



RESEARCH REPORT

Impact of State Higher Education Finance on Attainment

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July 2021

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Contents

Acknowledgments	iv
Executive Summary	v
Impact of State Higher Education Finance on Attainment	1
Literature Review	3
Data	5
Descriptive Statistics	6
The Impact of Recent Reforms to State Financial Aid Programs	10
The Impact of State Appropriations	31
Discussion	40
Appendix	43
Notes	55
References	56
About the Authors	59
Statement of Independence	60

Acknowledgments

This report was funded by Joyce Foundation and Lumina Foundation. We are grateful to them and to all our funders, who make it possible for Urban to advance its mission.

The views expressed are those of the authors and should not be attributed to the Urban Institute, its trustees, or its funders. Funders do not determine research findings or the insights and recommendations of Urban experts. Further information on the Urban Institute's funding principles is available at urban.org/fundingprinciples.

We would like to thank Sandy Baum, Kristin Blagg, Erica Blom, and Matthew Chingos for thoughtful comments and suggestions.

Executive Summary

We study the effects of the two main types of state funding for higher education—financial aid programs and state appropriations—on postsecondary enrollment and degree attainment, by race and ethnicity. We use two causal inference research designs to assess the impact of both types of state spending. First, we study state changes to student aid spending between 2003 and 2017, providing national-level estimates of the impact of recent reforms to student aid. For community colleges, we find a striking pattern of divergence between states that cut spending versus those that increased it: enrollment and degree awards rose in states that increased aid spending, but they decreased in states that made cuts. We show that this divergence is more severe for Black and Hispanic students, who experience larger losses than white and Asian students in states that underwent student aid spending cuts. We do not find meaningful impacts for these reforms on public universities.

Second, we study the impact of state appropriations—dollars intended to fund college operations, which have secularly declined over time as a share of college revenue—by comparing trends in enrollment and degree awards across colleges with different levels of dependence on this type of funding. For both universities and community colleges, we find that appropriations are key drivers of college enrollment and degree awards. Furthermore, our estimates consistently suggest that outcomes are more sensitive to appropriations funding for Black and Hispanic students, especially at the institutions that need this funding the most. Our results reinforce the notion that racial and ethnic inequality in college attainment is more severe when states limit funding for public colleges.

Impact of State Higher Education Finance on Attainment

Racial and ethnic inequality in socioeconomic outcomes is perhaps the most important issue facing US society today. One fundamental channel that perpetuates inequality is inequitable access to public education, which translates into inequality in income, wealth, and well-being. A key aspect of the education pipeline holding Black and Hispanic students back is a lack of access to high-quality postsecondary education. Research on labor markets shows that high-quality postsecondary credentials are key for securing good jobs in today's economy, the kinds of jobs that can generate sufficient income and benefits to lift families out of poverty (Autor, Katz, and Krueger 1998; Dale and Krueger 2002). But postsecondary education cannot further equity until public college is accessible and affordable to students from all backgrounds.

The US has had a questionable record of ensuring that public colleges are well funded. A large share of higher education financing comes from state governments, whose budgets are closely tied to contemporaneous economic conditions and are thus volatile. During recent economic crises, states have been forced to make difficult decisions regarding public college financing. In this report, we take stock of the impact of recent changes to state spending for higher education on college attainment (enrollment and degree awards) by race and ethnicity. Our research documents how cuts to state funding for higher education affect racial inequality.

There are two main types of state spending for higher education. First, there are state programs for student financial aid that provide grants, scholarships, and state loans to students based on financial circumstances, measures of academic preparation, or both. This type of funding varies considerably from state to state. Since the early 2000s, some states have increased their funding for student financial aid, while others have implemented policies that cut financial aid spending. Part of this state policy divergence is linked to differences in state politics, but often, the timing of abrupt changes to aid spending have happened for reasons unrelated to the state of higher education. In Arkansas, for example, funding for student aid skyrocketed when the legislature approved a state lottery, whose proceeds are partially used to fund student scholarships.

The other type of state funding for higher education is state appropriations for public colleges, which fund institutional operations and are generally a larger share of state higher education expenditures relative to student aid programs. Figure 12 shows that, on aggregate, the average share of public colleges' budgets stemming from state appropriations has declined steadily since 1994 in a cyclical fashion. Bust cycles see large dips in the appropriations share, and boom periods produce

plateaus in the share of appropriations with little or no recovery. The fall of the appropriations share of college revenues in recent years has coincided with a secular increase in colleges' posted tuition rates (appendix figure A.1). As such, college affordability, perhaps the most contentious topic in education policy, is linked to state budgetary decisions regarding state appropriations (Deming and Walters 2017).

To assess the impact of each type of state spending on college attainment by race and ethnicity, we implement two research designs. First, we leverage an event study design (i.e., a flexible difference-in-differences model) examining the impact of some states' divergence in aid spending between 2003 and 2017. Because these states changed student aid programs at different times, we can identify the impact of changes to aid programs independent of the Great Recession's impacts. States that did not change their aid programs serve as a control group. The divergent patterns of aid spending across certain states allow us to test a two-sided hypothesis of the impact of aid on attainment: When funding increases, do more students complete college? When funding decreases, do fewer students complete college?

Our second research design leverages the empirical framework proposed by Deming and Walters (2017) to study the impact of state appropriations on enrollment and degree awards. This design leverages both the timing of changes to state funding and the fact that some institutions are more exposed to state appropriations funding because it constitutes a larger share of their annual budgets. We combine both sources of variation in a fixed-effects model of enrollment and degree awards for undergraduate students at public postsecondary institutions, which allows us to identify the impact of appropriations spending separately for the four most populous racial and ethnic groups: Black, Hispanic, Asian, and white students.

The results indicate that recent decreases in state student aid spending had significant impacts on enrollment and degree awards at community colleges, especially for Black and Hispanic students. Relative to states that did not deviate from their trend in aid spending, states that implemented abrupt aid spending changes saw excess changes in the grant dollars students received at two-year colleges and in their enrollment and degree awards. We summarize these patterns with estimates of the nationwide average impact of recent changes to state student aid spending on college attainment outcomes. Given that aid program portfolios are complex and vary considerably across states, our average national-level estimates provide useful new evidence for policymakers and advocates invested in improving college affordability.

We do not find meaningful impacts of these recent reforms for four-year colleges, neither on the grant dollars institutions received nor on enrollment or degree outcomes. The changes to state student aid spending we study, from 2003 to 2017, do not appear to have produced highly consequential effects at public universities.

Our study of the impact of appropriations spending on college attainment produces similar qualitative findings for both community colleges and public universities. In line with the literature, we document large impacts of appropriations on enrollment and degree awards. Moreover, we provide new results suggesting that appropriations have larger impacts on attainment for students of color. As would be expected, the effects of appropriations declines have been greatest in institutions whose finances are most closely tied to state funding. We find that Black and Hispanic enrollment and degree awards are especially sensitive to appropriation dollars at institutions that have a historic dependence on appropriations, especially at four-year institutions.

Our findings highlight a consistent pattern in the data, providing two key takeaways: (1) greater state spending on higher education can increase college enrollment and degree awards, and (2) percentage-wise, the effects of state higher education spending are larger for students of color than for white students.

Literature Review

Financial aid improves college affordability, and evidence suggests that aid has heterogenous impacts across racial and ethnic groups. Observational evidence from the National Education Longitudinal Study suggests that state financial aid has differential impacts by income, race, and ethnicity (Kim 2012). Furthermore, experimental studies have established that merit-based scholarships boost college enrollment, with significantly larger impacts for racial and ethnic minorities and for applicants who tend toward less selective schools (Angrist et al. 2014, 2016). Nonetheless, an analysis of Georgia's influential HOPE scholarship in 1993—a merit-based financial aid program funded by the state—showed that it benefited mostly high-income households and white student enrollment, owing to specific design features of the application process (Dynaski 2000).

Research also suggests that aid promotes college access among financially vulnerable students and that the difference between need-based aid (relying on measures of financial circumstances) and merit-based aid (focusing on academic performance before college) is increasingly blurred in state programs. A study of a Texas grant program introduced in 2000 shows that targeted recruitment combined with adequate supports and financial aid can substantially increase enrollment of low-income students in high-quality colleges and improve labor market outcomes (Andrews, Imberman, and Lovenheim 2016). Comparative studies have shown that students holding need-based grants have better college outcomes than those not receiving financial aid, while students paying for college with loans perform significantly worse than those receiving other forms of aid (Cappelli and Won 2016). Evidence shows that grant eligibility can have a positive effect on attendance, particularly at public four-year

institutions (Castleman and Long 2016). Studies have also documented positive enrollment changes following the removal of loans and improvement of financial aid offers for low-income minority students (Linsenmeier, Rosen, and Rouse 2006).

Outside of total state aid spending, the literature has highlighted the importance of program implementation, design, and salience for heterogeneity in program impacts. In her study of the Georgia HOPE scholarship, Dynarski (2000) points to a program design feature that increased paperwork for families earning less than \$50,000 as a likely cause of the program's disparate impacts by family income and race or ethnicity. Evidence shows that informational nudges for recently unemployed people can have large impacts on program and college enrollment (Barr and Turner 2018). Additionally, research indicates that low-cost, informational interventions regarding financial aid eligibility significantly increases application and enrollment rates for low-income students (Dynarski et al. 2018).

State Appropriations

Public colleges depend on state appropriations to operate and must adjust their budgets according to their state's budgeting priorities. Colleges' budgets determine spending priorities, such that appropriations affect both the quality of education services and tuition pricing. Evidence shows that higher state appropriations spending leads to lower "sticker price" tuition rates in the four-year sector (Chakrabarti, Gorton, and Lovenheim 2020). At the same time, research in economics suggests that tuition rates have important impacts on the enrollment of low-income Black students (Black and Sufi 2002). Heller (1999) found that community colleges are more sensitive to the joint effects of price, state grants, and economic conditions than four-year universities, leading community colleges to respond to changes in state appropriations more drastically via cuts to instructional and student support spending.

Denning (2017) evaluates how tuition changes affect community college enrollment in Texas, finding that Black students responded the strongest to tuition reductions and were more likely to divert their enrollment from four-year colleges to community colleges. Affordability in terms of tuition pricing has also positively affected undocumented students. In cases where undocumented students can take advantage of in-state tuition pricing, Chin and Juhn (2011) found positive enrollment of older Mexican men. And in the case of a reversal of that policy at the City University of New York, where undocumented students could no longer pay in-state tuition, Conger and Turner (2015) found an adverse short-term effect on undocumented students' educational attainment.

The literature has documented both a link between appropriations and tuition (Deming and Walters 2017) and a link between tuition and racial equity in college matriculation and attainment. But we are not aware of empirical studies directly linking appropriations to student outcomes across racial and

ethnic groups. This mechanism is important, as appropriations affect not only tuition levels but instructional quality (Deming and Walters 2017). Average estimates of the overall impact of appropriations on college attainment by race and ethnicity are useful as a contribution to the literature and as a summary estimate of the impact of state spending on racial inequality.

Data

We use Integrated Postsecondary Education Data System (IPEDS) data from the National Center for Education Statistics, accessed via the Urban Institute’s Education Data Portal, to obtain college-level information on enrollment and degree award counts by race and ethnicity, as well as information on college finances and institutional characteristics from 1994 to 2017. The IPEDS dataset collects information from institutions receiving federal funds under Title IV, as mandated by the Higher Education Act of 1965. Because the IPEDS data include vocational and other nonacademic institutions, we limit the scope of our analysis of state appropriations to public two-year community colleges and public four-year college-credit-granting institutions.¹ We collect IPEDS records on total undergraduate fall enrollment as of October 15 of each school year (fall to spring, excluding summer enrollment) and annual degree awards. Financial information includes total revenue and revenue from state appropriations and posted tuitions rates. We also observe total college expenditures, including breakdowns for spending on student supports, operations and administration, instruction, and academic supports. Each fiscal year includes data from June of the previous year to July of the survey year—that is, the prior fiscal year.

Additionally, we use the Census Bureau’s Annual Estimates of the Resident Population to generate annual estimates of population by race or ethnicity for county-level estimates, the Current Population Survey’s Annual Social and Economic Characterization survey for annual estimates of population by race or ethnicity for state-level estimates, and the Census Bureau’s Small Area Income and Poverty Estimates data to estimate poverty rates and median income for counties and states. Further, we use the Local Area Unemployment data from the Bureau of Labor Statistics to estimate county and state unemployment rates. In all our regression models, we include these demographic and economic controls to rule out confounding mechanisms, including the population share of the four largest racial and ethnic groups, the local poverty rate, median income, and unemployment. We link these variables to colleges using their county and state location.

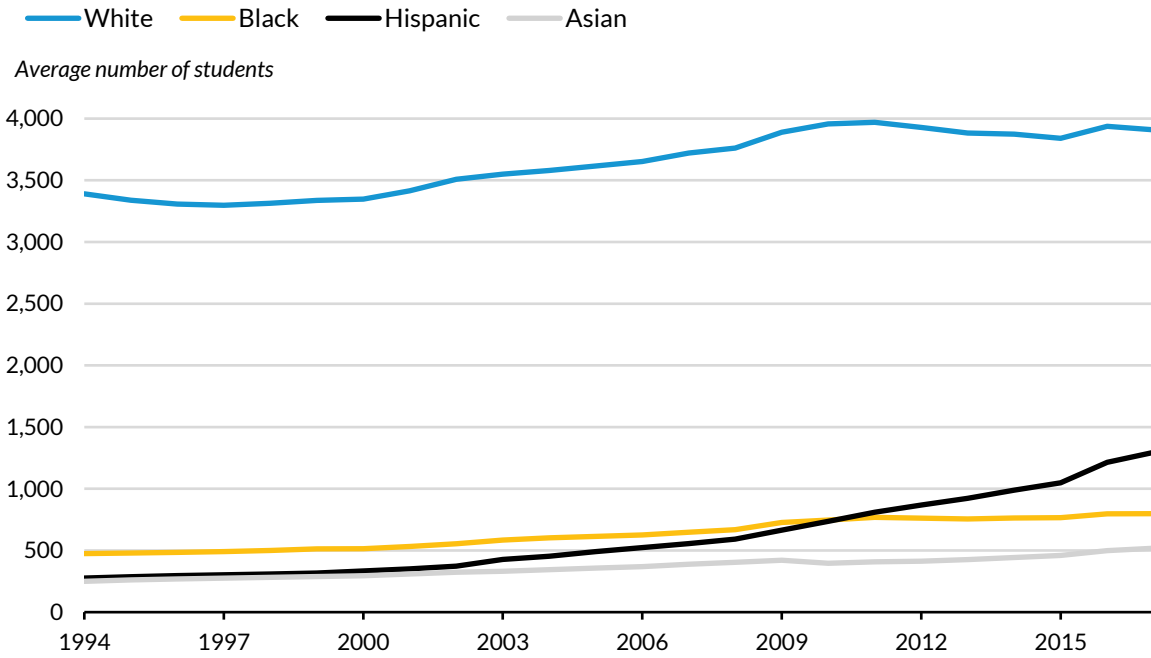
Descriptive Statistics

Figure 1 shows trends in average enrollment at public colleges by race and ethnicity. Average college-level trends are useful in the context of this study because our impact estimates of spending on college attainment reflect the experience of the average college. Public colleges enrolled 6,000 students, on average, in 2017, a 10 percent increase since 2003. Black enrollment increased 12 percent, while Hispanic enrollment doubled (appendix table A.2). At both two- and four-year colleges, Hispanic enrollment has increased considerably. Black, Asian, and white students have seen smaller enrollment increases at four-year colleges. White student enrollment at two-year colleges has decreased dramatically since 2009. These patterns reflect the representation dynamics we have documented in previous work (Monarrez and Washington 2020).

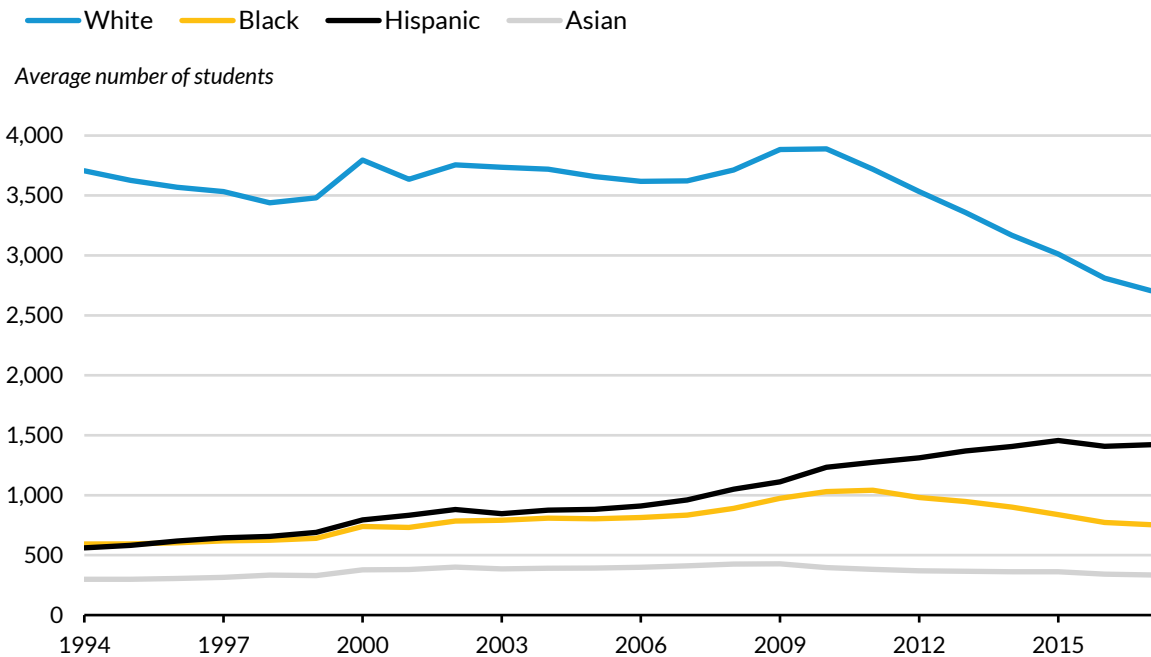
FIGURE 1

Average Enrollment at Public Colleges, by Race or Ethnicity, 1994 to 2017

Public four-year colleges



Public two-year colleges



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Source: Authors' estimates using Integrated Postsecondary Education Data System data.

