60.0% for dual credit students and 50.8% for non-dual credit students.

	Model 1	Model 2	Model 3	Model 4	Model 5 (PSM)
Dual Credit	0.616 (0.003)	0.595 (0.003)	0.594 (0.003)	0.598 (0.003)	0.600 (0.004)
95% Confidence Intervals	[0.610, 0.622]	[0.589, 0.602]	[0.587, 0.600]	[0.592, 0.605]	[0.592, 0.609]
Non-Dual Credit	0.497 (0.003)	0.516 (0.003)	0.519 (0.003)	0.516 (0.003)	0.508 (0.004)
95% Confidence Intervals	[0.491, 0.503]	[0.510, 0.523]	[0.512, 0.525]	[0.509, 0.522]	[0.500, 0.517]

*Note. 95% confidence Intervals were reported.
Robust standard errors are in parentheses.*



APPENDIX E

THE EFFECTS OF DUAL CREDIT AT DIFFERENT QUANTILES OF FIRST-YEAR GPA

Based on the quantile regression analysis results in the table below, dual credit was found to have a stronger impact on the grades of students who had a lower first-year GPA than those who had a higher first-year GPA. Compared with non-dual credit students, dual credit participants had an average of 0.295 points higher at the 25th quantile of first-year GPA, 0.180 points higher at the 50th, and 0.094 points higher at the 75th. In sum, the effects of dual credit decreased for students whose first-year GPAs were greater.

Variable	25th Quantile	50th Quantile	75th Quantile
Dual Credit	0.295*** (0.021)	0.180*** (0.013)	0.094*** (0.009)
¹ Covariates	YES	YES	YES
Cohort Fixed Effects	YES	YES	YES
Institution Fixed Effects	YES	YES	YES
Observations	30,792	30,792	30,792
Adjusted R ²	0.100	0.085	0.069

Note. ¹Covariates included gender, URM, low-income, college underpreparedness. Robust standard errors are in parentheses.

* $P \leq .05$. ** $P \leq .01$. *** $P \leq .001$.



APPENDIX F

AVERAGE PREDICTED PROBABILITY OF SECOND-YEAR PERSISTENCE ACROSS SUBGROUPS

Gender

Overall, dual credit had a positive impact on second-year persistence for both female and male students; however, the former group benefited more from dual credit than latter group. With dual credit, there was an increase of 2.6 percentage points in the probability of persisting to a second year for female students, and an increase of 1.6 percentage points for male students, as indicated in the table below. Without dual credit, male students were more likely to persist to the second year of college than female students (after controlling for other confounding variables). On average, the predicted probability of persisting to a second year of college for a non-dual credit male student was 0.8 percentage points higher than a non-dual credit female student. The relationship was reversed with dual credit. A dual credit female student was slightly more likely to persist to a second year of college than a dual credit male student. However, the 95 percent confidence intervals of the average predicted probability of male and female students with and without dual credit overlapped. This evidence indicates that although there were gaps between male and female students with and without dual credit, both gaps were not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
<i>Model 1: Interaction between dual credit and gender</i>			
Gender			
Female	0.897 (0.004)	0.923 (0.003)	0.026*
95% Confidence Intervals	[0.890, 0.904]	[0.917, 0.930]	
Male	0.905 (0.003)	0.922 (0.003)	0.017*
95% Confidence Intervals	[0.898, 0.912]	[0.915, 0.928]	
Difference	0.008	0.001	

College Preparation

Dual credit had a positive effect on second-year persistence only for college prepared students. On average, a non-dual credit prepared student had a 90% chance of persisting to a second year, while an otherwise comparable prepared student who enrolled in dual credit had a 92.3% chance of persisting. The increase of 2.3 percentage points with dual credit was statistically significant. Although a dual credit underprepared student had a 1.7 percentage points increase in the probability of persistence, the increase was not statistically significant.

