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A NATIONAL ANALYSIS OF THE IMPACT OF PERFORMANCE-BASED FUNDING ON COMPLETION OUTCOMES AMONG UNDERSERVED STUDENTS

Justin C. Ortagus, Kelly Rosinger, Robert Kelchen
Nicholas Voorhees, Garam Chu

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Introduction

Public higher education institutions in the United States have faced longstanding criticism for what many perceive as low completion rates among students who begin college (e.g., Schneider & Yin, 2011). Sixty-one percent of first-time, full-time students who began at public universities in 2012 graduated from that institution within six years, while 28 percent of first-time, full-time students who started at community colleges in 2016 graduated within three years. These rates have improved markedly over the past two decades even as more students attended college (National Center for Education Statistics, 2021), but completion rates remain a concern for students, their families, and policymakers as they invest in higher education.

Perhaps the most pressing concern facing public higher education is the growing gaps in the outcomes of students from historically underserved groups (e.g., racially minoritized and adult students) relative to their peers. For instance, the gap in Black/white graduation rates at public universities increased from 16 to 20 percentage points between the 1996 and 2012 cohorts, while the Black/white gap at community colleges widened from eight to 15 percentage points between the 2000 and 2016 cohorts (National Center for Education Statistics, 2021). Substantial gaps in college completion rates also exist by age upon college entry (Taniguchi & Kaufman, 2005; Tennant, 2014).

Due to these concerns about student outcomes and the rising price of higher education, a growing number of states have sought to identify ways to hold public colleges and universities accountable for their outcomes

(Ortagus et al., 2020; Rosinger et al., 2020). Performance-based funding (PBF) is an increasingly popular higher education policy designed to achieve that aim by tying state appropriations to institutional performance metrics, such as the number of certificates, associate degrees, and bachelor's degrees produced (Ortagus et al., 2020). Over the past few decades, 41 states have allocated at least a portion of their appropriations to public colleges and universities based on student outcomes, with multiple PBF-adopting states now allocating more than 10 percent of state funds for performance (Ortagus et al., 2020; Rosinger et al., 2020).

While a large body of research has generally found null or at most modest positive effects of PBF on student degree completion outcomes as a whole (Ortagus et al., 2020), some studies have found that PBF policies can lead to unintended consequences, such as restricting access to higher education for historically underserved students (Gándara & Rutherford, 2020; Umbricht et al., 2017). In response to the unintended consequences of PBF and widespread disparities in completion outcomes across demographic groups, several states have incorporated equity metrics into their PBF systems in order to provide targeted funds for institutions that graduate more racially minoritized students, adult students, and other historically underserved subgroups of students.

Roughly half of the 32 states that tied appropriations to performance in 2020 consider racially minoritized student outcomes in their PBF system. For example, Ohio's PBF formula provides an added weight for completions for racially minoritized students—defined as Black, Hispanic, or American Indian students (Carey, 2014). Some PBF-adopting states also incentivize adult student completions in their PBF formula. More specifically, Illinois, Ohio, Tennessee, Montana, and other states offer bonus funding for institutions that graduate adult or "non-traditional" students defined as age 25 and older (Rosinger et al., 2020).

While a growing body of research has examined the impact of PBF on degree production outcomes, we know relatively little about how PBF shapes certificate and degree production by race/ethnicity, a critically important question given the completion gaps noted earlier. In addition, prior analyses of PBF policies have largely grouped these policies together under one umbrella category indicating whether an institution was subject to PBF in a given year, despite wide variation that exists in how these policies operate. To date, we are not aware of other studies that consider how specific design features of PBF policies—for instance, the amount of funds at stake under performance funding or the specific equity metrics states include—shape completion outcomes. This leaves policymakers with limited insight regarding whether and how PBF policies can be designed to reduce educational attainment gaps facing racially minoritized and adult students.

Our research advances the body of knowledge by leveraging the first comprehensive dataset that contains details on whether a PBF policy was actually funded in a given year, what share of state funding was at stake, and whether colleges were rewarded for successfully serving students who have been underrepresented in higher education. Our research questions are the following:

1. To what extent do PBF policies impact the number of certificates, associate degrees, or bachelor's degrees obtained by historically underserved college students?
2. Do results vary according to the design of the PBF policy?