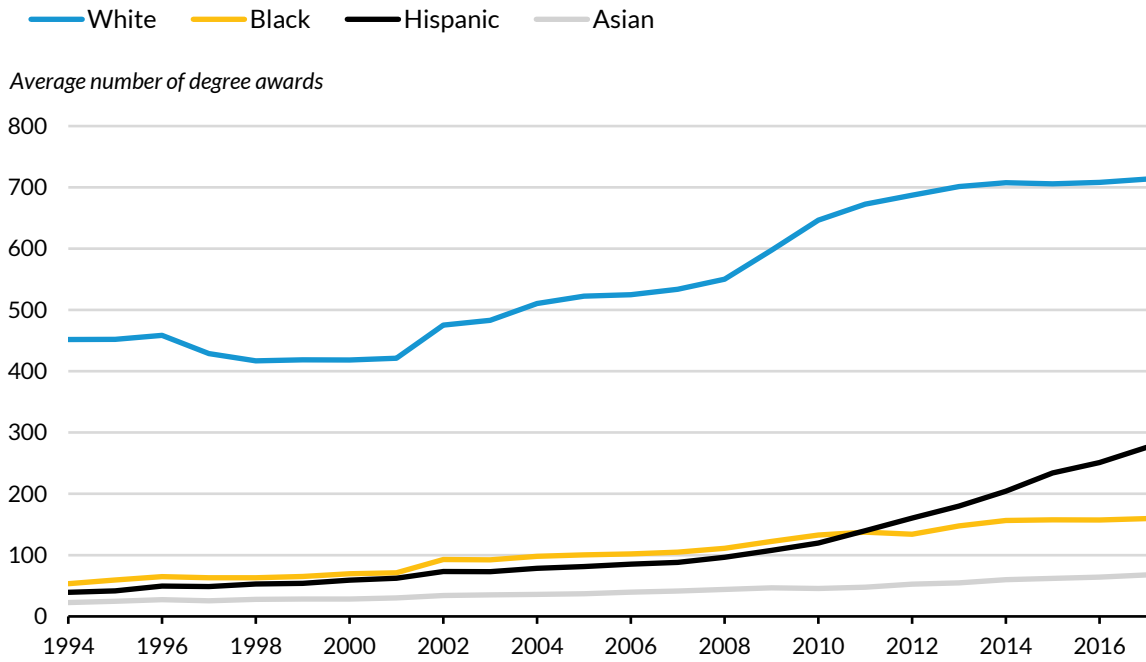
Figure 2 shows trends in average degree awards at public colleges by race and ethnicity. Degree awards steadily increased between 1994 and 2017. In the mid-2000s, Black and Hispanic students had a roughly similar number of degree awards (i.e., Black students earned, on average, only 19 degrees more than Hispanic students). But by 2017, Hispanic students, on average, completed 275 degrees while Black students completed 160 degrees, representing a 77 percent increase for Black students and a 277 percent increase for Hispanic students (appendix table A.2). Since 1994, the average number of degree awards for Hispanic students has increased fivefold at two-year institutions and between four- and fivefold at four-year institutions. This increase is only partially explained by an explosion in Hispanic enrollment. Black students have, on average, increased total degree awards by about two-thirds since 2003. Since 1994, Black students have nearly tripled their average number of degree awards at two-year institutions and doubled it at four-year institutions, following the overall trend of the total average degree awards.

The composition of the sources of college finances did not change much between 2003 and 2017 (appendix table A.2). The share of total revenue stemming from state appropriations has remained the same, on average. State appropriations still make up about 33 percent of average total revenue, while net tuition corresponds to nearly 20 percent of an institution's average total revenues. There has been a modest decrease in the average share of expenses being instruction-related expenses, while the average share of expenses related to student services has not changed. Additionally, the composition of the sources of student aid has not changed dramatically. Federal grants still compose about 75 percent of average total student aid, while state grants compose about 17 percent.

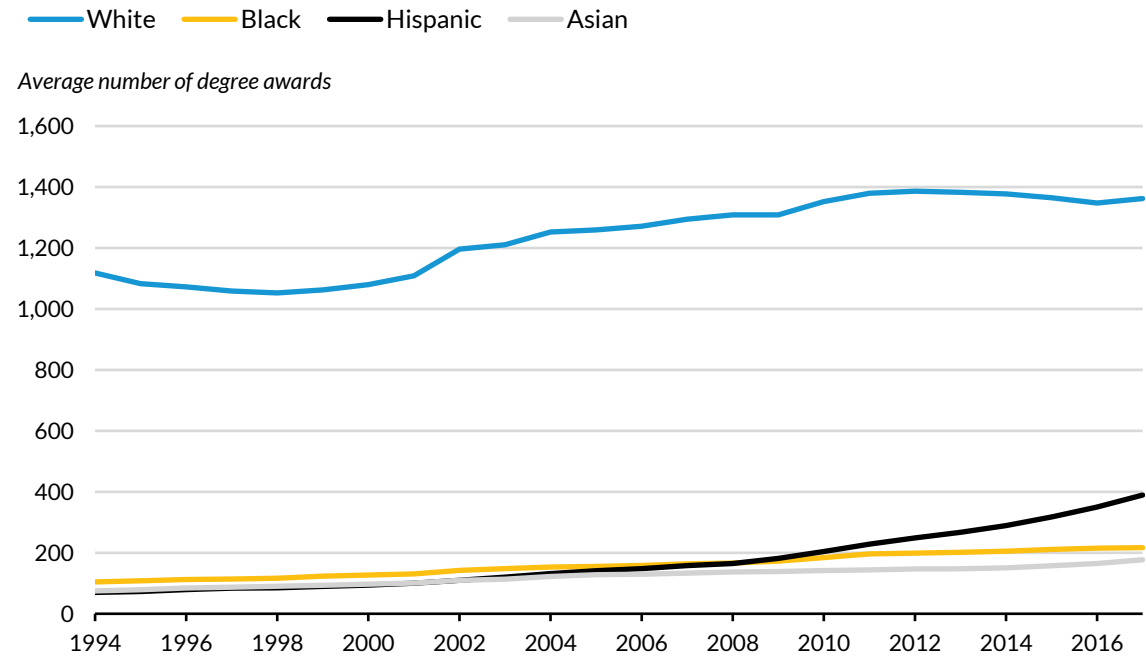
FIGURE 2

Average Number of Degree Awards at Public Colleges, by Race or Ethnicity

Public two-year colleges



Public four-year colleges



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Source: Authors' estimates using Integrated Postsecondary Education Data System data.

The Impact of Recent Reforms to State Financial Aid Programs

Does state aid affect college enrollment and degree attainment? Are there meaningful differences in the effects of state aid across racial and ethnic groups? We examine these questions in an analysis of the causal impact of recent changes to state financial aid on college enrollment and degree awards.

The first task is to identify states that underwent substantial changes in student aid spending during our study period. To do so, we leverage the National Association of State Student Grant and Aid Programs (NASSGAP) survey of state-funded expenditures of postsecondary student financial aid for undergraduate students. The survey reports information on student grant and aid programs provided by states from 2003 to 2017. The NASSGAP data are collected annually to assess state-funded expenditures for student financial aid and grant programs. The information gathered in the survey reflects need-based and non-need-based state aid and grants to students. It reflects financial supports disbursed during the academic year, including the fall and spring semesters. The NASSGAP survey data are observed at the program-by-year level. Each observation reflects a different aid or grant program provided by the state, for all 50 states and the District of Columbia. We observe total program expenditures in Consumer Price Index–adjusted dollars and total recipients. NASSGAP also lists breakdowns for need-based and non-need-based aid, although definitions change substantially over time, limiting our ability to analyze distinct impacts for different types of aid.

We quantitatively identify clear breaks in states' aid expenditures and total aid recipients, which we then confirm using archival research.² To do so, we first estimate models of a structural break in the time series of states' total aid expenditures, using every year between 2004 and 2016 as a candidate year for a break. For each state, we pick the year that provides the best fit (lowest mean squared error) for the structural break model, making it that state's candidate policy change year. Next, we take these candidate years and conduct archival research of official state websites and congressional proceedings to confirm that these abrupt expenditure changes are driven by real policy changes executed by state governments. We throw out any candidate years for which we cannot find such evidence. Using this procedure, we identify states and years with abrupt increases and decreases in aid spending.

In table 1, we provide a detailed description of each of the aid spending events in our data. The table shows that abrupt decreases in aid spending are clustered around the Great Recession years. We identify nine states that underwent large and sudden decreases in aid spending during our study period: Alaska (2009), Florida (2011), Georgia (2011), Hawaii (2008), Illinois (2007), Michigan (2009), New Hampshire (2011), North Carolina (2010), and Ohio (2009). Eight states increased spending for student

aid: Arkansas (2010), Kentucky (2015), Louisiana (2007), Missouri (2007), Mississippi (2012), Nebraska (2007), North Dakota (2009), and Wisconsin (2010).

Sudden changes in state grant spending largely stem from changes in state legislature allocations. Wisconsin's 2010–11 budget increased funding across award programs, including an additional \$8 million for its largest grant, the need-based Wisconsin Higher Education Grant. In Arkansas, lawmakers created an additional revenue stream for an existing grant, the Arkansas Academic Challenge Scholarship, when the state legalized a lottery in 2008. The lottery is now the scholarship's primary funding mechanism, and funding increased by more than \$100 million, or 213 percent, from 2010 to 2011, after the lottery was fully implemented.

In contrast, many of the sudden cuts to state grant funding were enacted in response to tightened state budgets during the Great Recession. One dramatic example of this is Ohio in 2009, when the state sliced funding for multiple state grant programs, with NASSGAP reporting a \$176 million decrease in spending. This included an almost 50 percent decrease in funding for the Ohio College Opportunity Grant program and the elimination of the Student Choice Grant program.

In other cases, generous state grant programs that guaranteed funding to all students who met certain criteria were forced to cut their budgets when they could not keep up with the number of eligible applicants. Georgia's HOPE program, which has separate merit-based and need-based components, reduced its award levels in 2011 such that most students received 90 percent of tuition (down from 100 percent). The bill also eliminated funding for books, fees, and remedial classes. When Florida cut funding for its Bright Futures Scholarship in 2010, it cut award levels and implemented higher academic criteria.

TABLE 1

Years with Abrupt Changes to State Student Financial Aid Programs

State	Year	Direction	Spending change amount (\$millions)	Percentage change	Change in recipients (thousands)	Percentage change	Explanation
Alaska	2009	Decrease	-25.2	-25.6	-6.6	-31.0	After the 2008 financial crash, investor concerns prompted Alaska to add additional criteria to its loan program to ensure borrowers had sufficient credit. The Alaska Supplemental Education Loan served more than 6,000 students in 2009 but served just over 2,000 in 2010.
Arkansas	2010	Increase	103.8	212.8	26.4	117.2	The Arkansas Academic Challenge Scholarship dates back to 1991, but expenditures increased from \$22 million to \$122 million from 2010 to 2011 because the scholarship began to receive funding from the state lottery, which was legalized in 2008 and began to sell tickets in 2009.
Florida	2011	Decrease	-104.0	-15.5	-8.2	-2.3	This change is mainly driven by a funding decrease for the Florida Bright Futures Scholarship, the state's largest program. In 2009 and 2010, the Florida legislature passed changes that decreased award levels and eventually implemented higher academic criteria. As a result, from the 2010 to 2011 academic years, the total program cost decreased by about \$90 million.
Georgia	2011	Decrease	-209.1	-27.1	-60.1	-18.7	In 2011, the Georgia legislature passed a large funding cut to the HOPE program, which has both a scholarship and grant program and is the state's largest program. The bill cut the grant and scholarship to 90 percent of tuition (down from 100 percent) and eliminated funding for books, fees, and remedial classes.
Hawaii	2008	Decrease	-23.3	-92.4	-9.1	-89.7	Hawaii made significant funding cuts (\$98 million for the University of Hawaii System) in 2009 in response to the recession.
Illinois	2007	Decrease	-25.6	-5.6	-61.0	-24.7	In 2009, in response to a large state deficit, Illinois dramatically cut its Monetary Assistance Program.

State	Year	Direction	Spending change amount (\$millions)	Percentage change	Change in recipients (thousands)	Percentage change	Explanation
Kentucky	2015	Increase	13.0	6.3	7.2	5.9	Kentucky's 2016-18 budget expanded funding for need-based scholarships by \$14.7 million (and about 8,000 scholarships).
Louisiana	2007	Increase	16.7	13.7	16.9	35.1	The Louisiana GO Grant was first administered in the 2007-08 academic year and distributed more than \$168 million worth of grants in its first year.
Michigan	2009	Decrease	-123.8	-60.6	-91.9	-55.8	Michigan passed large cuts to its grants and scholarships programs in the 2009-10 fiscal year, including to the Michigan Competitive Scholarship, Michigan Merit Award, and Michigan Tuition Grant. The Michigan Promise Scholarship (worth more than \$69 million in 2009) was eliminated. Michigan's cuts to higher education funding were larger than in any other state during the recession.
Mississippi	2012	Increase	2.1	6.9	1.2	4.3	NASSGAP data suggest that Mississippi increased funding for its Higher Education Legislative Plan (HELP) in 2012. Funding for HELP is made available such that award levels are consistent with tuition levels and are guaranteed for all eligible students.
Missouri	2007	Increase	49.8	70.0	23.5	52.6	In the 2007-08 academic year, the Access Missouri program replaced the Charles Gallagher Student Financial Assistance and Missouri College Guarantee programs. The programs it replaced were worth \$24 million combined in the year before, but the Access Missouri program spent more than \$72 million its first year.
Nebraska	2007	Increase	32.4	38.0	1.3	3.2	Nebraska reported a large increase in spending on tuition waivers in the 2007-08 academic year. Tuition waivers for the University of Nebraska-Lincoln alone increased by \$15 million over the previous year.
New Hampshire	2011	Decrease	-3.2	-100.0	-5.3	-100.0	Federal funding for the Leveraging Educational Assistance Partnership Program, which provided states incentives to fund state grants through matching funds, was eliminated in 2010. New Hampshire discontinued its state grant programs in response.

State	Year	Direction	Spending change amount (\$millions)	Percentage change	Change in recipients (thousands)	Percentage change	Explanation
North Carolina	2010	Decrease	-4.5	-1.0	-12.0	-5.4	NASSGAP data suggest that the decrease in North Carolina was caused by an overall decrease in spending on state grant aid. State grant aid is funded through state appropriations, including through the state lottery, and is variable year over year.
North Dakota	2009	Increase	5.8	161.3	4.0	100.1	The North Dakota State Student Incentive Grant Program significantly increased expenditures in the 2009–10 academic year and reported funding an additional 3,600 grants over the previous year.
Ohio	2009	Decrease	-175.9	-61.8	-117.4	-59.6	In response to the recession, Ohio dramatically cut its state aid funding. Need-based financial aid lost more than half its funding.
Wisconsin	2010	Increase	12.5	10.9	9.0	14.0	Wisconsin significantly increased its funding for the 2010–11 school year over the year prior. This included more than \$8 million in additional funds for the Wisconsin Higher Education Grant and more than \$2 million in additional funds for the Wisconsin Tuition Grant.

Sources: NASSGAP and authors' archival research.

Notes: NASSGAP = National Association of State Student Grant and Aid Programs. See the appendix tables for links to references for each event.

We leverage comparisons before and after the student aid change events across states to identify the impact of aid spending on college enrollment and degree awards. We estimate the following class of differences-in-differences models:

$$Y_{it}^g = \beta D_{s(i)t} + \Pi X_{it} + \alpha_i + \gamma_t + \epsilon_{it}^g, \quad (1)$$

where Y_{it}^g is the log enrollment or log degrees completed for a given racial or ethnic group g in college i and year t , α_i is a college fixed effect, γ_t is a year fixed effect, and X_{it} are time-varying controls observed at the college level, including log state appropriations, log tuition, log total Pell grant aid, and log total college expenditures.³ In addition, X_{it}^g includes controls that proxy for local demographics and economic conditions, including county unemployment rate, county poverty rate, log county median household income, and log county population (by race or ethnicity).

The variable $D_{s(i)t}$ is an indicator for colleges in a state s that saw changes to student aid that is switched on during the period in which the state had higher levels of student aid spending. Notice that $D_{s(i)t}$ is defined to capture the effects of periods of relatively higher spending on student aid. For states that decreased spending for their student aid programs, $D_{s(i)t}$ equals 1 during the period $t < t_s^*$, where t_s^* is the year of the change in student aid for state s . Conversely, $D_{s(i)t}$ equals 1 during the period $t \geq t_s^*$ for states that implemented increases to student aid spending. The model also includes colleges in states that had no abrupt changes in aid spending during the study period, in which case $D_{s(i)t}$ is always 0. Therefore, the coefficient β captures the pooled impact of periods of higher student aid spending on enrollment and degree outcomes, provided that the model's identification assumptions are met (more on this below).

Before studying the effects of these state policy changes on student outcomes, we conduct a confirmatory analysis evaluating how state-level financial aid changes (identified using NASSGAP data) affect aid dollars received by individual colleges (as reported in IPEDS). Figure 3 summarizes our model estimates of the average impact of state changes to student aid on grant dollars received by public colleges, as reported in IPEDs. The figure reports estimates for every type of grant funding reported by IPEDS. We use the log of the total amount of grants the college receives as the outcome in the models, meaning that the impact estimates can be interpreted as percentage changes.

Noticeably, we cannot reject the hypothesis that public four-year colleges see no meaningful changes in state grant dollars following the state aid changes that took place between 2003 and 2016, though the point estimate is positive. This suggests that universities in states that changed their aid programs during this period did not see meaningfully different trends in grant aid relative to universities in states with no changes. This result should not be interpreted as evidence for a broad

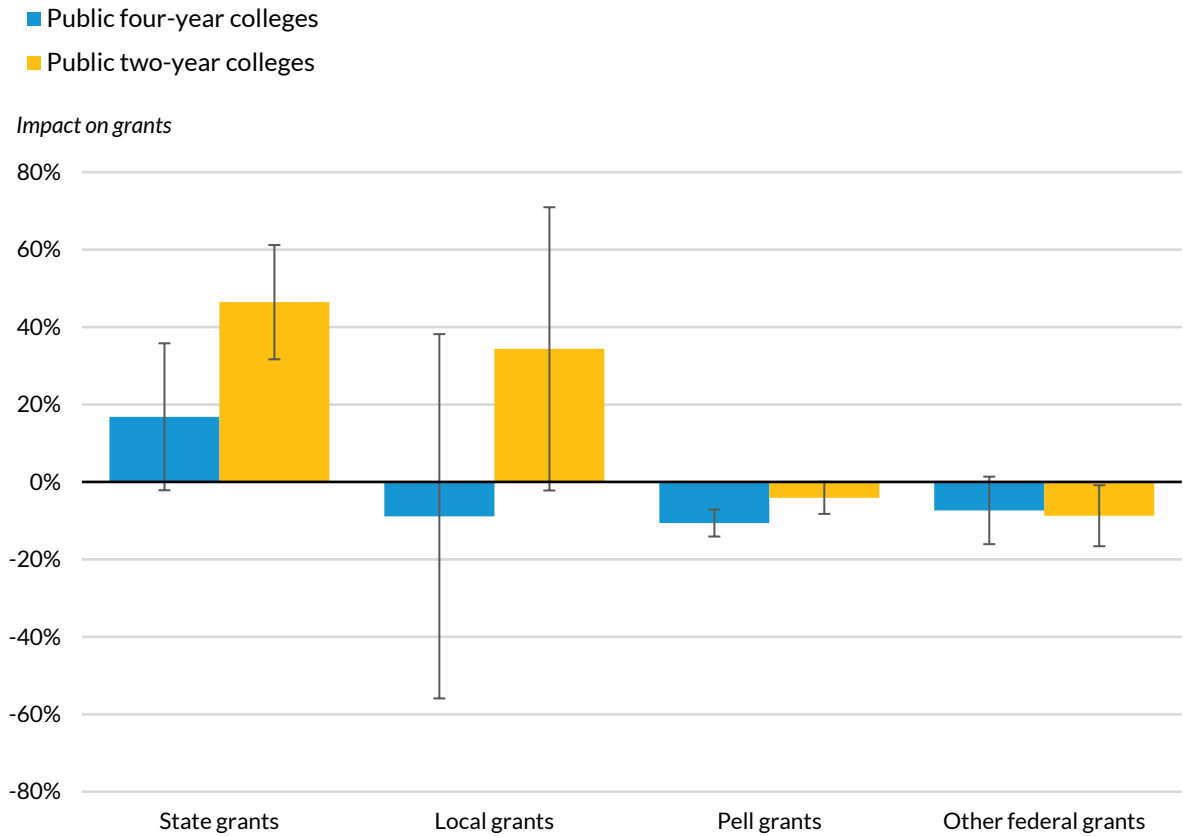
hypothesis that state spending on aid does not matter for grant dollars at universities. Instead, these patterns suggest that the portfolio of state aid reforms taking place between 2003 and 2016, on average, did not lead to large impacts on state grant aid going to public universities.