Overall, dual credit widened the gap between college-prepared and underprepared students. Without dual credit, prepared and underprepared students shared a similar likelihood of persisting to a second year. With dual credit, an underprepared student was 0.5 percentage points more likely to persist than a prepared student. However, this difference was not statistically significant, as the confidence intervals for these groups overlapped.

Subgroup	Non-Dual Credit	Dual Credit	Difference
<i>Model 2: Interaction between dual credit and preparation</i>			
Underprepared			
Yes	0.901 (0.005)	0.918 (0.002)	0.017
95% Confidence Intervals	[0.891, 0.912]	[0.905, 0.931]	
No	0.900 (0.003)	0.923 (0.002)	0.023*
95% Confidence Intervals	[0.895, 0.906]	[0.918, 0.928]	
Difference	0.001	0.005	

Income

Dual credit had a positive impact on second-year persistence for both low-income and non-low-income students. A non-dual credit non-low-income student had a 91.3% chance of persisting to a second year, while an otherwise comparable dual credit non-low-income student had a 92.8% chance. The low-income students showed similar results. On average, dual credit low-income students were 3.0 percentage points more likely to persist than their non-dual credit peers. Low-income students benefited more from participation in dual credit than non-low-income students. With or without dual credit, non-low-income students were more likely to persist to the second year of college than low-income students. However, dual credit narrowed the gap between the two groups from 3.1 percentage points to 1.6 percentage points. Both gaps were statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
<i>Model 3: Interaction between dual credit and income</i>			
Low-Income			
Yes	0.882 (0.004)	0.912 (0.007)	0.030*
95% Confidence Intervals	[0.874, 0.890]	[0.907, 0.919]	
No	0.913 (0.003)	0.928 (0.006)	0.015*
95% Confidence Intervals	[0.906, 0.919]	[0.922, 0.934]	
Difference	0.031*	0.016*	

Race

Dual credit students were more likely to be persist to a second year of college than non-dual credit students for both URM and non-URM subgroups. With dual credit, there was an increase of 2.3 percentage points in the probability of persisting to a second year for URM students, and an increase of 2.1 percentage points for non-URM students. Both increases were statistically significant. Regardless of dual credit participation, URM students were more likely to persist than non-URM students. However, both differences were not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
<i>Model 4: Interaction between dual credit and race</i>			
URM			
Yes	0.907 (0.005)	0.930 (0.005)	0.023*
95% Confidence Intervals	[0.896, 0.918]	[0.920, 0.939]	
No	0.900 (0.003)	0.921 (0.003)	0.021*
95% Confidence Intervals	[0.894, 0.905]	[0.916, 0.926]	
Difference	0.007	0.011	

Income and Race

Dual credit had a statistically significant effect on second-year persistence for all four noted subgroups. Overall, whether or not they participated in dual credit, non-low-income non-URM students had the highest probability of persisting to a second year, while low-income URM students had the lowest probability. However, participation in dual credit significantly narrowed the gap in the probability of second-year persistence between non-low-income non-URM students and low-income URM students, from 12.2 percentage points to 8.8 percentage points. Additionally, participation in dual credit significantly narrowed the gap between non-low-income URM students and low-income URM students, from 8.0 percentage points to 4.9 percentage points. Moreover, low-income non-URM students benefited the most from participating in dual credit, with an increase of 9.3 percentage points in their chance of being retained for a second year. Low-income URM students benefited the second most from participating in dual credit, with an increase of 8.2 percentage points.