Literature Review

Completion Gaps for Historically Underserved Students

Researchers have previously identified considerable completion gaps between racially minoritized students and their white peers. Flores et al. (2017) reported that the average college completion rate was 14.1% lower for Hispanic students and 21.9% lower for Black students relative to the average completion rate among white students. Numerous studies found that Black students (Titus, 2006) and Hispanic students (Contreras & Contreras, 2015) were less likely to earn their college degrees relative to white students. Prior research has also examined college students' completion rates by considering a comparison group of white and Asian students, finding that Black, Hispanic, and Native American students have lower completion rates than their white and Asian peers (Adelman, 2004). However, additional research has called into question the model minority myth attributed to Asian students' educational attainment by showing achievement gaps between Asian students and their white peers (Pang et al., 2011).

Prior literature has also shown completion gaps between adult students when compared to younger students. Specifically, Tennant (2014) found that adult students were less academically prepared upon entering college and thereby had lower graduation rates relative to their younger peers. Additional researchers have reported that adult students are less likely to complete college than younger students (Taniguchi & Kaufman, 2005).

The Impact of PBF on Credential Completion

For states, the policy goal of the implementation of a PBF system is to improve targeted institutional outcomes, such as the number of degrees awarded, by tying material incentives to the outcomes of interest in the PBF formula (Dougherty & Reddy, 2013). Although qualitative work has shown that institutions adapt or reorganize their program and staffing in response to PBF formulas (Li, 2017), faculty leaders in PBF adopting states reported a clear disconnect between the PBF system and instructional practices related to teaching and learning (Harbour & Nagy, 2005). Taken together, prior quasi-experimental research focused on the effects of PBF adoption has shown that PBF policies do not typically lead to increases in degree completion (Ortagus et al., 2020).

Numerous quasi-experimental studies reported no statistical relationship between the implementation of a PBF system and the number of associate degrees produced. More specifically, prior work focused on Washington (Hillman et al., 2015), Ohio (Hillman et al., 2018), and Tennessee (Hillman et al., 2018; Li & Ortagus, 2019). has shown that the adoption of a PBF policy was unrelated to associate degree production. In

recent work including both two-year and four-year institutions, Ward and Ost (2021) found that PBF systems had no effect on total degree completion.

PBF literature has also focused specifically on the effect of PBF adoption at public four-year colleges and universities, reporting that the implementation of a PBF policy was unrelated to bachelor's degree production (Boland, 2018; Hillman et al., 2014). In a study focused on the impact of PBF in Pennsylvania, Hillman et al. (2014) found that PBF adoption did not lead to increases in bachelor's degree completions when public four-year institutions in the Pennsylvania State System of Higher Education were compared to otherwise-similar four-year institutions in surrounding states. In addition, prior work has shown that the implementation of a PBF system did not lead to increases in bachelor's degree production at public four-year historically Black colleges and universities (HBCUs) throughout the United States (Boland, 2018).

Some states incentivize the completion of certificates as a component of their PBF formula (Rosinger et al., 2020). In studies of one or two PBF-adopting states, previous scholars have suggested that a focus on certificate production, particularly short-term certificate production, rather than long-term degrees represents a form of institutional gaming of the PBF system (Hillman et al., 2018; Hillman et al., 2015; Hu, 2019; Li & Ortagus, 2019). Hillman et al. (2018) report that community colleges in Tennessee, but not Ohio, responded to PBF by increasing the number of certificates awarded. Additional work revealed that community colleges increased their short-term certificate production in Tennessee (Li & Ortagus, 2019) and Washington (Hillman et al., 2015).

The Paradox of PBF

Before delving into empirical work focused specifically on the unintended consequences of PBF in higher education, we consider the lessons learned from performance management literature focused broadly on performance-based reforms in the public sector. Performance management literature contends that performance-based reforms often incentivize the intended outcomes but fail to properly account for the complexities associated with the underlying structures and politics of a given institution (Radin, 2000). Similarly, previous research has highlighted the historical futility of performance-based reforms and suggested that reformers typically mimic private sector ideas in ways that are not necessarily compatible with the institutional structures and functions of the public sector (e.g., Andrews & Moynihan, 2002). As a result, performance-based reforms in the public sector do not typically work as intended and may actually lead to unintended outcomes (Thompson, 1999).