In contrast to public universities, we estimate a statistically significant impact of recent state aid reforms for grants going to community colleges (about 45 percent), suggesting that recent reforms to state aid have had their greatest financial impact on two-year colleges. We hypothesize that this discrepancy in impacts between two-year and four-year colleges is likely caused by the types of aid reforms taking place during this period, offering an opportunity for future researchers to study how particular aid programs affect different types of colleges. Nevertheless, the results are in line with the rest of the analysis, which documents large significant impacts on community college enrollment and degree awards and noisy null impacts in four-year university enrollment and degree awards. As such, though somewhat counterintuitive, the evidence in this analysis is consistent.

Finally, we detect economically significant impacts on local grant dollars for community colleges, though these are only marginally significant. We also find negative impacts on Pell grants and other federal college grants that suggest a small degree of substitutability between state and federal aid spending.

FIGURE 3

Average Percentage Impact of Aid Spending Changes on Grant Dollars Public Colleges Receive
Recent changes to state financial aid spending have mostly affected grant dollars for community colleges



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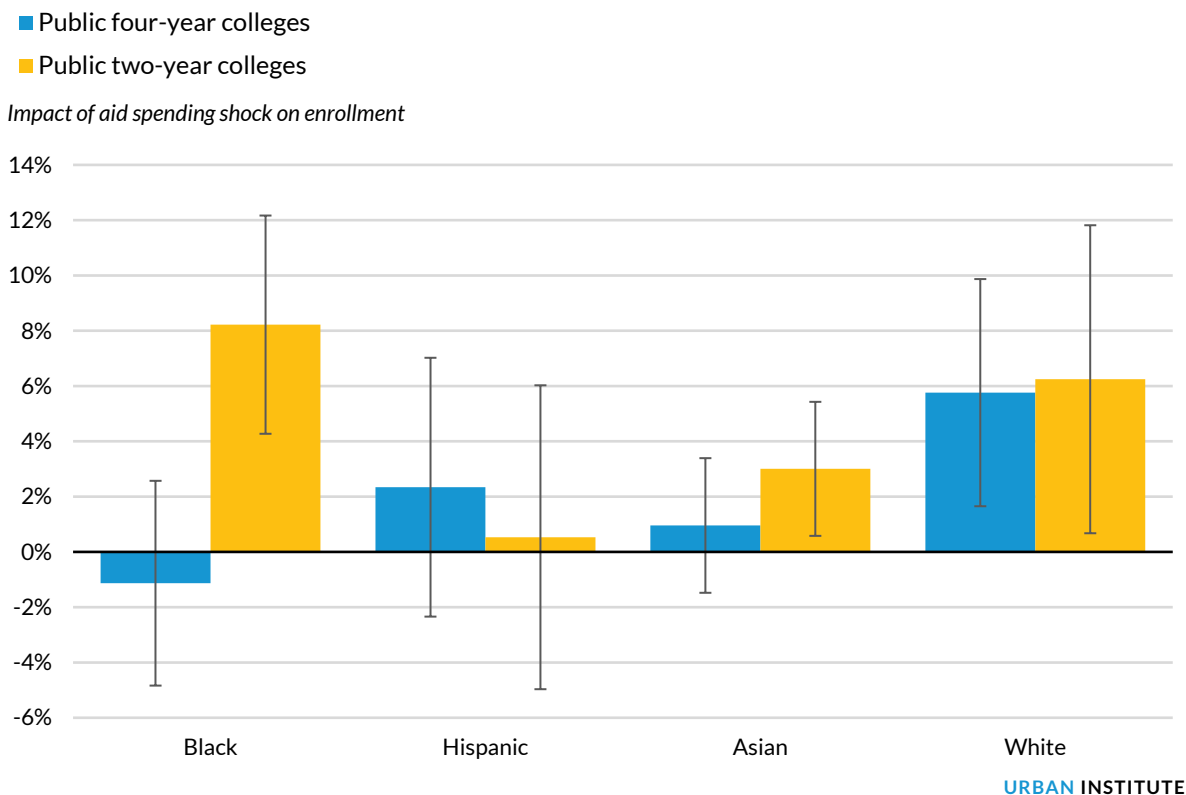
Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 1 in the text. The standard errors are clustered at the institution level in all models. The figure also shows model estimates of equation 1 in the text. The model includes controls for institution fixed effects and year fixed effects.

FIGURE 4

Average Impact of Aid Spending Changes on Public College Enrollment, by Race or Ethnicity

Recent changes to state financial aid spending have affected Black community college enrollment the most



Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 1 in the text. The standard errors are clustered at the institution level in all models. The figure also shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

Figure 4 shows the estimated average impact of increased state aid spending on college enrollment, separately for two-year and four-year colleges and by race and ethnicity. The impact estimates tend to be positive, with varying levels of statistical precision.⁴ The effects tend to be larger for community colleges than for four-year universities. Specifically, the estimated impact of aid spending on Black student enrollment at community colleges is the largest of the set (almost double the effect of any other group), and it is highly statistically significant, suggesting that recent increases in state aid spending have led to an 8 percent increase in their enrollment, or about 62 more students per college. We estimate statistical zero effect for Black student enrollment at universities. We also do not detect statistically significant impacts for Hispanic students, but our point estimates suggest that they also see gains from increased aid spending, potentially more so at universities than at community colleges. Asian

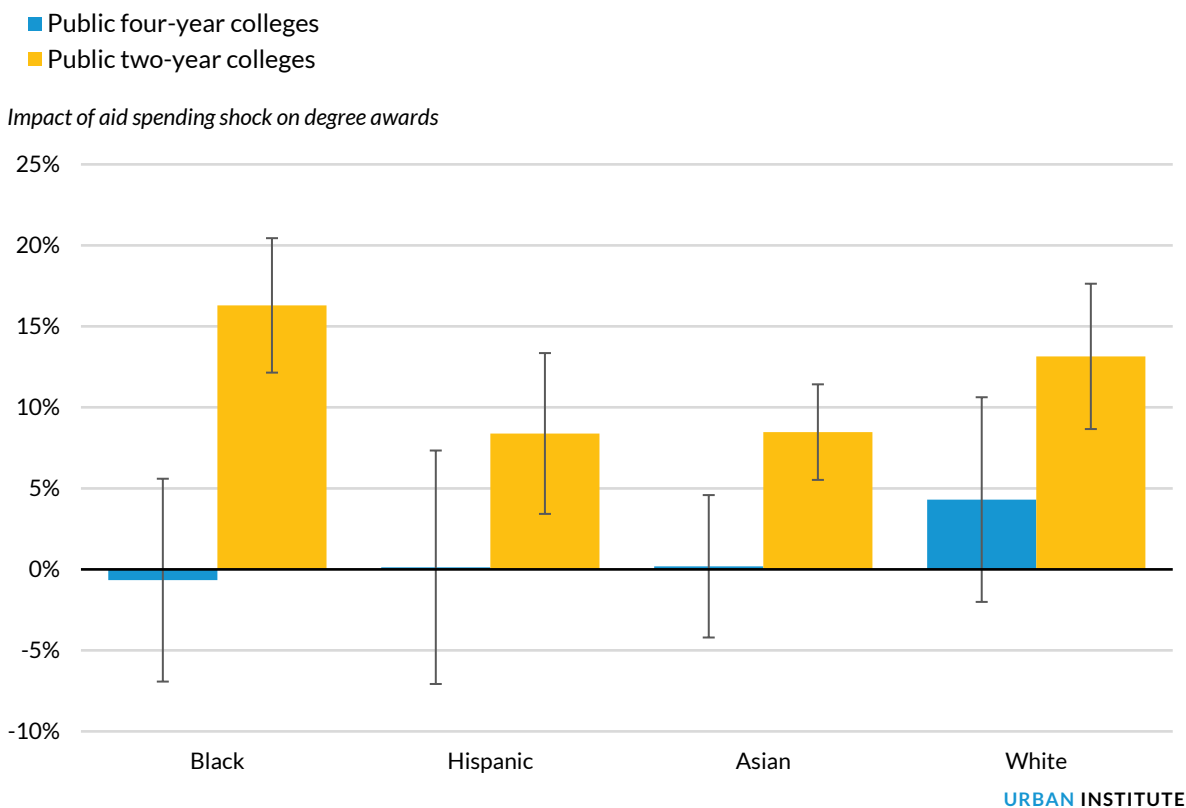
students also see a significant increase in two-year enrollment following aid increases, but not for universities. Finally, impacts for white students are positive and marginally significant, suggesting about a 6 percent increase in enrollment at both two-year and four-year colleges.

Figure 5 shows similar estimates for the impact of increased state aid spending on degree awards. It is readily apparent that effect estimates are considerably larger for community college degree awards than for university degree awards. Across racial and ethnic groups, none of the impact estimates for university degree awards are statistically distinguishable from zero. In contrast, the estimated effects for community colleges are positive, statistically significant, and large in magnitude. For Black students, they suggest that recent aid spending changes have led to an average 15 percent increase in community college degree awards. For Hispanic and Asian students, these figures are about 8 percent. White students see gains in degree awards of about 13 percent. Just as we saw for enrollment, the estimated impact of state student aid programs is larger, though not statistically distinguishable, for Black students than for white, Hispanic, and Asian students.

FIGURE 5

Average Impact of Aid Spending Changes on Public College Degree Awards, by Race or Ethnicity

Recent changes to state financial aid spending have affected Black community college degree awards the most



Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 1 in the text. The standard errors are clustered at the institution level in all models. The figure also shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

Two inferences can be drawn from these model estimates, takeaways that echo throughout this analysis. First, the impact of state aid programs on enrollment and degree awards is generally more pronounced in the community college sector than in the public university sector. This implies that changes to student aid programs are more likely to move the needle at the community college level than at the university level. This is in line with evidence showing that, relative to university students, community college students are more financially vulnerable and have fewer potential sources of financial or grant aid (Goldrick-Rab 2010). Second, Black students tend to benefit from student aid more than other groups. The predominance of the evidence shown here (and in the analysis that follows) strongly suggests that Black student degree attainment at community colleges—and to a lesser

extent, their enrollment—is more sensitive to abrupt changes in state student aid programs. This finding carries important implications for equity, which we discuss below.

Thus far, our analysis of the impact of state student aid programs has pooled cases in which states decreased or increased aid spending. This is useful as a data reduction exercise, providing summary national estimates of the impacts of all recent state reforms. The pooled estimates also draw from a richer set of variation in policy across the country and from policy changes triggered across different time periods, which can limit the influence recessionary effects and other unobserved confounders have on our estimates. But a pooled analysis introduces assumptions that may hide meaningful heterogeneity in impacts. In particular, one may be concerned that the impact of a decrease in aid spending need not have a symmetric impact to an increase in aid spending.

To address this, we estimate models akin to those described above, separately for states that increased or decreased their student aid spending.⁵ In this analysis, we define the treatment status indicators in the standard way, where $D_{s(i)t}$ is switched on for states with reforms during the period after the reform. As such, we hypothesize that models of colleges in states with increased aid spending should have positive first-stage impacts on state grants, while models for states with decreased aid spending should uncover negative impacts on grants.

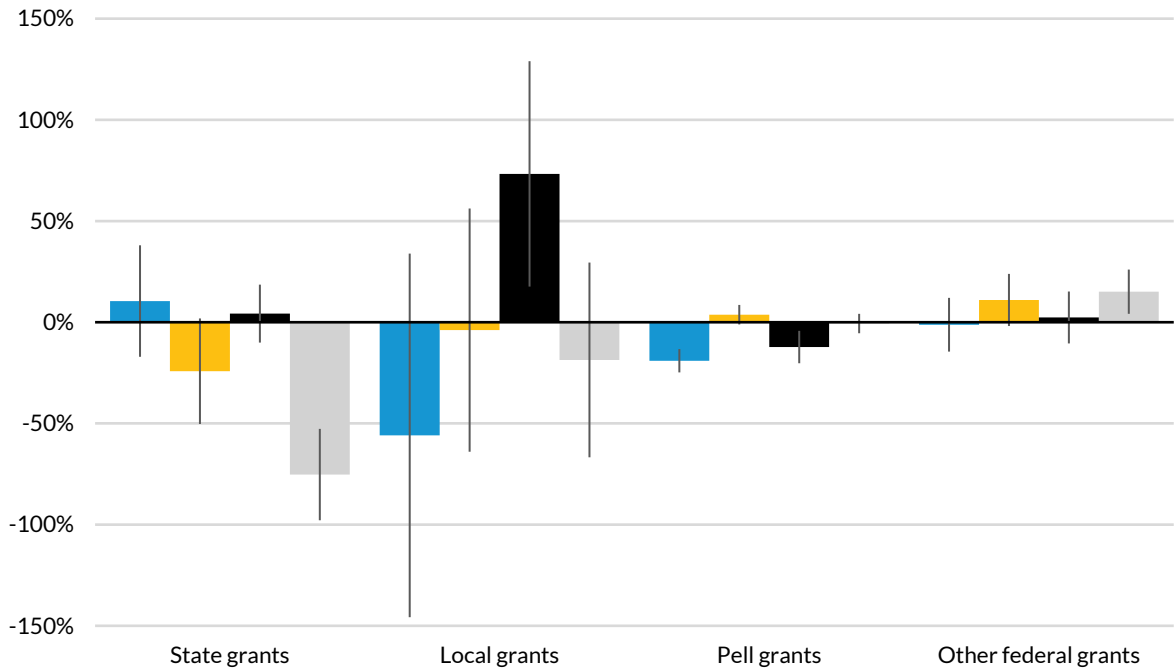
FIGURE 6

Impact of Aid Spending Changes on College Grants

Community colleges in states with decreased spending had drops in state grant dollars

- Spending increases at four-year colleges
- Spending decreases at four-year colleges
- Spending increases at two-year colleges
- Spending decreases at two-year colleges

Impact on grants



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 1 in the text. The standard errors are clustered at the institution level in all models. The figure also shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

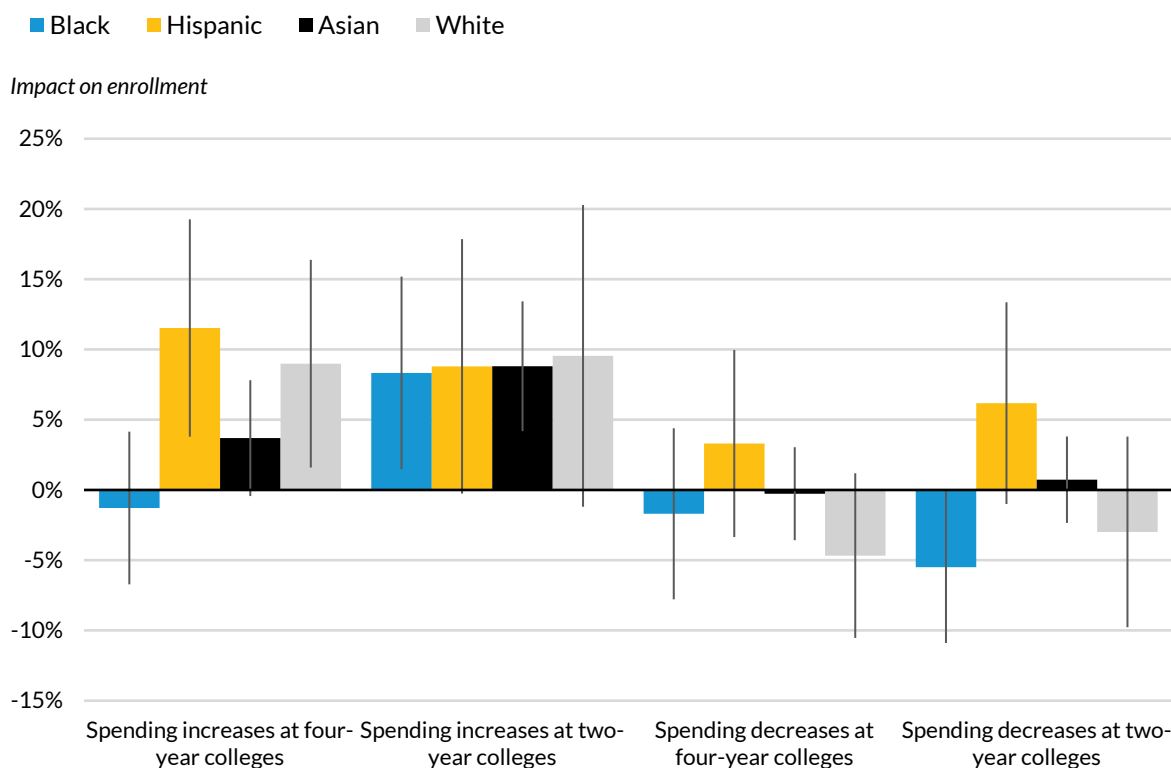
Figure 6 shows our estimates of the impact of aid spending changes on state grants, establishing that state aid changes occurring between 2003 and 2016 had their largest impact on decreased grants for community colleges. Although the point estimates suggest state grants at universities are also decreasing, we cannot reject that there was no change, on average. Interestingly, the model suggests that community colleges in states with spending increases were affected primarily via increases in local grants.

How did enrollment trends differ for colleges in states with increased aid spending versus decreased aid spending? Figure 7 shows that in terms of community college enrollment, the bulk of the impact on Black students stems from large and significant losses in states that decreased student aid, as well as by smaller and imprecisely estimated gains in states that increased it. Moreover, the split models reveal previously masked Hispanic student enrollment gains in four-year colleges in states with increased spending. Effects of decreased spending on four-year college enrollment are not significantly different from zero across racial and ethnic groups. It is also notable that estimated effects of increased spending for community college enrollment are consistently positive, albeit statistically imprecise.