Subgroup	Non-Dual Credit	Dual Credit	Difference
<i>Model 5: Interaction between dual credit, race and income</i>			
URM & Low-Income			
No & No	0.853 (0.004)	0.901 (0.003)	0.048*
95% Confidence Intervals	[0.845, 0.861]	[0.895, 0.908]	
No & Yes	0.747 (0.006)	0.840 (0.005)	0.093*
95% Confidence Intervals	[0.735, 0.759]	[0.830, 0.850]	
Yes & No	0.811 (0.013)	0.862 (0.012)	0.051*
95% Confidence Intervals	[0.786, 0.837]	[0.839, 0.886]	
Yes & Yes	0.731 (0.012)	0.813 (0.010)	0.082*
95% Confidence Intervals	[0.709, 0.755]	[0.792, 0.833]	

Note. For all tables, covariates included gender, URM, low-income, college underpreparedness and first-year GPA. The analyses included cohort and institution fixed effects. Robust standard errors are in parentheses.

* $P \leq .05$.



APPENDIX G

AVERAGE PREDICTED PROBABILITY OF EARNING A FIRST-YEAR GPA OF 3.0 OR HIGHER ACROSS SUBGROUPS

Gender

Overall, dual credit had a positive impact on the first-year GPA of both male and female students. The predicted probability of obtaining a GPA equal to or greater than 3.0 for both groups with dual credit was greater than for their non-dual credit peers. The difference between dual and non-dual credit female students was 7.5 percentage points, while the difference for male students was 11.1 percentage points. Male students benefited more from dual enrollment than female students.

Additionally, female students were more likely than male students to obtain a first-year GPA equal to or greater than 3.0, with or without dual credit. The predicted probability for female students with or without dual credit was 57.8% and 65.3%, respectively. By comparison, the probability was 41.6% for male non-participants and 52.7% for male participants. There were statistically significant differences between the two groups regardless of dual credit, as the confidence intervals did not overlap. However, dual credit narrowed the gap in the probability of earning a first-year GPA equal to or greater than 3.0 between female and male students, from 16.2 percentage points to 12.6 percentage points.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 1: Interaction between dual credit and gender			
Gender			
Female	0.578 (0.006)	0.653 (0.005)	0.075*
95% Confidence Intervals	[0.567, 0.589]	[0.642, 0.663]	
Male	0.416 (0.006)	0.527 (0.006)	0.111*
95% Confidence Intervals	[0.404, 0.429]	[0.514, 0.539]	
Difference	0.162*	0.126*	

College Preparation

College-prepared students were more likely to obtain a first-year GPA equal to or greater than 3.0 than underprepared students, regardless of dual credit. Prepared students with dual credit were 9.4 percentage points more likely to obtain a first-year GPA equal to or greater than 3.0 than their non-dual credit peers. For underprepared students, the predicted probability of earning a first-year GPA equal to or greater than 3.0 was 4.4 percentage points greater with dual credit than without dual credit. However, this increase was not statistically significant.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 2: Interaction between dual credit and preparation			
Underprepared			
Yes	0.268 (0.009)	0.312 (0.015)	0.044
95% Confidence Intervals	[0.250, 0.286]	[0.283, 0.341]	
No	0.546 (0.005)	0.640 (0.004)	0.094*
95% Confidence Intervals	[0.537, 0.555]	[0.631, 0.648]	
Difference	0.278*	0.328*	

Income

Dual credit had a positive impact on the first-year GPA of both low-income and non-low-income students. The predicted probability of obtaining a GPA equal to or greater than 3.0 for both groups with dual credit were significantly greater than their non-dual credit peers. The difference between dual and non-dual credit low-income students was 7.9 percentage points, while the difference for non-low-income students was 10.7 percentage points. Low-income students benefited more from dual credit than non-low-income students.