An emerging body of literature on the unintended consequences of PBF in higher education suggests that PBF-adopting institutions may not always respond to the material incentives within PBF formulas in the ways the state originally intended (Gándara & Rutherford, 2018; Ortagus et al., 2020). Previous researchers have reported that PBF policies led to restricted access for racially minoritized students (Umbricht et al., 2017).

More specifically, Umbricht et al. (2017) reported that the implementation of a PBF system in the state of Indiana had a negative impact on racially minoritized student enrollment at public four-year universities.

In addition, PBF can exacerbate an already-inequitable funding structure by disadvantaging under-resourced institutions that enroll disproportionately large shares of underserved student groups (Hillman & Corral, 2018). In a study of community colleges in Texas, McKinney and Hagedorn (2017) reported that Black students, Hispanic students, and adult students generated significantly less revenue in a PBF system when compared to their peers. Additional work on the financial implications of PBF policies among four-year institutions found that PBF adoption led to increases in the amount of state funding for selective, research universities but decreases in the amount of state funding for less-selective, non-doctoral universities (Hagood, 2019).

Given widespread concerns about the inequity of PBF policies, several states have altered historical PBF formulas to better account for the equity-oriented issues described above and attempt to improve the likelihood of improvements in access and success among underserved students. These equity-oriented changes frequently include a targeted bonus or premium for graduating historically underserved subgroups of students (e.g., racially minoritized students and adult students) as a way to prevent institutions from restricting access to students who are at the greater risk of not completing their degree (Hillman & Corral, 2018). The limited body of evidence exploring the effectiveness of equity-oriented metrics in PBF systems showed that equity metrics are not statistically related to racially minoritized student enrollment at community colleges and offered mixed evidence on the effect of equity metrics on Black and Hispanic student enrollment at four-year institutions (Gándara & Rutherford, 2018; Kelchen, 2018). While prior research has begun to focus on examining the impact of equity metrics in PBF systems on college enrollment, we know little about how PBF systems or targeted equity metrics impact degree completion among underserved subgroups of interest, such as racially minoritized students and adult students.

Conceptual Framework

The logical rationale associated with *why* PBF policies may affect PBF-adopting institutions' completion outcomes is guided by principal-agent theory (Jensen & Meckling, 1976). In a principal-agent relationship, the principal (e.g., a state government) pays the agent (e.g., a public college or university) to complete a task, such as graduating students. Principal-agent theory rests on the notion that the principal lacks the expertise, time, or necessary skills to complete the required tasks and thereby relies upon the agent to leverage its expertise to carry out the delegated tasks for the principal (Eisenhardt, 1989). In order for performance contracts to be effective, the outcomes of the agent, such as the number of college graduates, should be observable by both the principal and the agent.

One challenge facing state policymakers and institutional decision-makers in principal-agent relationships is the potential for a misalignment between the principal's interests and the agent's interest (Eisenhardt, 1989). In the context of PBF in higher education, information asymmetry may lead to a system in which the principal, such as the state government, is unable to monitor the decisions and day-to-day operations of agents, such as public colleges, in order to evaluate whether those behaviors align with the goals of the principal (Lane & Kivisto, 2008). Consequently, the principal may implement performance-management systems as a way to mitigate potential challenges associated with information asymmetry and general concerns about the agent shirking its obligations.

Although principal-agent theory provides a useful framework through which to explicate the logical rationale of this study, performance management literature also offers important lessons by repeatedly showing that performance-based reforms do not typically work as intended and may actually lead to unintended outcomes (Thompson, 1999), indicating that such reforms fail to account for the complicated structures, functions, and political realities of the public sector (Radin, 2000). As noted previously, recent PBF literature has also shown that PBF-adopting institutions may restrict access to higher education for historically underserved students, such as racially minoritized and adult students, who are deemed less likely to graduate in ways that could serve to exacerbate inequities facing historically underserved subgroups of students (Jones et al., 2017; Ortagus et al., 2020).