FIGURE 7

Impact of Aid Spending Changes on Public College Enrollment

Community colleges in states with decreased spending had drops in Black student enrollment



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 1 in the text. The standard errors are clustered at the institution level in all models. The figure also shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

Figure 8 runs a parallel analysis for degree attainment, showing strong positive impacts of increased aid spending on community college enrollment across racial and ethnic groups. The patterns of the effect estimates reveal the dynamics behind the large, pooled effects of aid spending on community college degree awards for Black students in figure 5. In states with increased aid spending, Black students saw degree award gains of about 10 percent, while in states with decreased spending, they experienced sharp losses of about 18 percent. White students also saw gains in increased-spending states and losses in decreased-spending states; interestingly, white students saw larger gains than Black students in states with increased spending, but Black students saw larger losses than white students in states with decreased spending. Although these patterns may not be statistically significant, the large differences across estimates for different racial and ethnic groups point in one direction: Black students' degree attainment in community colleges is vulnerable to changes in state aid spending.

Because these summary estimates point to the community college sector as more likely to be strongly affected by recent changes to state spending for student aid, the rest of the analysis presented here focuses on community colleges. See the appendix for a parallel analysis for public four-year universities.

A key assumption for the causal interpretation of our effect estimates is that had it not been for the changes to student aid programs, colleges in states with and without aid changes would have had similar trends in enrollment and degree awards. We test the validity of this assumption by estimating models that test for preexisting differences between the enrollment and award dynamics of colleges in states with abrupt student aid changes. Specifically, we estimate the following class of event study models:

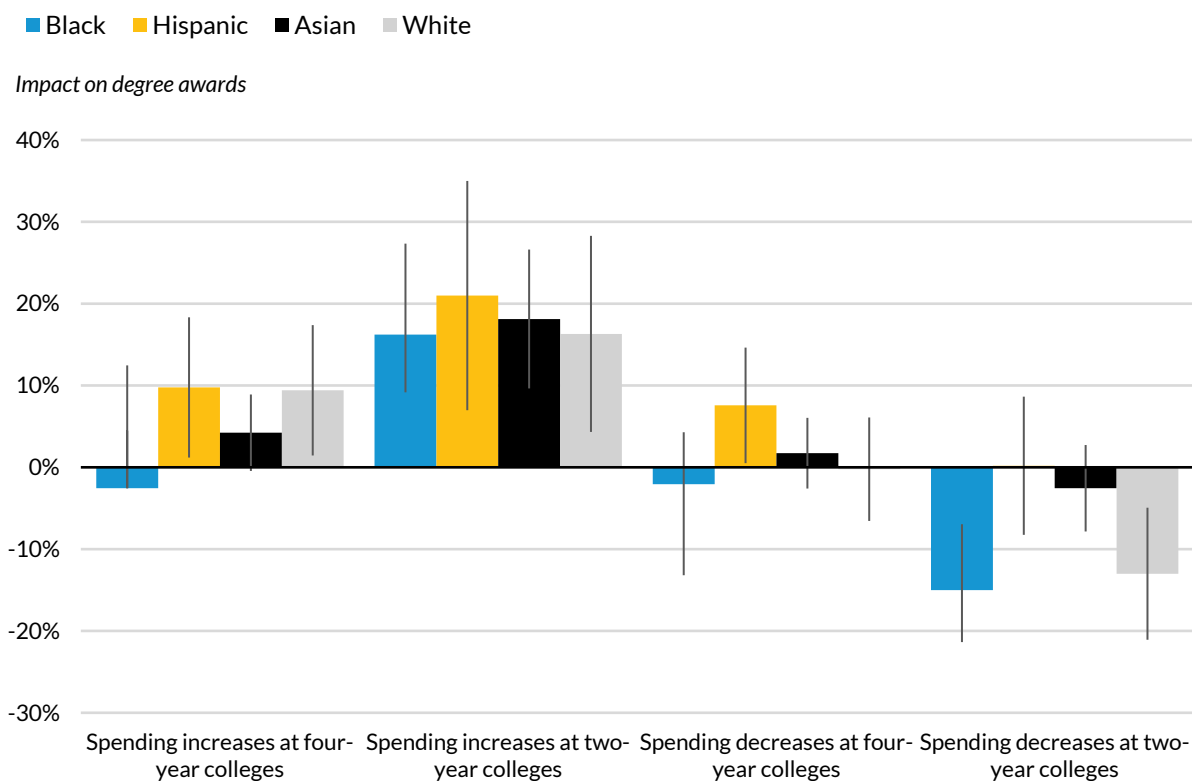
$$Y_{it}^g = \sum_{k=-5, k \neq -1}^5 \beta_k D_{s(i)k} + \Pi X_{it} + \alpha_i + \gamma_t + \epsilon_{it}^g \quad (2)$$

The variables $D_{s(i)k}$ are indicators for the number of years since the change to student aid took place; negative values correspond to years before the student aid policy change, and positive ones denote years after the change. As such, estimates of β_k for $k < 0$ provide a test for the required common trends assumption: large positive estimates for these coefficients would suggest that relative to the year before the abrupt change in aid spending, colleges in states with changes had enrollment (or awards) that was trending down at a faster rate than at control colleges (those in states with no changes to their aid programs). Similarly, significant negative values for these coefficients would imply that treated colleges (those in states with aid changes) had enrollment or awards that were trending up at a faster rate than at control colleges.

FIGURE 8

Impact of Aid Spending Changes on Public College Degree Awards

Community colleges in states with decreased spending had drops in Black degree awards



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 1 in the text. The standard errors are clustered at the institution level in all models. The figure also shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

The interpretation for the positive event study coefficients β_k is the average difference in enrollment and awards at colleges k years since the aid reform, relative to the year before the reform $k \neq 1$, adjusted for the average changes taking place at control colleges and for the influence of college characteristics listed in X_{it} . Therefore, the positive event study coefficients capture both the immediate impact of the reform and the evolution of this effect over time.

Figure 9 presents plots of the event study model estimates of log state grants going to community colleges, done separately for colleges in states with either increased or decreased student aid spending events. A divergent pattern is of note in the average impact estimates (the coefficients corresponding to positive years since the policy change). On average, community colleges in states that cut spending for student aid saw immediate and massive losses to state grants, on the order of 75 to 85 percent. These

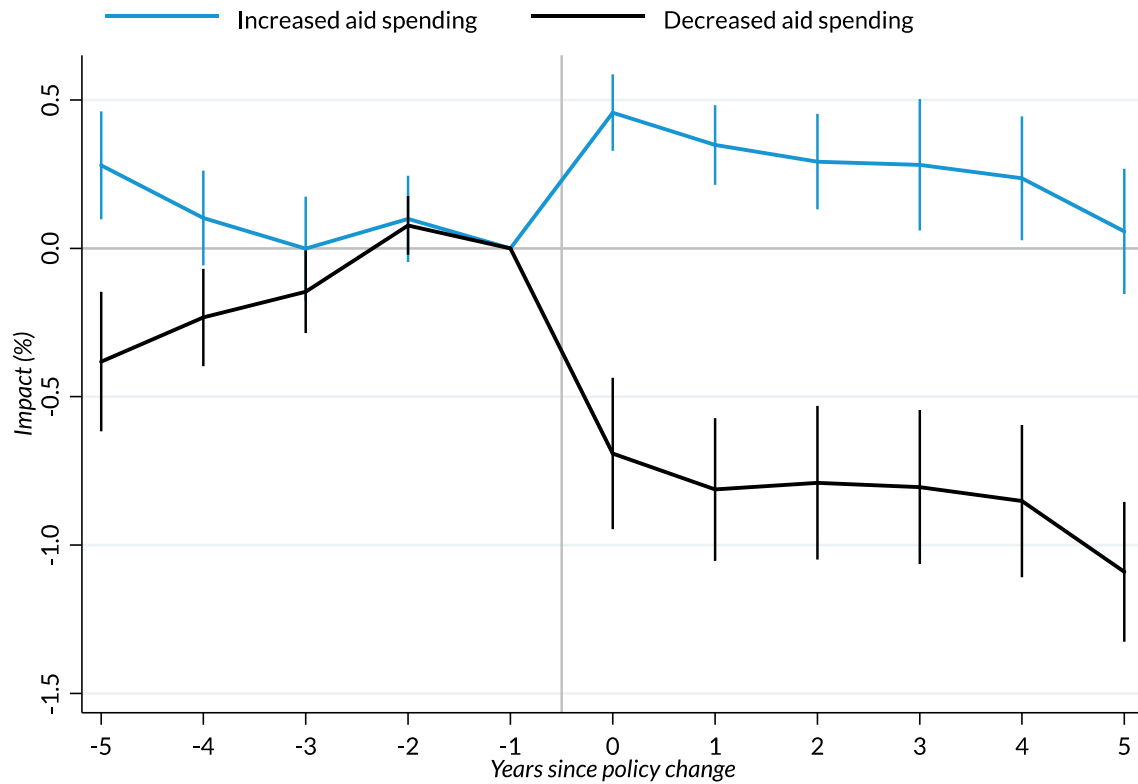
losses persisted, as noted by the stability of the event study coefficient over the three years following the state's spending cuts. In contrast, colleges in states that increased their aid spending saw large immediate average increases in state grants, almost 50 percent. Over time, these gains waned, decreasing to about 25 percent three years after the state made the initial spending hikes.

The negative event study coefficient estimates show some significant evidence of preexisting trends in log grants four years before the reforms, which could complicate the interpretation of our findings. But one encouraging pattern is that preexisting trends become less pronounced and statistically insignificant as the event date approaches. It is thus unlikely that our effect estimates are an artifact of confounded preexisting trends.⁶ Still, we do not claim that our parameter estimates are bias-free but that the breadth of the evidence points to clear qualitative implications.

The evidence supports the claim that divergent changes to student aid spending across states led to divergent changes to the state grant dollars colleges received. Did the changes in dollars going to community colleges lead to measurable changes in student outcomes? In figure 10, we present event study estimates of the average impact of state aid spending on log enrollment by race and ethnicity. The top left panel shows a clear divergence in average Black student enrollment between colleges in states that increased their spending on student aid versus states that decreased their spending. Notably, the divergence is not immediate but gradual. For states with spending cuts, Black student enrollment is barely down two years after the reform, but three years later, losses start to accumulate to nearly 10 percent. Black student gains for colleges in states that increased aid spending are estimated to be, on average, about 5 percent two years later but is closer to 12 percent three years after. The gradual nature of these changes can partly explain why the estimates in the summary models showed low levels of statistical precision.

FIGURE 9

Event Study Estimates of the Impact of Changes to Aid on State Grants for Public Two-Year Colleges
Grant dollars diverge for colleges in states with decreased versus increased aid spending



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 2 in the text. The standard errors are clustered at the institution level in all models. The model controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

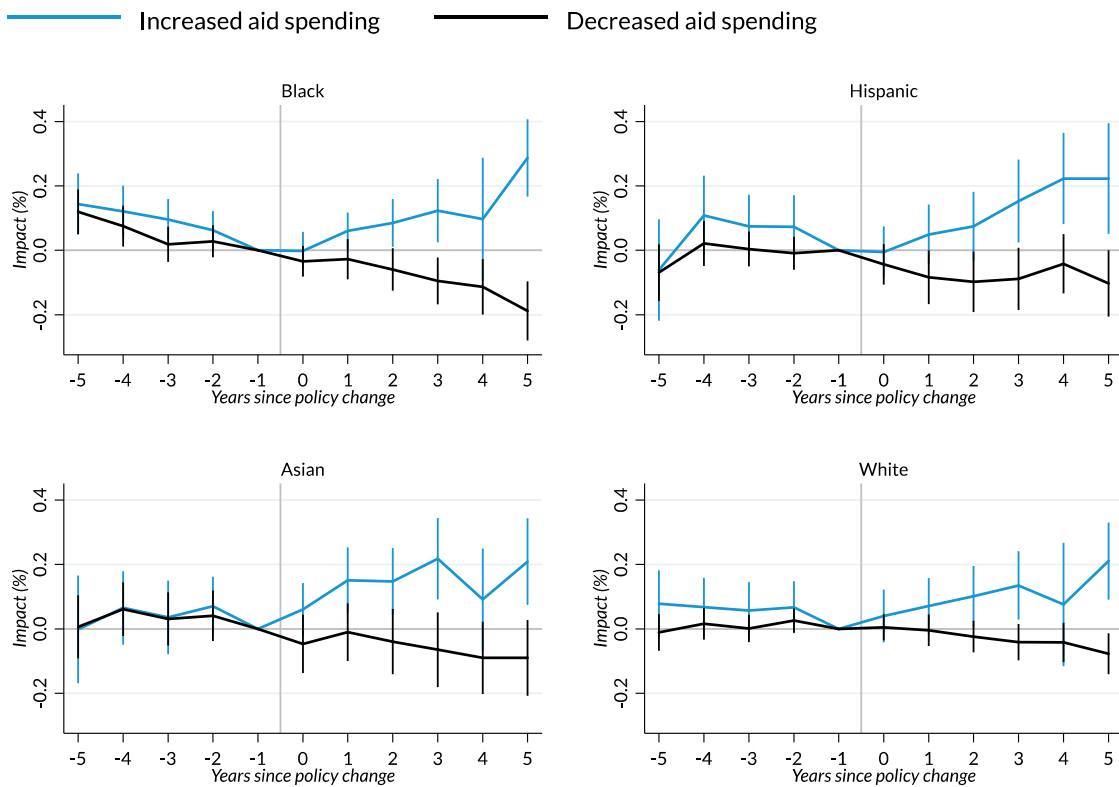
A similar pattern emerges for the event study model of Hispanic student enrollment in figure 10. The estimates suggest that state aid increases cause mean gradual gains in Hispanic enrollment, maxing out at about 20 percent four years after the aid reforms. Estimated losses in Hispanic enrollment in states with spending cuts are somewhat smaller but statistically significant, unlike what we saw in figure 8. This is likely explained by the gradual effect pattern that appears to be corrected starting four years after the reform.

Patterns are similar for Asian and white student enrollment. Both groups show average enrollment gains in community colleges in states that increased aid, about 10 to 20 percent. But neither group

seems to suffer losses in the states that cut their aid spending. This is in line with the summary estimates shown in figure 9.

The overall pattern of the event study enrollment effects by race and ethnicity again suggests the general takeaway that Black and Hispanic students stand to gain the most from robust funding for state student aid programs.

FIGURE 10
Event Study Estimates of the Impact of Abrupt Aid Spending Events on Enrollment at Public Two-Year Colleges
Enrollment divergence for colleges in states with decreased versus increased aid spending



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 2 in the text. The standard errors are clustered at the institution level in all models. The model controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

Figure 11 shows a parallel event study analysis for community college degree awards. Here, we find coefficient trends similar to what we did for enrollment. If anything, the estimated divergent

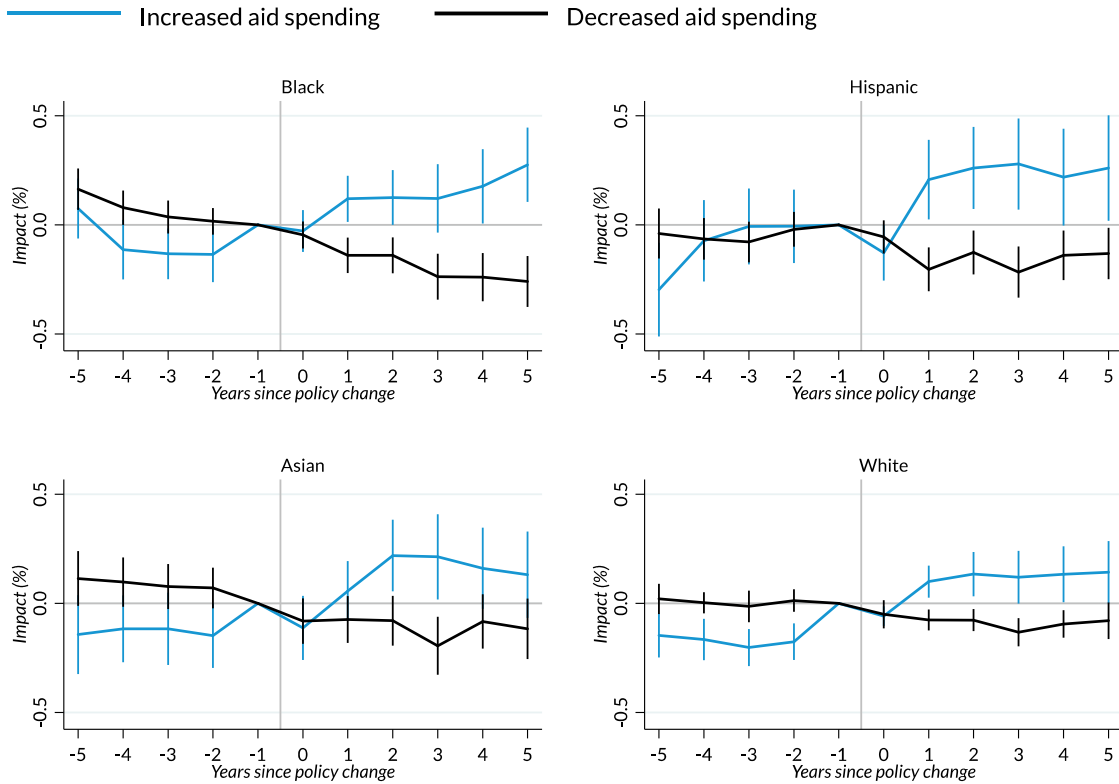
trajectories for colleges in states with increased aid spending versus decreased aid spending look even more pronounced for degree awards. This is not surprising, given the summary effect estimates reported in figure 9. There is a stark symmetry in the divergence of degree awards for Black students across the different type of states. Three years after the policy changes, colleges in states with cuts had, on average, about 20 percent fewer Black student degree awards. In contrast, states that increased their spending saw average gains of about 18 percent around the same stage. In subsequent years, the gap grows even wider. A stark separation of degree award trends is also clear for Hispanic students, who have seen degree awards increase nearly 30 percent in states with increased spending and but have seen awards decrease 20 percent in states with cuts.

The event study models of degree awards for Asian students also show large gains from increased spending (about 18 percent) and no significant losses from decreased spending. Finally, white student degree awards show a pattern of divergence that is statistically significant, unlike in the case of enrollment. But as we first reported in figure 10, the gains experienced by white students are somewhat larger than the gains experienced by Black students, but their losses were considerably smaller than Black student losses. Four years after reforms, we estimate that awards are down less than 10 percent for white students but are down nearly 20 percent for Black students.