Additionally, non-low-income students were more likely to obtain a first-year GPA equal to or greater than 3.0 than low-income students, with or without dual credit. The predicted probability for non-low-income students was 57.3% without dual credit and 65.2% with dual credit. By comparison, for low-income students, it was 41.4% without dual credit and 52.1% with dual credit. These differences between dual credit participants and non-participants were statistically significant, as the confidence intervals did not overlap. However, dual credit narrowed the gap in the probability of obtaining a first-year GPA equal to or greater than 3.0 between low-income and non-low-income students - from 15.9 percentage points to 13.1 percentage points.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 3: Interaction between dual credit and income			
Low-Income			
Yes	0.414 (0.007)	0.521 (0.007)	0.107*
95% Confidence Intervals	[0.401, 0.428]	[0.508, 0.533]	
No	0.573 (0.003)	0.652 (0.005)	0.079*
95% Confidence Intervals	[0.562, 0.584]	[0.642, 0.662]	
Difference	0.159*	0.131*	

Race

Dual credit had a positive impact on the first-year GPA of both URM and non-URM students. Non-URM students benefited more from dual credit than URM students on this variable. The predicted probability of obtaining a GPA equal to or greater than 3.0 for both URM and non-URM students with dual credit was greater than for their non-dual credit peers. The difference between dual and non-dual credit non-URM students was 9.4 percentage points, while the difference for URM students was 7.5 percentage points. Both differences were statistically significant.

Additionally, non-URM students were more likely to obtain a first-year GPA equal to or greater than 3.0 than URM students, with or without dual credit. The predicted probability for non-URM students without dual

credit was 52.4%, compared to 61.8% with dual credit. For URM students without dual credit, it was 42.1%, compared to 49.6% with dual credit. With dual credit, the probability of obtaining a first-year GPA of at least 3.0 for both URM and non-URM students increased, but dual credit slightly widened the gap between URM and non-URM students - from 10.3 percentage points to 12.2 percentage points.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 4: Interaction between dual credit and race			
URM			
Yes	0.421 (0.011)	0.496 (0.011)	0.075*
95% Confidence Intervals	[0.399, 0.443]	[0.475, 0.518]	
No	0.524 (0.005)	0.618 (0.005)	0.094*
95% Confidence Intervals	[0.515, 0.533]	[0.610, 0.627]	
Difference	0.103*	0.122*	

Income and Race

Dual credit had a statistically significant effect on probable GPA for three of the noted subgroups (with the exception of non-low-income URM students). Compared to the other three categories, low-income non-URM students benefited the most from dual credit, with an average 11.1 percentage-point increase in the probability of obtaining a GPA equal to or greater than 3.0. Low-income URM students benefited the second most from dual credit, with an increase of 8.6 percentage points. Students who were neither URM nor low-income had the greatest probability of obtaining a GPA equal to or greater than 3.0. The probability for non-participants was 58.8%, and for participants it was 66.9%. Students who were both URM and low-income had the lowest probability, at 32.8% for non-participants and 41.4% for participants. Participation in dual credit slightly narrowed the gap in probable GPA between non-low-income non-URM students and low-income URM students, from 26.0 percentage points to 25.5 percentage points. Additionally, participation in dual credit significantly narrowed the gap between non-low-income URM students and low-income URM students, from 16.8 percentage points to 13.5 percentage points.

Subgroup	Non-Dual Credit	Dual Credit	Difference
Model 5: Interaction between dual credit, race and income			
URM & Low-Income			
No & No	0.588 (0.006)	0.669 (0.005)	0.081*
95% Confidence Intervals	[0.576, 0.599]	[0.658, 0.679]	
No & Yes	0.430 (0.008)	0.541 (0.007)	0.111*
95% Confidence Intervals	[0.416, 0.445]	[0.526, 0.555]	
Yes & No	0.496 (0.018)	0.549 (0.017)	0.053
95% Confidence Intervals	[0.462, 0.530]	[0.515, 0.582]	
Yes & Yes	0.328 (0.013)	0.414 (0.014)	0.086*
95% Confidence Intervals	[0.302, 0.354]	[0.387, 0.440]	

Note. For all tables, covariates included gender, URM, low-income, college underpreparedness and first-year GPA. The analyses included cohort and institution fixed effects. Robust standard errors are in parentheses. 95% confidence intervals were reported.

* $P \leq .05$.

NOTES





NOTES

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