PBF policies are designed to positively impact the total number of college graduates, but any state policy designed to alter institutional behavior has the potential to lead to unintended consequences. Specifically, the implementation of PBF systems has been linked to enrolling fewer historically underserved students (e.g., Gandara & Rutherford, 2020; Umbricht et al., 2017), institutional gaming of the system by focusing on shorter-term programs over longer-term degrees (e.g., Hillman et al., 2015), and exacerbating already-existing funding disparities across institution types (e.g., Hagood, 2019). Given that the types of institutions that are underfunded in PBF systems serve a disproportionate share of racially minoritized and adult students, prior work has suggested that PBF policies may create an incentive structure that introduces additional disadvantages for already-disadvantaged students and institutions (Ortagus et al., 2020).

In response to compelling evidence showing the ineffectiveness and inequity of PBF in higher education, numerous states have placed a larger share of state funding at stake and introduced equity-oriented premiums to incentivize underserved student completion (Dougherty & Natow, 2019; Hillman & Corral, 2018; Ortagus et al., 2020). The extent to which PBF policies are able to achieve their intended goals and mitigate (or exacerbate) educational disparities facing historically underserved students will likely vary depending on how the PBF policies are designed.

Data and Methods

To examine the impact of PBF policy design on completions among underserved students, we leveraged a four-year data collection initiative to be able to combine the first comprehensive longitudinal dataset of PBF policy details with a host of federal data sources capturing institutional characteristics and completion outcomes. The resulting analytic sample included the population of degree-granting public colleges and universities between 1997 and 2019. To ensure we identify community colleges offering mostly associate degrees and only a small number of bachelor's degrees as two-year institutions, we classified two- and four-year institutions according to their 2018 Carnegie classification. In addition, we excluded special-focus institutions, graduate-only universities, and military academies, resulting in a final sample consisting of 1,091 two-year institutions and 552 four-year institutions. For additional details on our four-year PBF data collection initiative and data collection protocol, see Authors (2019).

The data for our study include detailed PBF policy information to capture whether any PBF policy existed in a given year, whether the PBF policy was actually funded in a given year, and the percent or "dosage" of state general funds tied to institutional performance. Due to distinctions in policy details (and existence) across institutional levels, we conduct separate analyses for two- and four-year institutions. In Figure 1, we provide maps of the U.S. showing the relative share or dosage of state funds tied to PBF across PBF-adopting states in Fiscal Year 2019. Our dataset also indicates whether equity metrics—such as a bonus or premium for adult student completion or racially minoritized student completion—are included as part of the PBF formula to incentivize the production of certificates, associate degrees, and bachelor's degrees among historically underserved subgroups of students. Figure 1 also shows which PBF-adopting states include adult student metrics or racially minoritized student metrics in Fiscal Year 2019.

See Figure 1. Presence of PBF dosage and PBF equity metrics across states (FY 2019)

The treatment variables used in our analyses vary across specifications. We first examined a treatment variable to account for the relative share or "dosage" of state appropriations tied to institutional performance—a categorical measure distinguishing between high-dosage PBF policies (greater than 10% of funds tied to performance) and low-dosage PBF policies (fewer than 10%). In the Online Appendix, we used a continuous measure, rather than a categorical measure, of dosage to capture the percent of state funds linked to institutional performance. Both treatment variables focused on dosage provide an indicator to capture the percentage of a given state's PBF policy for two-year institutions and a separate indicator to capture the percentage of a given state's PBF policy for four-year institutions within a given fiscal year.[1] The categorical

[1] For states, such as Pennsylvania, in which some colleges are subject to PBF and other colleges are not subject to PBF, we identify those colleges not subject to PBF as allocating 0% of state funds to institutional performance.

treatment variable was coded as a dummy variable in which the "no PBF policy" category represented the reference category across specifications.