FIGURE 11

Event Study Estimates of the Impact of Abrupt Aid Spending Events on Degrees at Public Two-Year Colleges

Degree award divergence for colleges in states with decreased versus increased aid spending



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The figure shows ordinary least squares estimates of equation 2 in the text. The standard errors are clustered at the institution level in all models. The model controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

Although we have tried to be careful to uncover the potential role of preexisting trends and time-varying policy impacts, our analysis still pools information from changes to student aid programs across states with different types of higher education financing structures. Student aid programs can be immensely different between states. Some states have clear demarcations between need-based and merit-based aid, often pouring uneven levels of funding for programs across these categories. Other state aid programs draw a fuzzier line between need-based and merit-based aid. Differences in aid may vary across many other dimensions, including targeting formulas, career-specific programs, and special allocations for public servants.

In appendix figures A.3 and A.4, we provide state-specific estimates of the impact of each aid spending change event shown in table 1. These estimates show that reported effects for particular racial and ethnic groups and institution types are most likely driven by a small group of states. For example, panels C and D in appendix figure A.3 show that Black student losses at community colleges following state spending cuts were concentrated in Florida, Illinois, and North Carolina. In addition, panels A and B show that Black student attainment in public universities also suffered from cuts in Illinois and Michigan. These findings suggest that funding cuts in Illinois, driven mostly by cuts to the Monetary Award Program (table 1), were particularly pernicious for Black students. This type of comparative exercise can help spawn future research on the impact of state aid program design on student outcomes by race or ethnicity.

This type of analysis is not meant to capture the causal impact of the nuances of state aid program design. Instead, it allows us to take stock of the overall impact of massive cuts or hikes to state aid programs at the national level. In this sense, our estimates provide summary statistics for the overall effects of this class of state aid policies. Readers should be especially convinced by the clear divergent trends in Black and Hispanic student outcomes, showing that cuts to spending hurt outcomes and increased spending improves them. The bulk of the evidence presented here supports the notion that states concerned with racial inequality in educational attainment and economic outcomes should provide ample funding for student financial aid programs.

The Impact of State Appropriations

Recent research on higher education financing has shed light on the effects of changes to state appropriations for public colleges on student enrollment and degree attainment. Notably, Deming and Walters (2017) explore the impact of appropriations budget shocks, prices, and tuition caps on postsecondary enrollment and degree awards. They find that budget cuts to appropriations spending have large effects on enrollment and degree awards. Furthermore, the authors document that appropriations cuts lead to increases in tuition and have negative impacts on instructional and student support spending, which affect student quality and experience. Public institutions facing state appropriation funding cuts can also compensate by reducing overall costs, such as by reducing the level of student supports provided, reducing the number of faculty, eliminating courses or programs, or slashing funding for research centers.

Although Deming and Walters (2017) provide convincing evidence of the causal effects of state appropriations on total enrollment at public institutions, it is not clear whether effects are

heterogenous across racial and ethnic groups. To address this, we develop a similar empirical approach focusing on the overall impact of changes to state appropriations on enrollment and degree awards of Black, Hispanic, Asian, and white students.

Descriptive Statistics

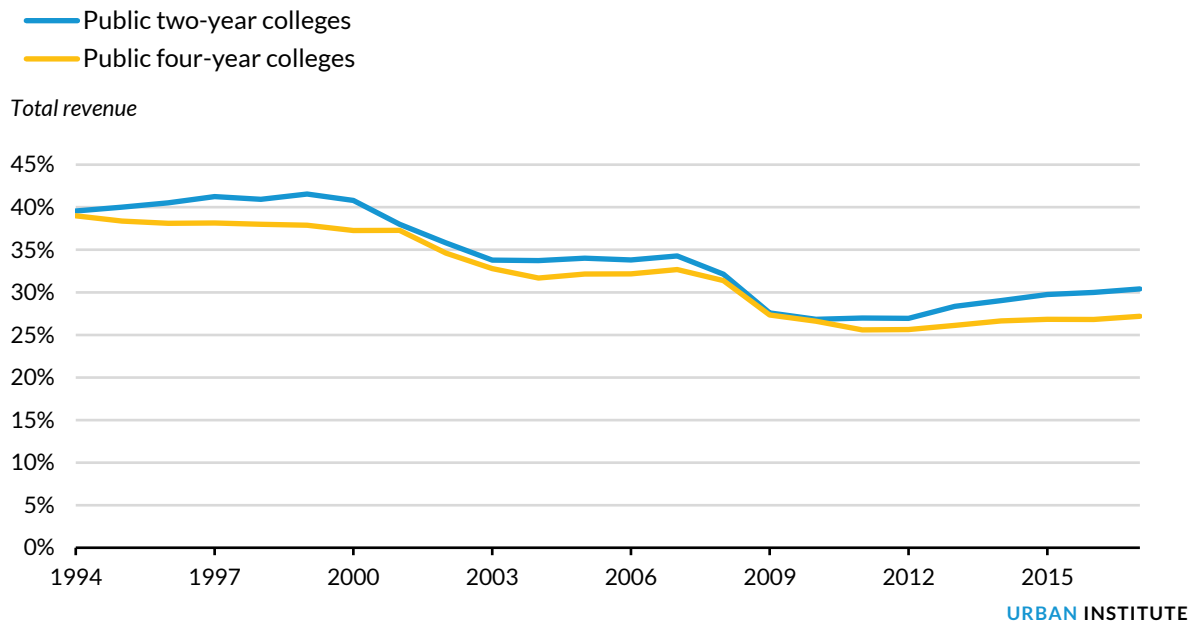
Since 1994, the state appropriations share of total revenue at two- and four-year public colleges has declined (figure 12). This trend has been accentuated by steep drops in the appropriations share during or immediately following recessions. Following the 2001 recessionary drop is a period of tepid or stagnant recovery, followed by another steep drop in 2008 and incomplete recovery thereafter. In 1994, 39 percent of four-year colleges' revenue came from state appropriations. At the end of the Great Recession in 2011, just 26 percent of revenue stemmed from appropriations. By 2017, the share reached 27 percent, or 12 percentage points below its 1994 value. Public two-year colleges saw mild recoveries following recessions and have not returned to their 1994 appropriations shares.

Figure 12 speaks to the uncertainty public colleges face regarding their state funding. When recessions hit and states see a decline in tax revenue and other income, postsecondary institutions see striking drops in state funding as public funds are diverted from public postsecondary education. During ensuing economic recoveries, states are slow to reallocate funds back to state appropriations to postsecondary education.

FIGURE 12

Average State Appropriations Share of Total College Revenue

State spending on appropriations for public colleges has decreased over time



Source: Authors' calculation using Integrated Postsecondary Education Data System data from 1994 to 2017.

Note: The mean share of appropriations is defined as the college-level average of the ratio of revenue from state appropriations and total college revenue.

Dependence on Appropriations

Deming and Walters (2017) identify the causal effects of appropriations on college outcomes using the “shift-share” (or “Bartik”) research design (Bartik 1991). They identify impacts by drawing comparisons between colleges with differential exposure to a shared shock (Goldsmith-Pinkham, Sorkin, and Swift 2020). In this case, the shared shock is the secular drop in state appropriations, and exposure is measured by colleges’ initial dependence on appropriations funding. The identification assumption in this design is that following statewide cuts to appropriations, differences in outcome dynamics between high- and low-dependence institutions are driven by the causal impact of state funding and not by other unobserved time-varying factors.

We follow this logic by segmenting institutions into three groups based on their degree of dependence on state appropriations. We divide the sample of public colleges into three quantiles based on the 1994 cross-college distribution of the appropriations share of total revenue. Low-dependence institutions receive 0 to 35 percent of their revenue from states, medium-dependence institutions receive 36 to 44 percent, and high-dependence institutions receive 45 to 82 percent.⁷ Our analysis aims

to estimate models of college outcomes as a function of state appropriations separately for these three groups. This reduced-form strategy looks directly at the structural relationship between enrollment and degree awards and changes to state appropriations. Inferences into the mechanisms through which state appropriations affect enrollment and degree awards are outside the scope of our study.

Table 2 shows mean differences between institutional characteristics and the level of dependence on state appropriations in 2017. Across four- and two-year public institutions, low-dependence colleges tend to have higher average enrollment than higher-dependence institutions. But Black and Hispanic students enroll more at four-year colleges that are highly dependent on state appropriations. Different patterns are reflected in the data at two-year colleges. Nearly three times as many Hispanic students enroll at low-dependence institutions than at high-dependence institutions.

Black and Hispanic students already enrolled at four-year colleges with high dependence on state appropriations may face budget cuts, translating to fewer and lower-quality student services, reduced institutional academic supports, and higher tuition. These measures can lead to an overall deterioration in these students' postsecondary experiences and higher levels of educational debt and spending. Incoming and prospective students may see fewer instructional and counseling supports for colleges and compete with a greater number of out-of-state students during admissions, on top of the greater costs and deteriorated services caused by cuts to state appropriations for higher education.

More students complete degrees at low-dependence institutions than at higher-dependence institutions at both two- and four-year public colleges. And nearly twice as many Hispanic students complete their degrees at four-year high-dependence institutions than those completing their degrees at four-year low-dependence institutions. Hispanic students also tend to graduate at higher rates from low-dependence two-year colleges than from high-dependence ones. Black students enroll at similar rates all levels of dependence and tend to complete their degrees more frequently at high-dependence two-year institutions, despite having higher enrollment at low-dependence institutions.

On average, the revenue share of appropriations at high-dependence universities is twice as large as at low-dependence ones, and a greater share of their revenue goes to instructional and student services. High-dependence universities also rely more on state and federal grants for student aid than low-dependence ones. On the other hand, highly dependent two-year colleges rely less on state grants and more on federal grants, but low-dependence ones rely more on state grants and less on federal grants.

TABLE 2

Summary Statistics of Public Colleges, by Dependence on Appropriations, 2017

	Public Four-Year Colleges			Public Two-Year Colleges		
	Low dep.	Medium dep.	High dep.	Low dep.	Medium dep.	High dep.
Enrollment						
Total	12,361	9,740	10,473	7,323	7,896	4,918
Black	1,056	1,092	1,279	848	1,082	869
Hispanic	1,612	1,498	2,510	1,829	1,989	882
Degrees						
Total	3,022	2,119	2,426	1,424	1,568	1,092
Black	198	195	261	142	185	185
Hispanic	354	301	540	313	353	153
Total student aid (\$millions)	84.77	49.91	48.07	14.08	15.18	9.86
% state grants	0.15	0.17	0.20	0.14	0.16	0.12
% federal grants	0.36	0.44	0.52	0.75	0.73	0.77
Total revenue (\$millions)	1,251.85	303.68	250.42	77.53	69.88	45.34
% state appropriations	0.17	0.27	0.34	0.22	0.32	0.40
% net tuition	0.26	0.30	0.24	0.18	0.20	0.15
Total expenditures (\$millions)	1,172.41	291.52	241.62	74.32	66.75	43.76
% instruction	0.33	0.38	0.38	0.41	0.42	0.42
% student services	0.07	0.10	0.10	0.11	0.12	0.10
Total observations	162	295	207	303	166	234

Source: Authors' calculation using 2017 Integrated Postsecondary Education Data System data.

Notes: dep. = dependence. The table reports average characteristics of colleges by dependence on state appropriations, defined as the share of total college revenue stemming from appropriations. For four-year colleges, the dependence bins are 0 to 35 percent (low), 36 to 44 percent (medium), and 45 to 82 percent (high). For two-year colleges, the bins are 0 to 30 percent (low), 31 to 47 percent (medium), and 48 to 86 percent (high).

Empirical Strategy

We are interested in estimating the partial effects of state appropriations spending on college attainment, by race or ethnicity, within each level of dependence on state appropriations. As such, our estimates capture the compounded effects of every mechanism mediating the impact of state appropriations funding on student outcomes. We estimate the following model, splitting the sample by appropriations dependence:

$$Y_{it}^{gq} = \beta Z_{it} + \eta X_{it} + \alpha_i + \gamma_t + \sigma_{s(i)} * t + \epsilon_{it}^{gq} \quad (3)$$

where Y_{it}^{gq} is log enrollment or degree awards at institution i , at time t , in q level of dependence for each racial or ethnic group g ; and Z_{it} is the log of annual state appropriations funding for a college.⁸ The parameter of interest (β) is interpreted as the percentage change in enrollment or degree award stemming from a percentage change in state appropriations to an institution. The fixed-effect variables α_i and γ_t represent college and year fixed effects, and $\sigma_{s(i)} * t$ are state-specific linear time

trends. The control variable X_{it} includes county unemployment, the percentage of race or ethnicity g in a county, and the county-level poverty rate. Standard errors are clustered at the college level.

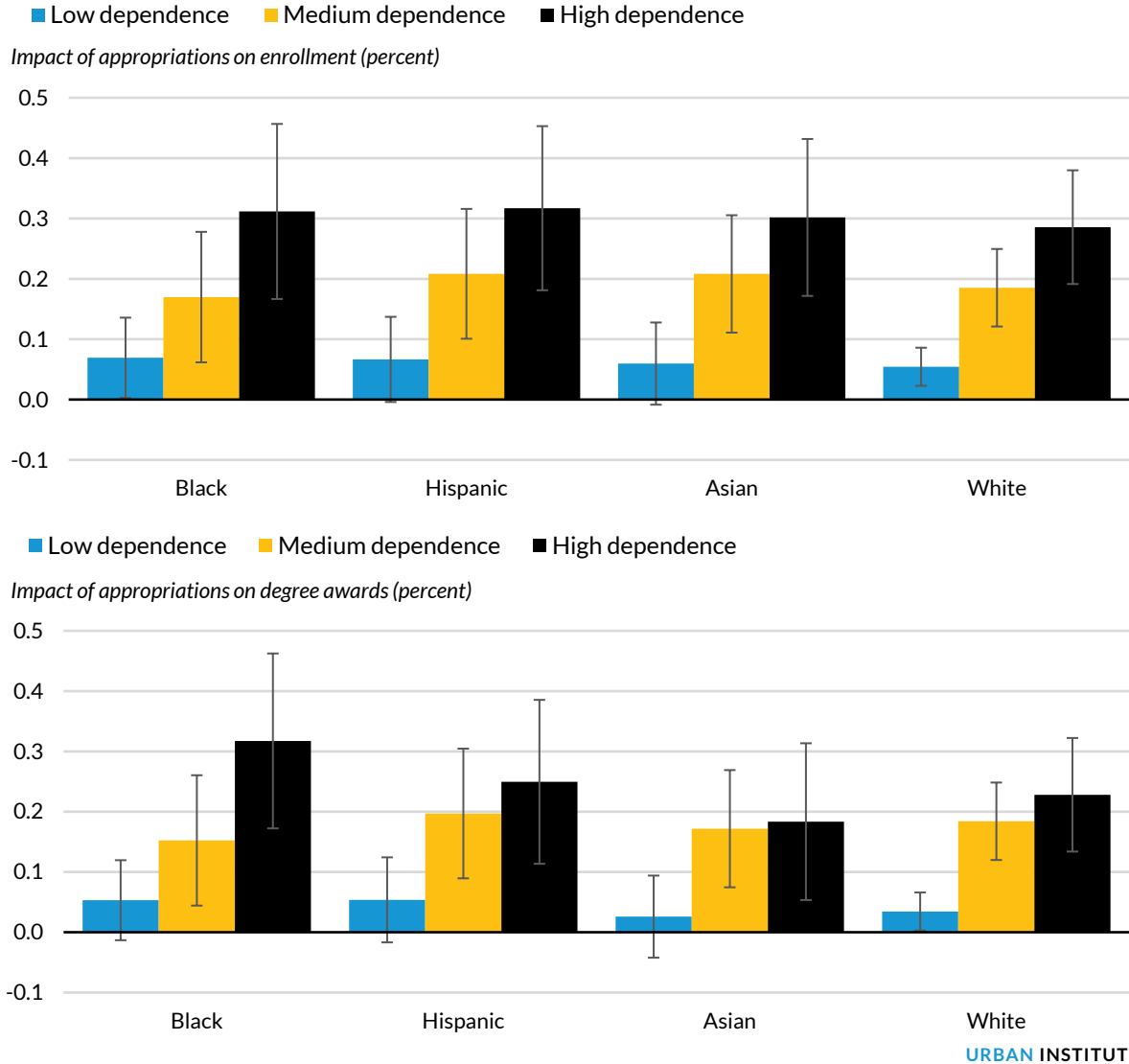
Figure 13 presents our estimates of the effects of a 1 percent increase in state appropriations on student enrollment by race or ethnicity at two-year colleges. Black, Hispanic, and white enrollment is most sensitive to state appropriations at high-dependence institutions. Black enrollment increases by about 0.30 percent for each 1 percent increase in appropriations, while the same increase leads to a 0.06 percent increase in enrollment at low-dependence institutions. Black student enrollment is thus about three times as sensitive to state appropriations funding in highly dependent institutions.

Hispanic enrollment is also affected by appropriations at two-year colleges. A 1 percent increase in state appropriations is related to a 0.30 percent increase in Hispanic enrollment at high-dependence colleges, while at low-dependence colleges, the effect is statistically indistinguishable from zero. For Asian and white students, estimates are similar. These results show that appropriations funding matters more at colleges that are more financially dependent on state budget allocations.

FIGURE 13

Impact of Appropriations on Enrollment and Degree Awards at Two-Year Colleges, by Appropriations Dependence and Race or Ethnicity

State appropriations matter most at community colleges that depend on state funding



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Source: Authors' calculations using Integrated Postsecondary Education Data System data from 1994 to 2017.

Notes: The figure reports ordinary least squares coefficient estimates of equation 3 in the text, a log-log specification of the outcome on state appropriations separately by dependence. Dependence on state appropriations is defined as the share of total college revenue stemming from appropriations in 1999 or five years after the college's opening year. For four-year colleges, the dependence bins are 0 to 35 percent (low), 36 to 44 percent (medium), and 45 to 82 percent (high). For two-year colleges, the bins are 0 to 30 percent (low), 31 to 47 percent (medium), and 48 to 86 percent (high). The standard errors are clustered at the college level in all models. The models control for college fixed effects, year fixed effects, and state-specific time trends, as well as log total county population, log county population of the racial or ethnic group in question, county unemployment rate, county poverty rate, and log county median household income. Observations are weighted by baseline enrollment (defined as total enrollment in 1999 or five years after the college's opening year).

The bottom panel in figure 13 presents impact estimates for community college degree awards. Effect estimates of a 1 percent increase in state appropriations at low-dependence colleges are positive but small and not statistically significant. Degree awards at high-dependence two-year colleges are considerably more responsive, with estimates ranging between 0.2 and 0.3 percent and consistently significant. As expected, the medium-dependence college impact estimates are in between these extremes, establishing clear monotonicity in our results.

Black student degree awards are the most sensitive to appropriation shocks at highly dependent colleges. A 1 percent increase in appropriations is related to a 0.31 percent increase in degree awards. The estimate is about 0.25 percent for Hispanic students, 0.23 percent for white students, and 0.18 percent for Asian students. Although differences across racial and ethnic groups are not statistically distinguishable from each other, the consistency of the point estimates with the four-year results below suggests that Black student outcomes are more exposed to state funding shocks at colleges that depend more on public support.

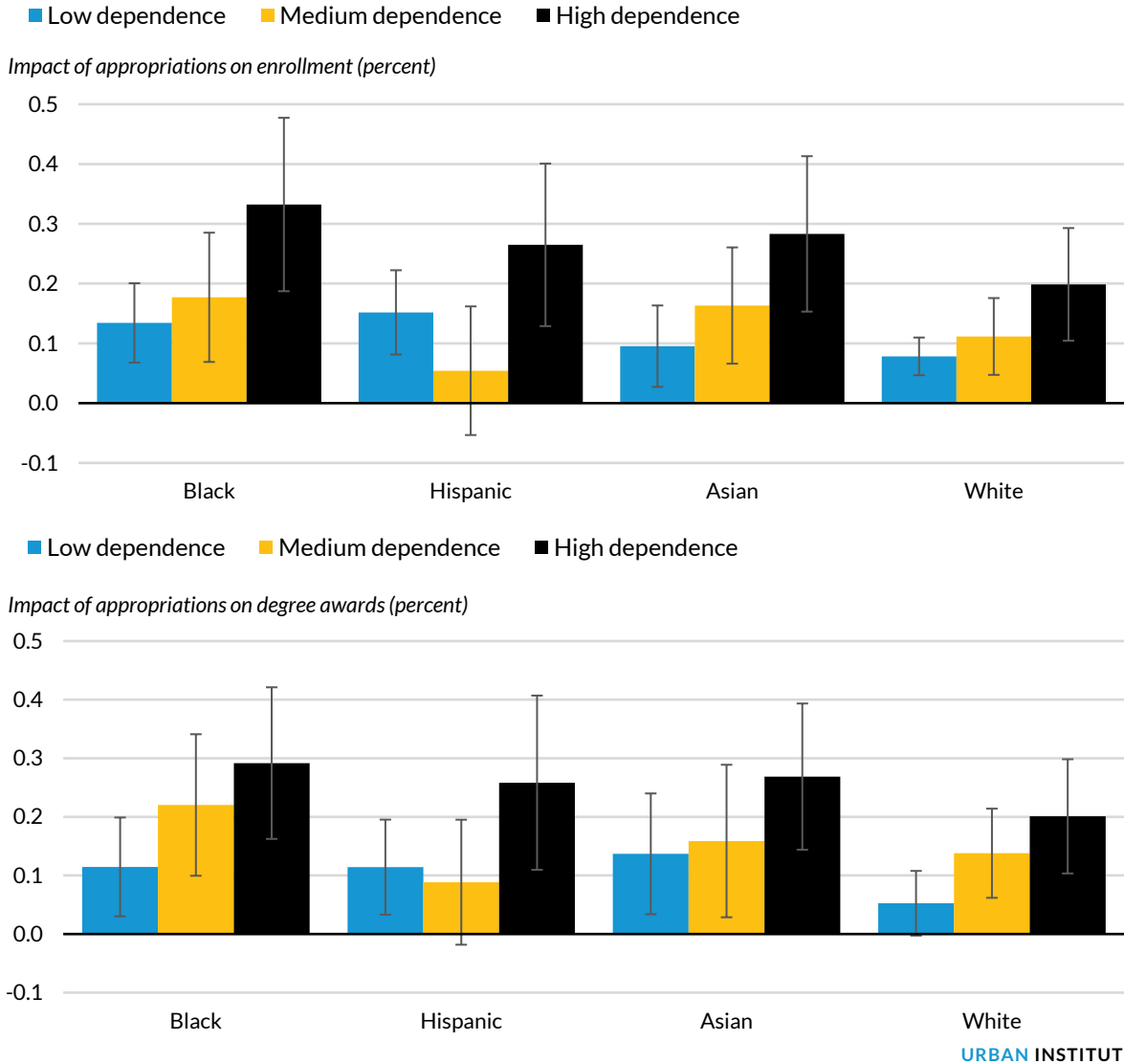
The estimates in figure 13 suggest a clear takeaway in how college enrollment and degree awards relate to changes in state appropriations for community colleges. For students likely to pursue studies at colleges that are highly dependent on state funding, sharp declines in state appropriations could be extremely harmful for their opportunity to obtain a college education. Moreover, our results suggest that cuts to appropriations have a disproportionate impact on Black student outcomes.

Figure 14 presents similar estimates for public universities. Consistent with the results for community colleges, appropriations have a greater impact at high-dependence universities. Except for Hispanic student enrollment, the results show a clearly monotonic pattern by dependence on appropriations. Low-dependence universities again show relatively smaller, though statistically significant, responses to variation in appropriations. Moreover, the effects of state appropriations on enrollment at highly dependent universities is consistently larger for Black, Hispanic, and Asian students than for white students.

FIGURE 14

Impact of Appropriations on Enrollment and Degree Awards at Four-Year Colleges, by Appropriations Dependence and Race or Ethnicity

State appropriations matter most at public universities that depend on state funding



Source: Authors' calculations using Integrated Postsecondary Education Data System data from 1994 to 2017.

Notes: The figure reports ordinary least squares coefficient estimates of equation 3 in the text, a log-log specification of the outcome on state appropriations separately by dependence. Dependence on state appropriations is defined as the share of total college revenue stemming from appropriations in 1999 or five years after the college's opening year. For four-year colleges, the dependence bins are 0 to 35 percent (low), 36 to 44 percent (medium), and 45 to 82 percent (high). For two-year colleges, the bins are 0 to 30 percent (low), 31 to 47 percent (medium), and 48 to 86 percent (high). The standard errors are clustered at the college level in all models. The models control for college fixed effects, year fixed effects, and state-specific time trends, as well as log total county population, log county population of the racial or ethnic group in question, county unemployment rate, county poverty rate, and log county median household income. Observations are weighted by baseline enrollment (defined as total enrollment in 1999 or five years after the college's opening year).

Finally, the bottom panel in figure 14 shows that degree awards at four-year colleges are also most responsive to state funding for students of color, especially at institutions highly dependent on appropriations. At highly dependent universities, a 1 percent increase in appropriations results in a 0.27 percent increase in degree awards for Asian students, a 0.28 percent increase for Black students, a 0.25 percent increase for Hispanic students, and a 0.20 percent increase for white students. Notably, degree awards for students of color are significantly associated with state appropriations at low-dependence institutions, while white degree awards are only marginally so. The generalized monotonic pattern of the effect estimates across dependence categories provides assurance that our models pick up a real and consistently estimated pattern of effects.

The evidence in figures 13 and 14 suggests that changes to state appropriations have their largest impact on enrollment and degree awards at public colleges with large shares of total revenue stemming from appropriations. Moreover, these impacts tend to be more pronounced for Black, Hispanic, and Asian student enrollment and degree awards.

This analysis has shed light on the importance of state investments for public postsecondary education institutions. Our work establishes that state dollars spent on financing public college operations translate to more college enrollment and degree awards at both two-year and four-year colleges. Our findings suggest that state funding has an important role in maintaining racial equity in access and attainment at colleges that historically have depended more on public dollars. As such, this work suggests that Black and Hispanic college outcomes may be subject to more volatility and exposure to state budgetary shocks. Funding for public colleges is vital to the educational enrichment and professional development of all citizens, particularly for Black and Hispanic students, for whom postsecondary education can be a vital pipeline into high-income employment opportunities and a mechanism of social mobility.

Discussion

This study has provided empirical estimates of the average impact of state higher education spending on college enrollment and degree awards of students by race and ethnicity, using observational data from IPEDS. We studied the two types of state spending on higher education: student financial aid programs and appropriations to public colleges. For student aid spending, we assessed the average effects of cuts and hikes to aid spending using a comparative analysis of recent changes to state aid programs. For state appropriations, we leveraged a recent approach from the literature (Deming and

Walters 2017), comparing how outcomes have evolved for colleges with different degrees of dependence on appropriations dollars.

Our analysis points to two broad takeaways. The first is that state funding for higher education matters for college enrollment and degree awards. We provide compelling evidence of divergent paths for states that increased versus decreased their spending on student aid. States that increased their spending saw higher enrollment and degree awards at two-year colleges, but these outcomes suffered in states that cut their aid spending. Similarly, we found that states' appropriations dollars are linked to enrollment and degree award outcomes at both community colleges and four-year universities, especially at those that historically have depended more on this source of funding. The fact that money matters for public colleges may not appear surprising. Nevertheless, questioning the overall value of public investments in education is common in public policy research. Indeed, for decades after the Coleman Report from the 1960s, many researchers and policymakers believed that spending more on K-12 schools would reap little benefit (Downey and Condron 2016). It is only recently that research has shown that the opposite is true, that funding matters a great deal for student outcomes (Jackson, Johnson, and Persico 2016; Johnson and Jackson 2019; Lafortune, Rothstein, and Schanzenbach 2018). We view our work as complimentary to this effort, establishing that state funding for public colleges has meaningful positive impacts on postsecondary educational attainment.

The second takeaway is that state funding for public colleges is especially important for Black and Hispanic students. Our estimates suggest that Black and Hispanic student enrollment and degree awards at public colleges are more sensitive to changes in state funding than the same outcomes for white and Asian students. Although we cannot assess this directly in our data, one potential explanation is that Black and Hispanic students tend to be more financially constrained than white and Asian students because of historical and structural racism.

Our results are of key importance to policymakers, as they help draw a line directly from state funding decisions to racial and ethnic inequality, an issue that has gained renewed interest at the state and federal levels. If states cut funding for public colleges, enrollment and degree awards are likely to decline, and this will likely have a disproportionate impact on Black and Hispanic students, especially at community colleges. Policymakers and advocates invested in furthering access to higher education and racial equity can use this evidence to make the case for the importance of state funding for higher education.

Our study, however, has little to say on the optimal design of state student aid programs or on the desirability of detailed aspects of policy governing state appropriations for public colleges. Our study

provides solid evidence for the stylized claim that state investments in public colleges have meaningful impacts on student outcomes. But funding is more effective if invested in ways that match students' needs. Certain public investments have a higher impact than others. Readers interested in better designing state financial aid policy should read the Urban Institute's work in this realm. For example, recent evidence from Texas suggests clear steps toward improving student aid program designs, including improvements to the allocation of state aid funds to public universities (Baum and Blagg 2021).

Our approach instead has been to systematically establish an overall causal effect of state higher education spending on student outcomes by race and ethnicity, which was a gap in the existing literature. Furthermore, this study establishes a framework to understand the impacts of individual state programs by drawing comparisons between similar institutions that are exposed to different student aid program structures and spending. Future research could leverage this empirical approach to evaluate individual state programs.

Appendix

TABLE A.1

NASSGAP State Aid Spending Change Events

State	Year	Sources	Notes
Alaska	2009	Public Works, <i>Final Report: Performance Review of the Alaska Commission on Postsecondary Education and the Alaska Student Loan Corporation</i> (Anchorage, AK: Public Works, 2016).	The Alaska Supplemental Education Loan declined from \$40 million to \$16 million.
Arkansas	2010	"Scholarships," Arkansas Scholarship Lottery, accessed June 2, 2021, https://www.myarkansaslottery.com/scholarships .	
Florida	2011	Florida College Access Network, "College Affordability Adrift: Florida's Bright Futures Program Faces \$347 Million in Cuts by 2017-18" (Tampa: Florida College Access Network, 2014).	Florida's funding decrease is driven by a decrease in spending across the Florida Bright Futures Scholarship, which is split into four programs in NASSGAP (the Academic Top Scholars award, the Florida Academic Scholarship, the Florida Medallion Scholarship, and Gold Seal Vocational Scholarship). The Medallion Scholarship award was cut from \$291 million to \$226 million from 2011 to 2012.
Georgia	2011	Dorie Turner, "Georgia House Passes Bill Cutting HOPE Scholarships," <i>Valdosta Daily Times</i> , March 2, 2011, https://www.valdostadailytimes.com/news/local_news/georgia-house-passes-bill-cutting-hope-scholarships/article_31e8dc3d-d928-5df5-9cc0-7d6e3e0c6bef.html .	Georgia's funding decrease included cuts across the HOPE program. The grant declined from \$206 million to \$93 million, and the scholarship declined from \$527 million to \$367 million.
Hawaii	2008	M.R.C. Greenwood, "University of Hawai'i System Budget Briefing," testimony before the US Senate Committee on Ways and Means, Washington, DC, January 22, 2010.	The Hawai'i B Plus Scholarship (\$1.5 million in 2008) and the University of Hawaii tuition waiver (\$24 million in 2008) do not appear in the data in 2009. The tuition waiver appears in the data from 2003 to 2008. The B Plus Scholarship appears starting in 2009. Additionally, Hawaii made significant funding cuts in 2009 in response to the recession.
Illinois	2007	Lauren Kelly, "MAP Cuts Hurt Students' Futures," <i>Columbia Chronicle</i> , September 8, 2009, https://columbiachronicle.com/ff4f7c0d-9d2b-5114-85f9-6f060c185fcf .	The Monetary Award Program Plus (\$26 million in 2007) shows as having \$0 expenditures and no recipients in 2008.
Kentucky	2015	"Five Challenges Kentucky College Students Face in 2016," Kentucky Center for Economic Policy, accessed June 2, 2021, https://kypolicy.org/five-challenges-kentucky-college-students-face-2016/ .	Kentucky's funding increase included significant funding increases for the College Access Program Grant and the Kentucky Educational Excellence Scholarship from 2015 to 2016.

State	Year	Sources	Notes
Louisiana	2007	Kevin Crockett, Mark Heffron, and Mark Schneider, "Targeting Financial Aid for Improved Retention Outcomes: The Potential Impact of Redistributing State Gift Aid on Student Retention among Pell Grant Recipients in Louisiana's Statewide and Regional Universities" (Washington, DC: American Institutes for Research, 2011).	
Michigan	2009	Kyle I. Jen and Ellen Jeffries, <i>Fiscal Year 2009-10 Higher Education Appropriations Report: A Report to the House and Senate Appropriations Subcommittees on Higher Education</i> (Lansing: Michigan House and Senate Fiscal Agencies, 2009); and Dustin Dwyer, "Michigan Led the Nation in Cutting College Scholarships from 2003 - 2013," <i>State of Opportunity</i> , WUOM, February 11, 2015, https://stateofopportunity.michiganradio.org/post/michigan-led-nation-cutting-college-scholarships-2003-2013 .	Many grants had huge cuts from 2009 to 2010, including the Michigan Competitive Scholarship, the Michigan Merit Award, and the Michigan Tuition Grant. The Michigan Promise Scholarship (worth more than \$69 million in 2009) was eliminated.
Mississippi	2012	Sarah Pingel, "Redesigning State Financial Aid: Opportunities for the State of Mississippi" (Denver: Education Commission of the States, 2016).	Mississippi's funding increase included modest increases for the Higher Ed Legislative Plan program and Resident Tuition and Eminent Scholars grant 2012 to 2013 (about \$1 million each).
Missouri	2007	S.B. 389, 2007 Leg. (Mo. 2007).	Access Missouri Financial Assistance Program first appears in the data in 2008.
Nebraska	2007	Coordinating Commission for Postsecondary Education (CCPE), <i>2008 Tuition, Fees and Financial Aid Report</i> (Lincoln, NE: CCPE, 2008).	Nebraska's funding decrease included a large increase for remission and tuition waivers and a modest increase for the Nebraska State Grant.
New Hampshire	2011	Institute for Higher Education Policy (IHEP) and Lumina Foundation, "Where Financial Aid Began: Partnering with Campuses and States" (Washington, DC: IHEP; Indianapolis: Lumina Foundation, n.d.)	State aid spending went down to \$0 in 2012. All grants that existed in 2011 reported \$0 expenditures in 2012. The largest of these was the New Hampshire Incentive Program.
North Carolina	2010	H.B. 97, Gen. Assemb. 2015 Sess. (N. Ca. 2015).	Education Access Rewards NC was worth \$44 million in 2010 but is not in data in 2011. The state's total funding decline is mitigated by significant increases in other programs, including a \$30 million increase in the University of North Carolina Need-Based Grant.
North Dakota	2009	Office of Management and Budget (OMB), <i>Program Narrative 215: ND University System</i> (Washington, DC: OMB, 2012).	North Dakota's funding increase included a nearly \$6 million increase for the ND State Student Incentive Program.
Ohio	2009	Wendy Patton and Hannah Halbert, "Higher Education in Ohio: High Tuition, Low Aid, Too Little State Investment" (Cleveland: Policy Matters Ohio, 2015).	Ohio's funding decrease included large cuts across several state grants from 2009 to 2010: the Ohio College Opportunity Grant program decreased from \$157 million to \$76 million, and Student Choice Grants decreased from \$34 million to \$0.

State	Year	Sources	Notes
Wisconsin	2010	Higher Educational Aids Board (HEAB), <i>Report of the 2012 Commission on Financial Aid Consolidation and Modernization</i> (Madison, WI: HEAB, 2012).	Wisconsin's funding increase included increases for the Talent Incentive Program Grant (\$4.4 million to \$6.7 million), the Wisconsin Tuition Grant (\$26 million to \$28 million), and the Wisconsin Higher Ed Grant (\$55 million to \$59.5 million for the University of Wisconsin and \$16.7 million to \$20.3 million for Wisconsin Technical College)

Note: NASSGAP = National Association of State Student Grant and Aid Programs.