Two additional treatment variables consider specific equity-oriented metrics included in PBF policies to incentivize completion outcomes for historically underserved student subgroups in a given year. Specifically, we use a binary indicator to show whether a PBF-adopting state had an equity-oriented premium to incentivize completion outcomes among racially minoritized students (e.g., Black, Hispanic, and Native American students)[2] and a separate binary indicator to indicate whether a PBF-adopting state had an equity-oriented premium to incentivize completion outcomes among adult students (typically defined as 25 years of age or older). Because adult student completion data via IPEDS have only been available since 2012, we restrict treatment in the adult student subgroup analyses to PBF policies that implemented adult student completion incentives in 2014 or later. Similar to the categorical "dosage" treatment variable, we coded the equity-oriented treatment variables as dummy variables in which the "no PBF policy" category represented the reference category across specifications.

The outcomes for this study are the logged number of certificates, associate degrees, and bachelor's degrees produced, with a particular focus on completion outcomes among racially minoritized students and adult students. We focus initially on the completion outcomes of Black, Hispanic, and Native American students to capture racially minoritized student completions because that is how most states define racially minoritized subgroups in their PBF formulas. Given that previous research has identified achievement gaps between Asian students and their white peers (e.g., Pang et al., 2011), we also focus on the completion outcomes of Black, Hispanic, Native American, and Asian students relative to white students. Finally, we examine a separate outcome to capture the logged number of certificates, associate degrees, and bachelor's degrees among adult students. Because our completion outcomes of interest may not be experienced until years after PBF policy adoption, we account for the potential for lagged effects by including various lag periods in our empirical models. In addition to no-lag specifications, the sub-baccalaureate outcomes of certificate production and associate degree production include lags of one, two, and three years. Given that PBF-adopting institutions cannot increase the number of bachelor's degrees awarded during the same year as PBF policy adoption, the outcome of bachelor's degree production includes lags of one, two, three, four, five, and six years.

For all models, we controlled for numerous institution- and state-level characteristics that may influence the ways in which institutions respond to PBF systems and foster degree completion. At the institution level, we controlled for full-time equivalent undergraduate student enrollment (logged), in-state tuition and fees

[2] PBF policies designed to close completion gaps in degree completion by race/ethnicity typically include targeted incentives for Black, Hispanic, and Native American student completions; however, fewer states, such as Hawaii, also include incentives for Native Hawaiian student completions.

(logged), instructional expenditures per student (logged), the proportion of federal grant recipients, the proportion of part-time students, state appropriations per student (logged), and local appropriations per student (logged). At the state level, we controlled for a given state's unemployment rate, proportion of residents who earned a bachelor's degree or higher, per-capita income (logged), and college-aged population size by race and ethnicity (logged). We adjusted all financial variables for inflation using the Consumer Price Index. Table 1 provides descriptive statistics for all covariates and dependent variables used in our dataset, including separate columns for treated institutions (low-dosage, high-dosage, minority metric, adult metric) and those institutions that were not subject to PBF between 1997 and 2019.

See Table 1. Descriptive summary of covariates and dependent variables

Analytic Strategy

To report the average treatment effect of various PBF policies on completion outcomes among historically underserved students, we employed a generalized difference-in-differences (GDiD) approach with two-way fixed effects that allows for treatment adoption across different years in different states. We used the GDiD estimator (δ_1) to compare the difference in outcomes between and untreated observations following the adoption of the PBF policy type of interest and subsequently subtract the difference in outcomes before the adoption of the PBF policy type of interest. Formally, the regression model is represented by the following equation:

$$y_{ij} = \beta_0 + \delta_1 PBF_{ij} + c_i + h_j + Z_{ij} + \varepsilon_{sj}$$

where y_{it} represents the outcome variables described above at institution i in year j. β_0 is an institution-specific intercept. *PBF* is an indicator of the adoption of PBF policy type of interest for institution i in year j. δ_1 is the coefficient of interest. c_i represents the time-invariant institution-level fixed effect, and h_j represents the year fixed effect. By incorporating institution and year fixed effects, the model controlled for potential institution-specific effects over time as well as any time effects that were common across institutions in each year (Allison, 2009). Z_{ij} is a vector of state- and institution-level covariates described in the previous section. Following the recommendations of Cameron and Miller (2015), we estimated robust standard errors and clustered standard errors at the state level for each model.