TABLE A.2

Summary Statistics of Public Colleges in 2003 and 2017

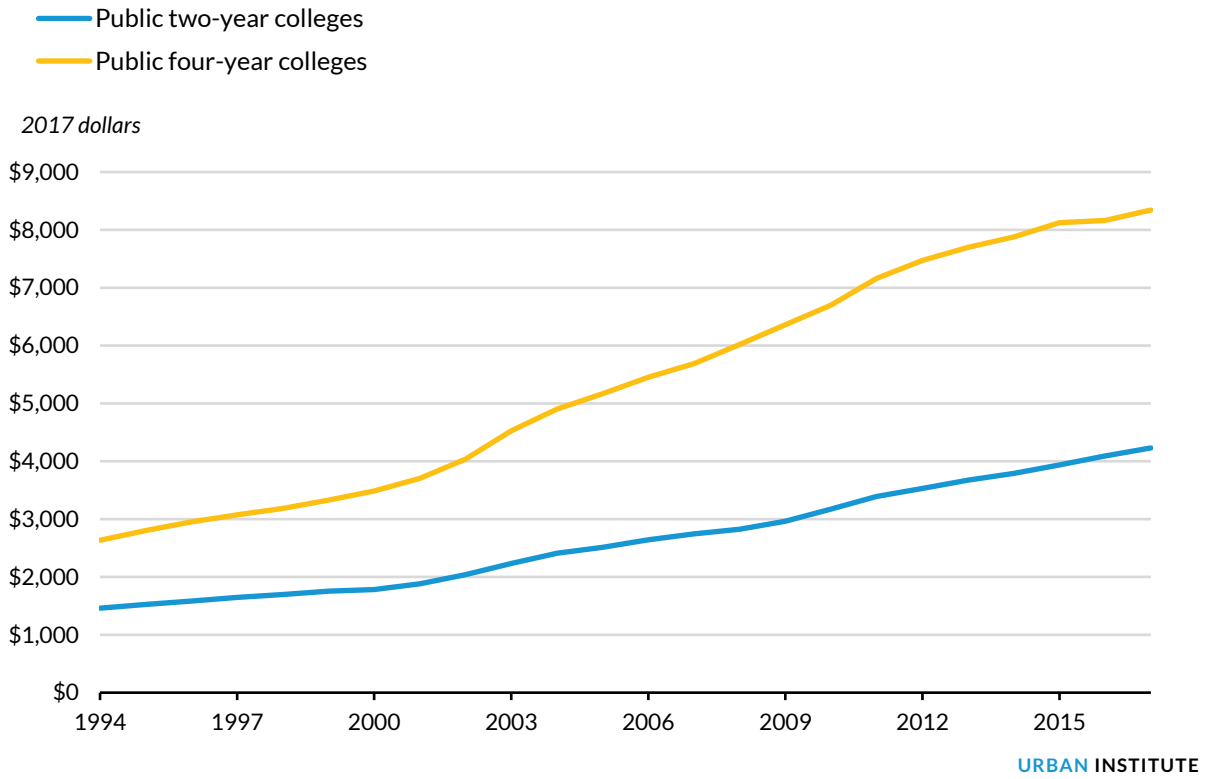
	2003		2017	
	Mean	SD	Mean	SD
Enrollment				
Total	5,443	(6,029.0)	6,006	(7,270.5)
Black	688	(1,186.3)	785	(1,374.8)
Hispanic	735	(1,773.8)	1,472	(2,976.9)
Degree awards				
Total	739	(671.4)	1,332	(1,528.1)
Black	92	(146.9)	160	(277.0)
Hispanic	73	(158.4)	275	(533.4)
Finance (\$millions)				
Total student aid				
State grants	14.6%	(12.7%)	14.0%	(11.7%)
Federal grants	78.3%	(15.0%)	73.9%	(16.9%)
Total revenue (\$millions)				
State appropriations	33.8%	(13.6%)	30.4%	(13.0%)
Net tuition	17.1%	(11.1%)	16.8%	(10.2%)
Total expenditures (\$millions)				
Instruction	45.8%	(10.2%)	41.2%	(9.0%)
Student services	10.6%	(4.7%)	11.5%	(4.2%)
Total observations	1,151		955	

Source: Authors' calculations using Integrated Postsecondary Education Data System data.

Note: SD = standard deviation.

FIGURE A.1

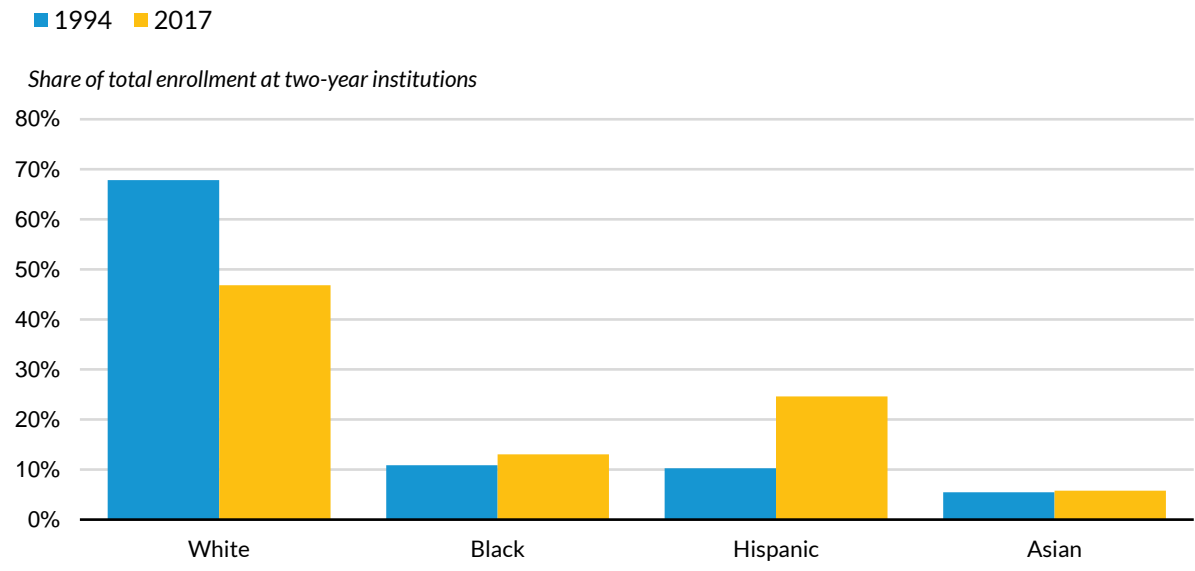
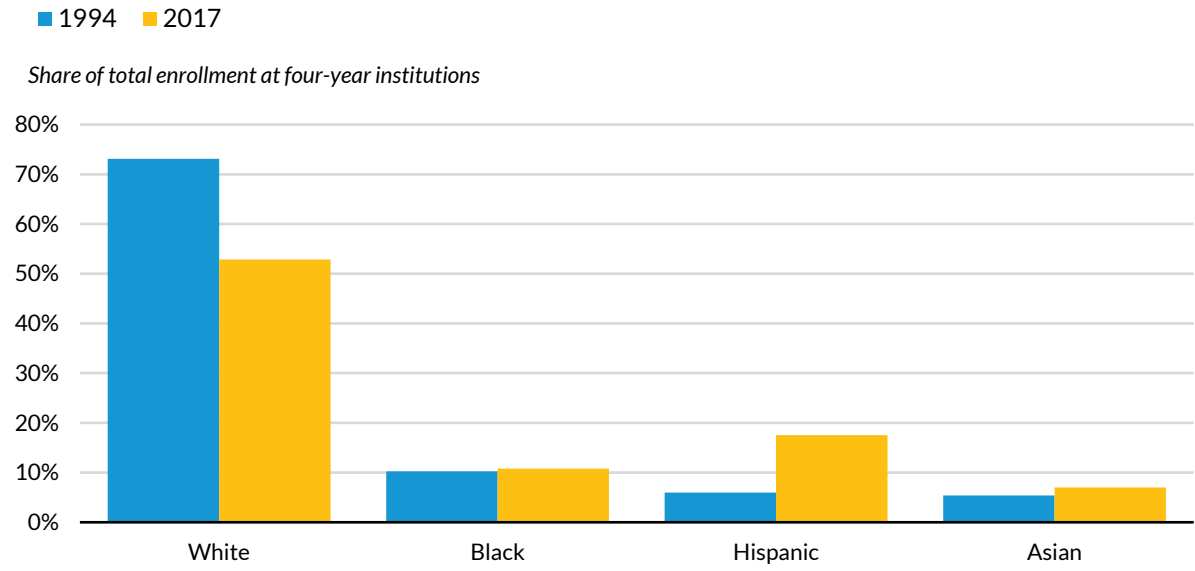
Inflation-Adjusted Average Tuition and Fees Charged at Two- and Four-Year Institutions



Source: Author's estimates using Integrated Postsecondary Education Data System data from 1994 to 2017.

FIGURE A.2

Share of Total Enrollment in Public Institutions, by Race or Ethnicity, 1994 and 2017



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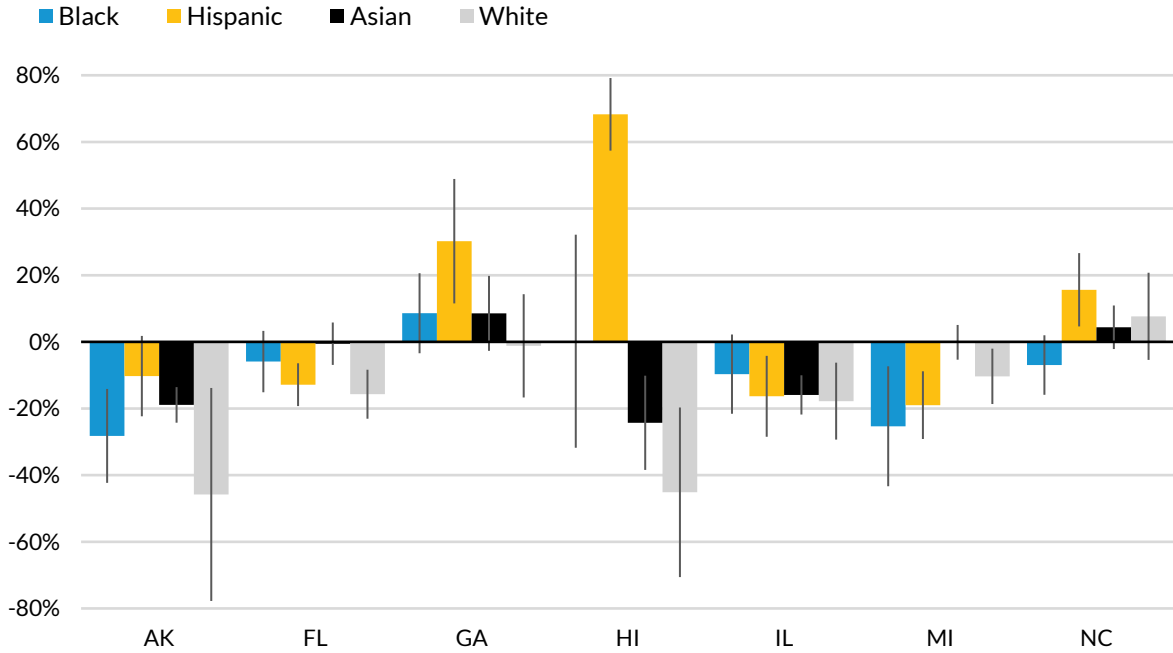
Source: Authors' estimates using Integrated Postsecondary Education Data System data in 1994 and 2017.

Note: Shares do not add up to 100 percent because other racial categories have been excluded.

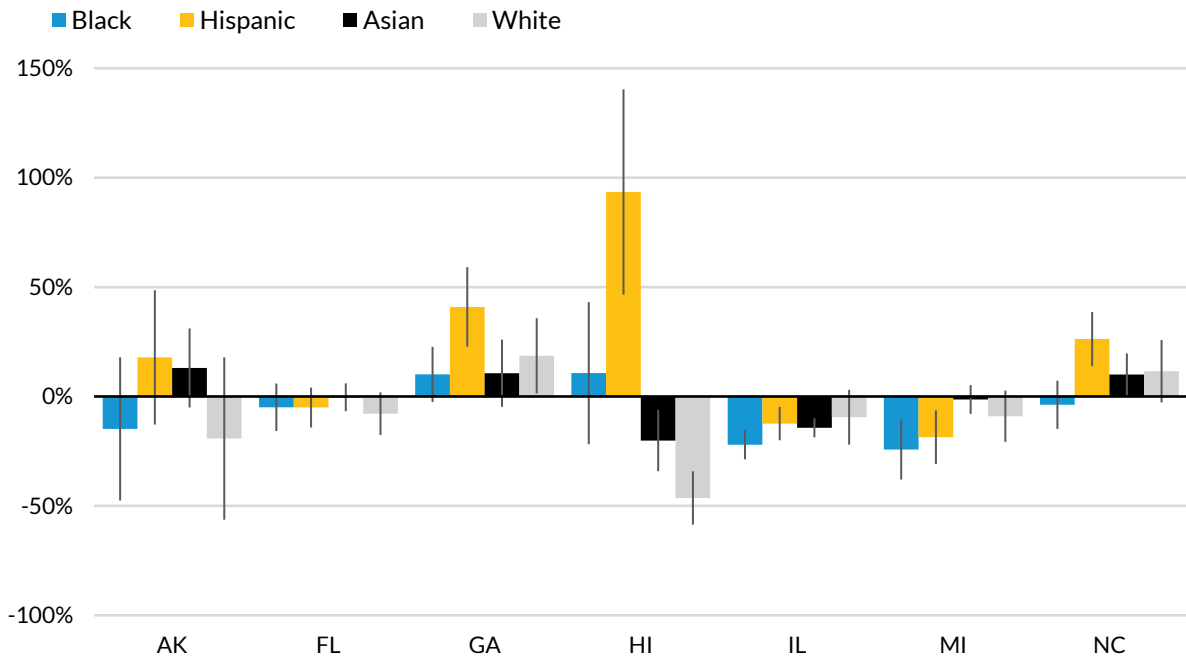
FIGURE A.3

Impact of Decreases in Student Aid Expenditures on College Enrollment and Degree Awards, by Race or Ethnicity

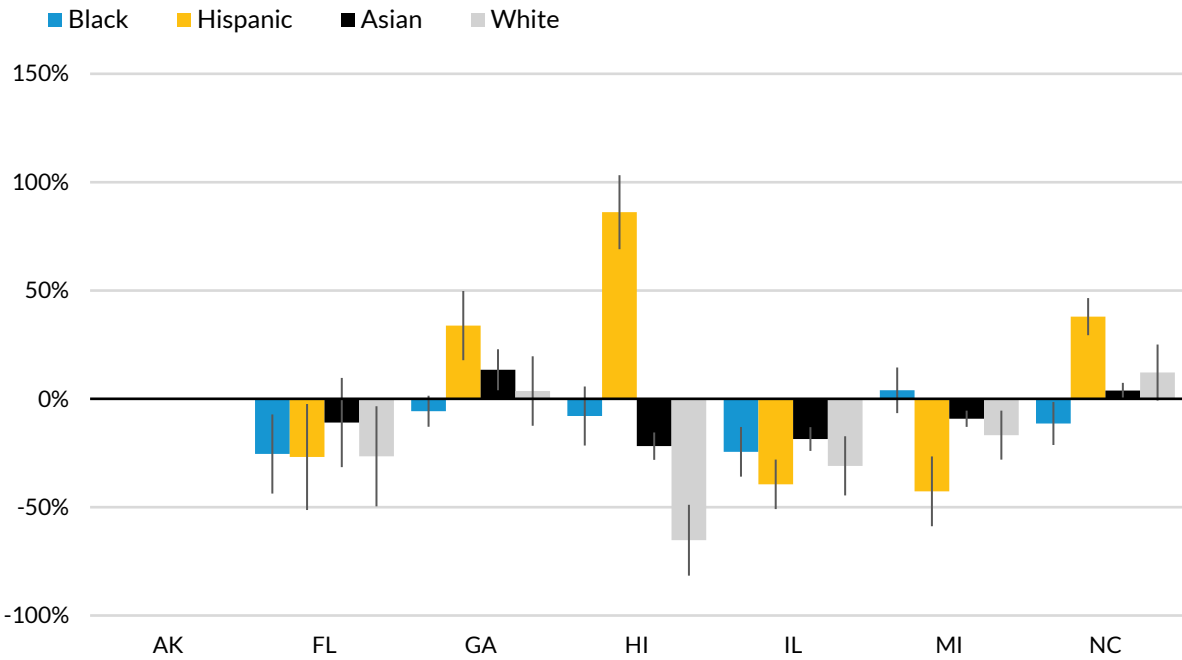
Impact on four-year enrollment per college



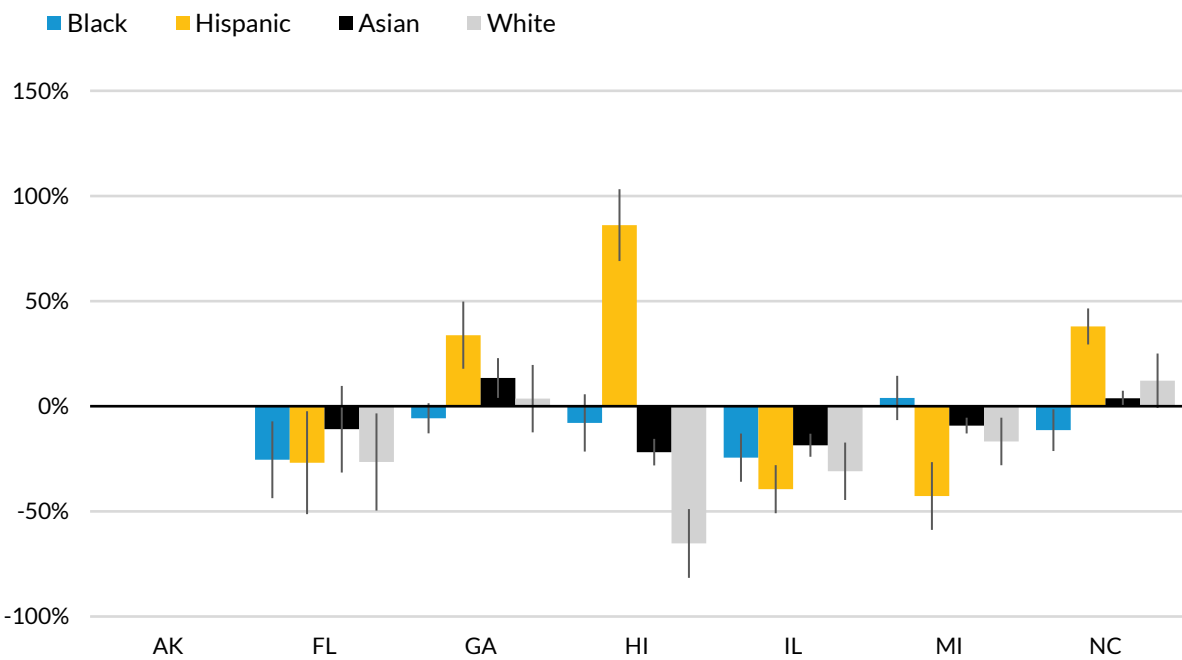
Impact on four-year degree awards per college