We estimated separate models to show the impact of various PBF policies on certificate production for public two-year institutions, associate degree production for public two-year institutions, and bachelor's degree production for public four-year institutions. As noted previously, we focused specifically on the impact of varying types of PBF policies on the completion outcomes among subgroups of historically underserved students. The specific PBF policy types were measured as (1) a categorical measure distinguishing between low-dosage and high-dosage PBF policies, (2) a categorical measure indicating the presence of a funded

premium to incentivize completion outcomes among racially minoritized students, or (3) a categorical measure indicating the presence of a funded premium to incentivize completion outcomes among adult students.

In the Online Appendix, we reported results using a continuous measure of dosage and included separate models examining the outcomes of Black students only, Hispanic students only, Native American students only, and Asian students only. In alignment with previous researchers using national treatment groups in PBF studies (Gándara & Rutherford, 2020; Hagood, 2019) and prior literature showing a relatively weak relationship between state characteristics and PBF adoption (Li, 2017; McLendon et al., 2006), we did not include a weighted comparison group among our primary specifications. However, the Online Appendix also includes results from a series of Inverse Propensity Score Weighting (IPSW) specifications, which requires control units with high propensities to be weighted more in regression analyses relative to control units with lower propensities that are not statistically similar to the treated units. We take the appropriate steps to show the overlap between treated and untreated units within each sample (two- or four-year institutions) by including multiple graphs demonstrating the probability densities for PBF adopters and non-adopters before and after IPSW (see the Online Appendix).

Limitations

Although this study represents a considerable advancement in our collective understanding of the extent to which various PBF policies impact historically underserved student groups, several limitations should be noted. First, numerous PBF-adopting states incentivize degree completion among low-income students, academically underprepared students, and other historically underserved subgroups of students, but IPEDS data do not allow for researchers to estimate completion outcomes among these additional historically underserved subgroups of students.

Second, analyses including treatments with time-varying adoptions may bias the estimator to the extent that a traditional GDiD approach may not adequately address potential biases (Goodman-Bacon, 2020). Although the Goodman-Bacon decomposition test can diagnose such a problem, recent developments in econometrics literature suggest that merely diagnosing the problem at hand would not adequately address this limitation in any GDiD approach with staggered adoption and heterogeneous treatment effects (e.g., Sun & Abraham, 2020). Because several PBF policy adoptions during the time period of our study were abandoned and readopted shortly thereafter, we address this limitation directly by conducting four different types of event studies in alignment with the most-recent advances in econometrics literature and outline this approach in the "Robustness Checks" section of the paper.

Third, Asian students are often not included in conversations surrounding completion gaps in higher education, even though Asian Americans and Pacific Islanders comprise a heterogeneous population of

individuals in which some subgroups excel academically and others do not (e.g., Pang et al., 2011). Although we include Asian students in additional models examining certificate and degree production among racially minoritized students, IPEDS data do not allow researchers to disaggregate subgroups of Asian students to be able to capture the diversity and complexity of Asian student achievement.

Fourth, IPEDS began providing completion data for adult students in 2012, which limits the time period we are able to examine when considering the effect of PBF policies or targeted incentives for adult student completion on the number of credentials conferred to adult students. Although we can leverage the entire panel to examine the impact of PBF policies and minority student completion metrics on completion outcomes by race/ethnicity, our findings related to adult student completion are restricted to PBF policies or adult student metrics adopted in 2014 or later and should be interpreted as exploratory in nature.

Results

Within this section, we show the results of our GDiD analyses for both four-year and two-year institutions, focusing initially on four-year institutions (Table 2) before restricting analyses to two-year institutions (Tables 3 and 4). Table 2 includes the outcome of bachelor's degree production, while Tables 3 and 4 include the outcomes of associate degree production and certificate production. We report outcomes capturing the total number and relative share of bachelor's degrees, associate degrees, and certificates among historically underserved college students. The treatment variables and subsamples vary across specifications. After presenting GDiD findings, we offer a series of robustness checks and provide results for four different event study analyses within each figure based on recent developments in econometrics literature (event study results available in the Online Appendix).