Impact on two-year enrollment per college



Impact on two-year degree awards per college



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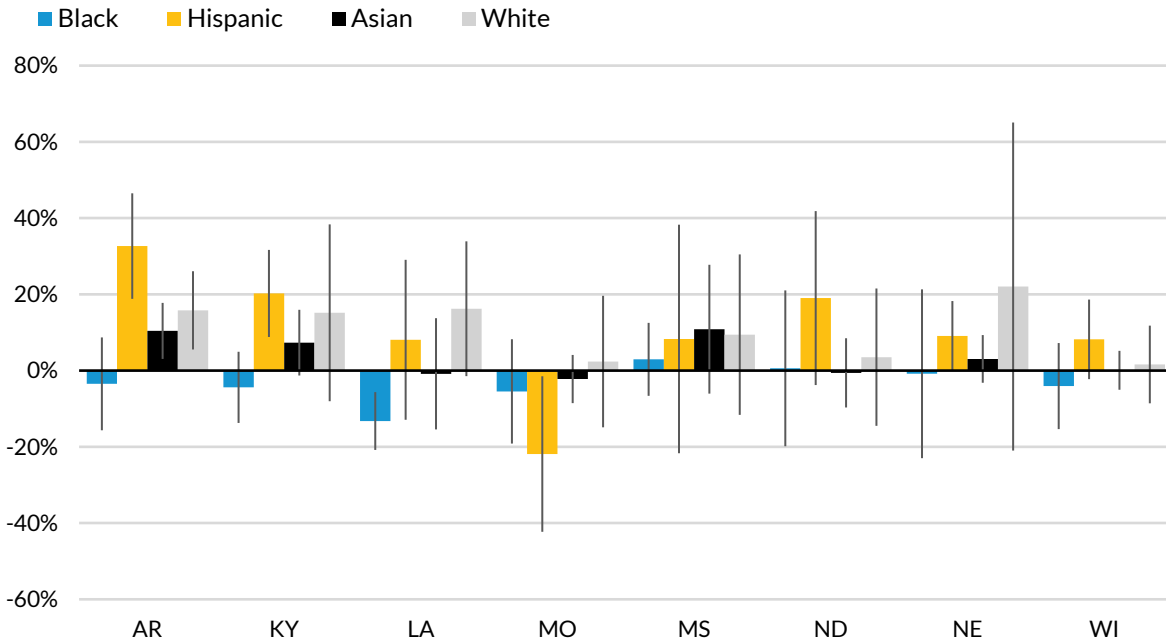
Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The standard errors are clustered at the institution level in all models. The figure shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

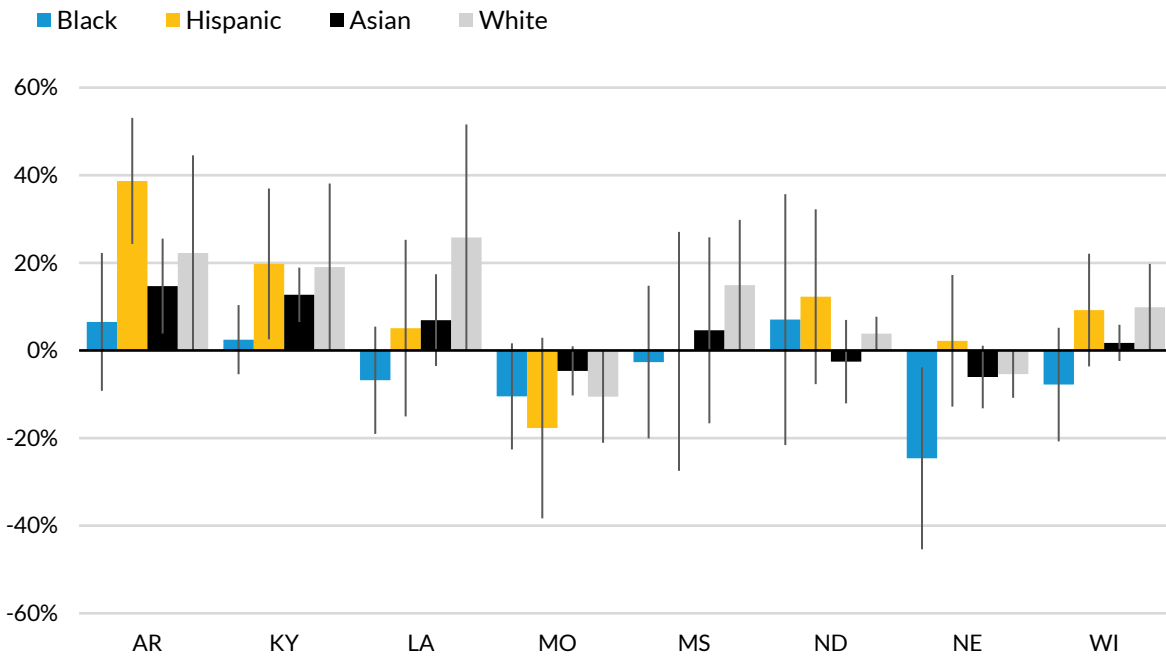
FIGURE A.4

Impact of Increases in Student Aid Expenditures on College Enrollment and Degree Awards, by Race or Ethnicity

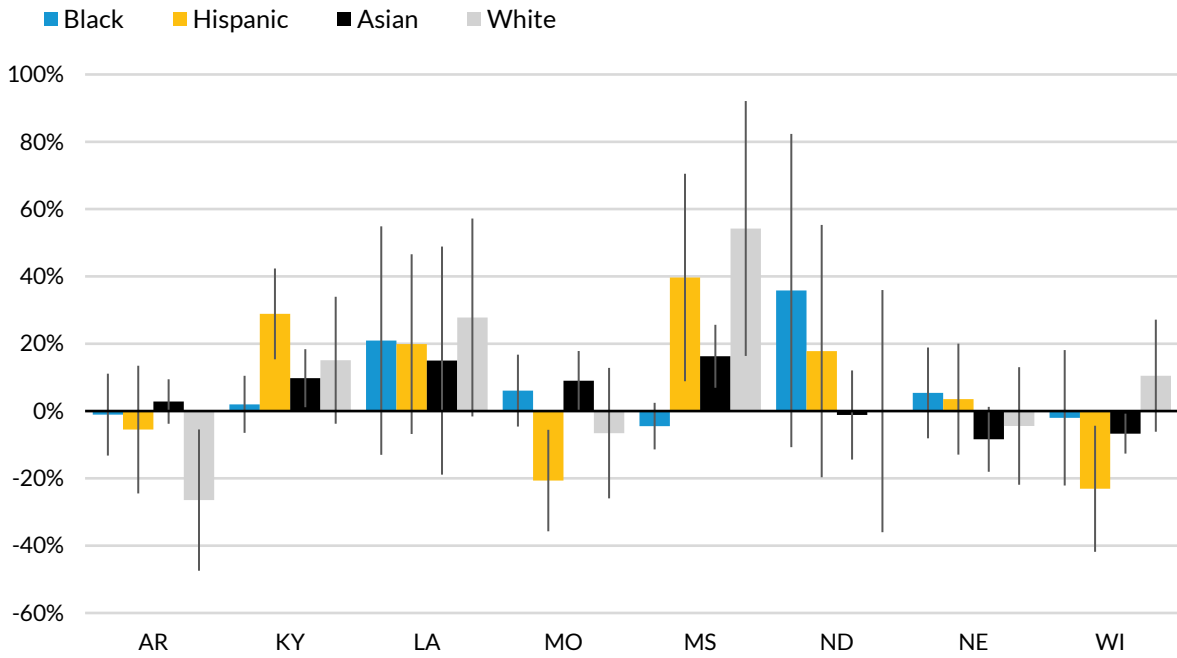
Impact on four-year enrollment per college



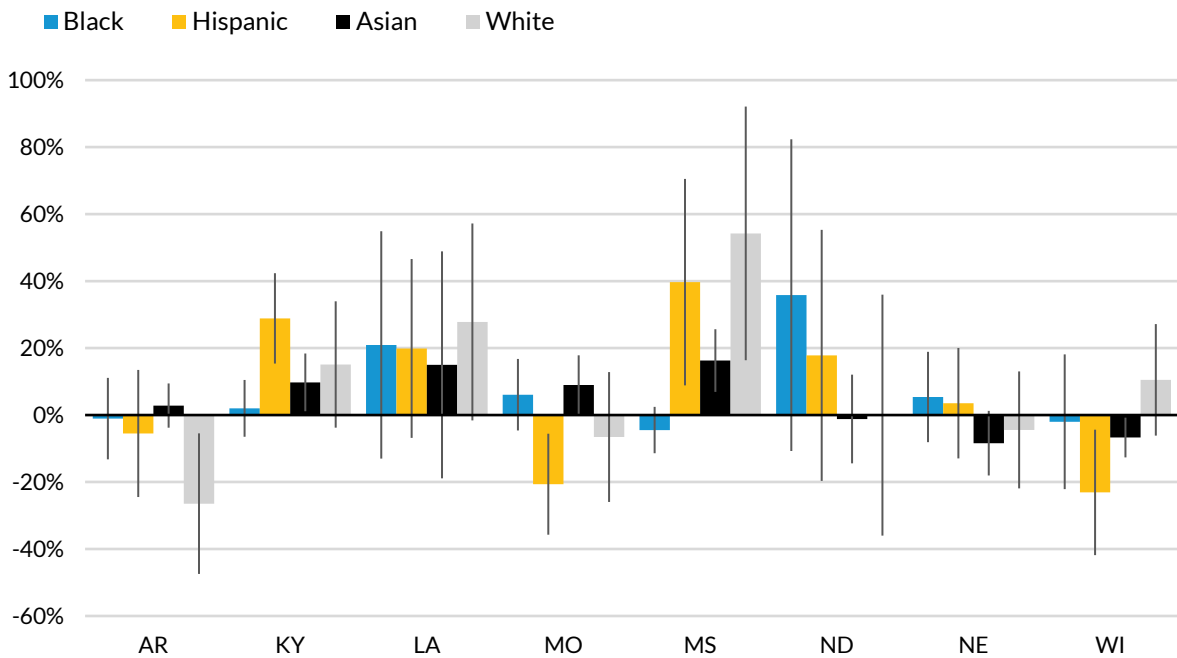
Impact on four-year degree awards per college



Impact on two-year enrollment per college



Impact on two-year degree awards per college



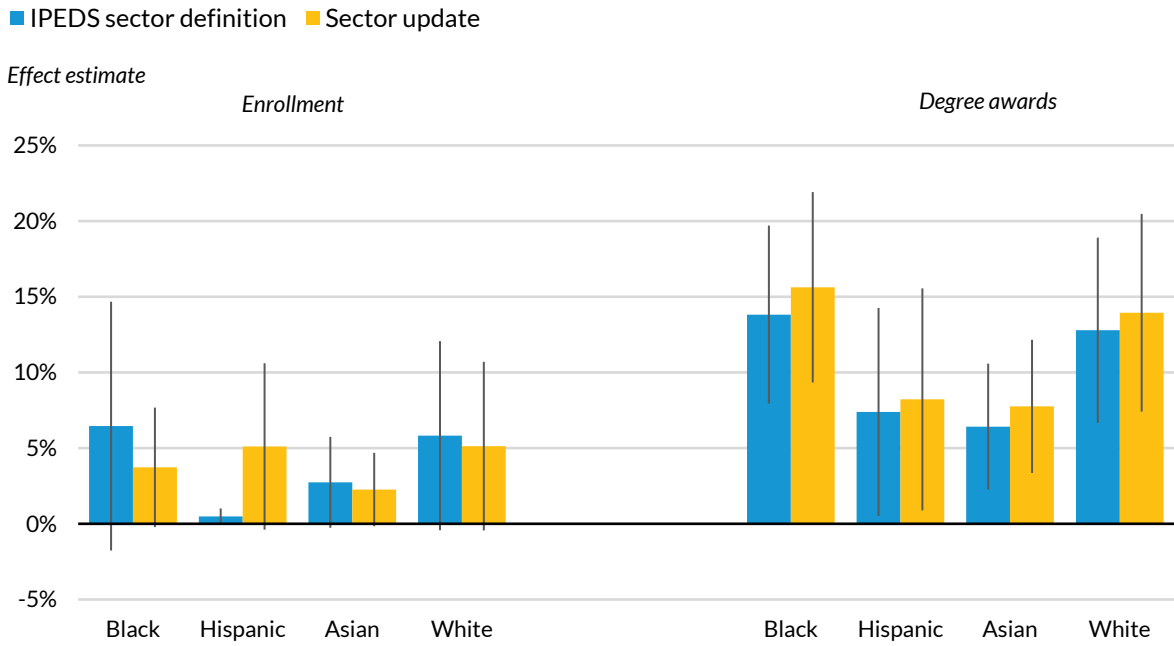
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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: The standard errors are clustered at the institution level in all models. The figure shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

FIGURE A.5

Robustness of State Aid Spending Differences-in-Differences Estimates to Institution Sector Updates
Two-year institutions



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Source: Authors' estimates using IPEDS data from 2003 to 2017.

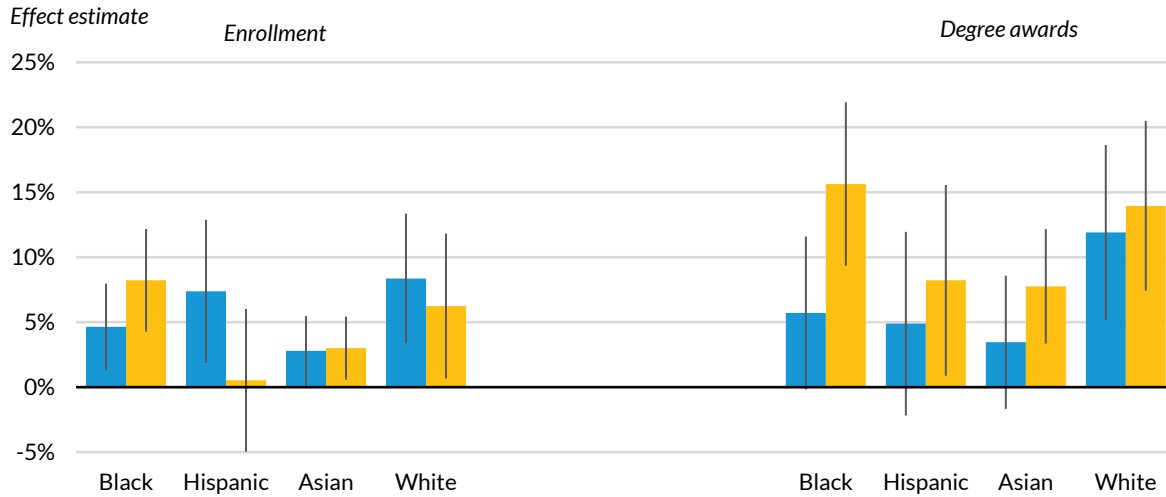
Notes: IPEDS = Integrated Postsecondary Education Data System. The IPEDS sector definition is defined using the "sector" variable in IPEDS, focusing on "public two-year" institutions. The sector update is defined using the "inst_category" variable and recoding colleges that are public and are ever classified as "Degree-granting, not primarily baccalaureate or above" as two-year colleges. The standard errors are clustered at the institution level in all models. The figure shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

FIGURE A.6

Enrollment-Weighted State Aid Spending Differences-in-Differences Impact Estimates

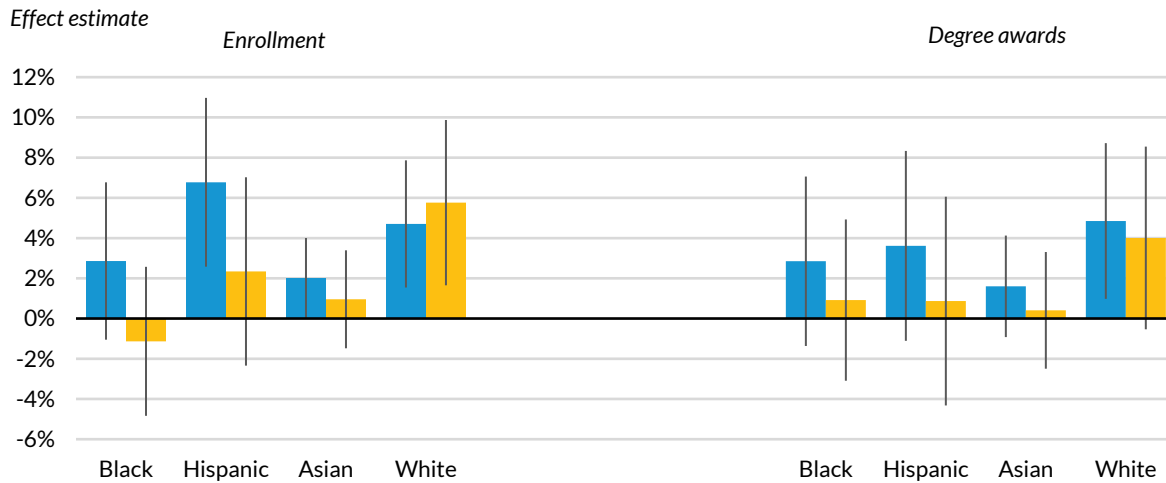
Two-year institutions

- Baseline enrollment weighted
- Unweighted



Four-year institutions

- Baseline enrollment weighted
- Unweighted



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Source: Authors' estimates using Integrated Postsecondary Education Data System data from 2003 to 2017.

Notes: Enrollment weights do not vary over time and are defined as the total enrollment of the institution in 1999 (or five years after its opening for colleges that have opened since 1995). The standard errors are clustered at the institution level in all models. The figure shows model estimates of equation 1 in the text. The model includes controls for log county population (by race or ethnicity), county unemployment rate, county poverty rate, institution fixed effects, and year fixed effects.

Notes

- ¹ The IPEDS data contain several postsecondary institutions not relevant to this study, including vocational schools and continuing professional education institutions. We keep only two- and four-year institutions, and where relevant, we indicate whether we censure our sample to include only public institutions.
- ² We follow the procedure that Lafortune, Rothstein, and Schanzenbach (2018) implement to quantitatively identify state K-12 finance reforms, using structural breaks in the time series of total state aid spending. For each state and $t^* = 2004, \dots, 2016$, we fit the model $Y_{st} = \alpha + 1(t > t^*) \kappa + \epsilon_{ts}$ and select the t^* that yields the lowest mean squared error for the model. We treat the selected date as a candidate event in state s . Bai (1997) shows that if there really is a structural break in the time series (with a nonzero true κ), this method is super consistent for the location of the break, permitting inference regarding κ to treat its location as known.
- ³ To handle cases in which there is zero enrollment or zero degree awards, we use the inverse hyperbolic sine transformation (defined as $\ln(x + \sqrt{x^2 + 1})$). This function has similar properties as the natural log, allowing an approximate interpretation of the regression coefficients as estimates of the impact of policy changes on percentage change in college outcome counts. For a detailed discussion of the inverse hyperbolic sine transformation and its use in econometrics, see Bellemare and Wichman (2020).
- ⁴ In all our models, we use standard errors that are clustered at the college level.
- ⁵ When estimating the difference-in-differences model for increased spending events, we exclude colleges located in states that have decreased spending events, leaving in colleges in states with no events as “pure” controls.
- ⁶ Other evidence supporting this inference is that trends switch with the onset of the aid reforms. Grants for colleges in states that increased spending were trending down and then quickly ticked up after the reform. Similarly, community college grants were trending up in states that cut spending, and immediately after the cuts, these trends turned negative.
- ⁷ We estimate the three quantiles separately for two-year and four-year institutions. For four-year institutions, the bins are 0 to 35 percent (low), 36 to 44 percent (medium), and 45 to 82 percent (high). For two-year institutions, the bins are 0 to 30 percent (low), 31 to 47 percent (medium), and 48 to 86 percent (high).
- ⁸ We use a transformation similar to the natural log (in terms of interpretation) that can handle outcomes equal to zero. The inverse hyperbolic sine transformation allows for values of zero and has a derivative approximately equal to the natural log, enabling the interpretation as percentage change.

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