GDiD Results

We report GDiD results based upon two primary model specifications to capture the total number (Columns 1 and 2) and relative share (Columns 3 and 4) of completions for the four- and two-year subsamples, respectively. The first specification only includes the treatment of interest and fixed effects (Columns 1 and 3), whereas the second specification includes the treatment of interest and fixed effects while controlling for state- and institution-level covariates (Columns 2 and 4). To account for multiple comparisons, we report Bonferroni-adjusted results at or below a significance level of 0.01.

Table 2 shows the impact of various types of funded PBF policies on the number of bachelor's degrees conferred to historically underserved college students. Although the presence of *any* funded PBF policy did not have a statistically significant effect on bachelor's degree production among racially minoritized or adult students, PBF policies appeared to have targeted effects on historically underserved college students when

considering the design of the PBF policy. For four-year universities, the adoption of a low-dosage PBF system was unrelated to bachelor's degree production among racially minoritized students across all specifications.

The presence of a high-dosage PBF system typically had a negative impact on the total number of racially minoritized students who obtained their bachelor's degree after five or six years (between 13.5 and 16.3 percent), but high-dosage PBF systems had a positive impact on bachelor's degree production for white students after three, four, or five years (between 6.4 and 9.4 percent). Similarly, the adoption of a high-dosage PBF system had a negative impact on the relative share of bachelor's degrees conferred to racially minoritized students decreased (between 2.18 and 3.35 percentage points) after four, five, or six years and a positive impact on the relative share of bachelor's degrees awarded to white students (between 1.96 and 3.76 percentage points) after four, five, or six years. This general pattern holds when we include Asian students when measuring racially minoritized student completions (Table 2) or use a continuous measure of percent PBF as the treatment variable rather than the categorical variable capturing low- or high-dosage PBF policies (see Online Appendix).

When we account for specific equity metrics designed to improve underserved student completion at four-year institutions, we found that PBF systems with incentives for racially minoritized student completion did not have an impact on bachelor's degree production among underserved students. The adoption of a PBF system with targeted incentives for adult student completion increased the number of bachelor's degrees conferred to adult students between 9.1 and 9.4 percent after five years. Findings related to the impact of including either equity-oriented metric were unrelated to the relative share, rather than the total number, of bachelor's degrees produced among the targeted subpopulation of students.

See Table 2. Coefficients for PBF dosage and equity metrics on baccalaureate degrees

For community colleges, the impact of various PBF policies appears to be more complex due to the provision of multiple sub-baccalaureate credentials—associate degrees and certificates. Tables 3 and 4 present the impact of various types of funded PBF policies on the number of associate degrees and certificates conferred to historically underserved college students. We found no relationship between the adoption of *any* funded PBF policy and the number of associate degrees or certificates awarded to racially minoritized or adult students; however, the relative share of associate degrees conferred to adult students at community colleges subject to *any* funded PBF policy increased between 1.49 and 1.54 percentage points after one year of PBF policy adoption.

Although the presence of low- or high-dosage PBF policies was unrelated to the number of associate degrees conferred to racially minoritized students, we found that a high-dosage PBF policy increased the number of associate degrees awarded to adult students by 9.5 percent. After accounting for equity-oriented metrics at community colleges, we found that PBF policies with incentives for racially minoritized student completion

had no effect on the number of associate degrees awarded to racially minoritized students across all specifications, whereas a PBF system with targeted incentives for adult student completion increased the number of associate degrees conferred to adult students by 2.08 percentage points during the first year of PBF policy adoption.

See Table 3. Coefficients for PBF dosage and equity metrics on associate degrees

The implementation of a low-dosage PBF system was unrelated to certificate production among racially minoritized or adult students across all specifications. Similarly, the presence of a high-dosage PBF system did not have an impact on certificate production for racially minoritized or adult students, but high-dosage PBF policies appeared to have a targeted positive impact on the number of certificates awarded to Black or Asian students after two or three years. Once again, the pattern of findings pertaining to the impact of PBF dosage on certificate production is relatively stable when we use a continuous measure of percent PBF as the treatment variable of interest (see Online Appendix). We found that PBF policies with targeted incentives for racially minoritized student or adult student completion typically had no impact on certificate production among racially minoritized or adult students in our preferred specifications. However, our IPSW models in the Online Appendix revealed some positive effects of these targeted PBF incentives on certificate production among racially minoritized students (14.7 percent), driven primarily by certificate production among Black students, and adult students (13.5 percent). Given that these findings are not consistent across models, we emphasize caution in interpreting this particular finding.

See Table 4. Coefficients for PBF dosage and equity metrics on certificates

Robustness Checks

In alignment with recent advances in econometrics literature outlining the challenges associated with time-varying treatment adoption (e.g., Goodman-Bacon, 2020; Sun & Abraham, 2020), we leveraged numerous event studies to improve confidence in our findings given the presence of staggered PBF adoption and heterogeneous treatment effects. Figures 3-8 in the Online Appendix show the results of four different types of event studies in which we drop (1) institutions that were subject to PBF in 1997 and employ the canonical approach by also dropping (2) institutions that were identified as treated but stopped adopting PBF prior to 2019. Specifically, we used *did_imputation*, *eventdd, did_miltiplegt*, and *eventstudyinteract* packages to allow for heterogeneity and dynamics of treatment effects. The corresponding event study results are typically consistent with the GDiD results we report above (see Online Appendix).

Discussion

PBF policies have garnered considerable support from state policymakers and influential advocacy organizations despite a lack of empirical evidence that such policies improve college completion outcomes.

Given that PBF policies appear to be a firmly entrenched feature of higher education finance, the conversation surrounding PBF must shift from whether PBF systems should persist to *how* to design and implement more equitable, effective, and evidence-based PBF policies. In this paper, we consider the wide variation in the design and dosage of PBF policies to examine the impact of various types of PBF policies on the college completion outcomes of historically underserved students.

We found that the presence of any funded PBF policy or a low-dosage PBF policy had no effect on bachelor's degree production among underserved students across specifications. However, high-dosage PBF policies had a negative impact on bachelor's degree production among racially minoritized students but a positive impact on bachelor's degree production among white students. The presence of a minority metric was unrelated to bachelor's degree production among underrepresented students, but an adult metric had a positive impact on the number of bachelor's degrees awarded to adult students after a considerable lag. We also found that high-dosage PBF policies or PBF systems with adult metrics had a positive effect on associate degree production among adult students. In the Online Appendix, we showed that high-dosage PBF policies had a targeted positive impact on certificate production among Black or Asian students.

This research contributes to our understanding of the impacts of various design features of PBF policies on completion outcomes and the heterogeneous effects of PBF policies on underserved subgroups of students. Although we typically found null effects when using a binary indicator capturing the presence of any PBF policy, which aligns with how previous literature measures the impact of PBF, we were able to leverage our comprehensive longitudinal dataset of PBF details in order to identify several targeted effects of various types of PBF policies. Previous work focused specifically on the impact of PBF policies on college access has warned that PBF may create additional barriers for traditionally disadvantaged students (Ortagus et al., 2020). The present study represents the first attempt to extend that argument to consider heterogeneous completion outcomes, indicating that white students may be more likely to earn bachelor's degree under a high-dosage PBF system while racially minoritized students in high-dosage PBF states appear to be less likely to earn a bachelor's degree in the long run.

In other words, PBF policies tying minimal proportions of state funds to institutional performance do not typically have an effect on completion outcomes, but high-dosage PBF policies have divergent effects across race/ethnicity subgroups. These findings complicate our understanding of PBF policies. While prior research on PBF reports null or modest positive effects on degree completion, we complicate this narrative by examining degree completion by underserved subgroups of students and demonstrating that PBF policies, particularly ones that tie a large share of funds to performance, can widen inequalities in degree completion by race/ethnicity. These results represent an additional, and previously unexamined, unintended consequence of PBF in which public colleges eventually graduate more white students while simultaneously graduating fewer racially minoritized students.

This study offers additional implications for how policymakers can design PBF policies to mitigate these inequities in degree completion, as the presence of equity-oriented metrics in PBF formulas can be rather effective in either mitigating the unequal effects of high-dosage PBF (minority student metrics) or even improving completion outcomes, particularly sub-baccalaureate outcomes, among their intended subgroup of students (adult student metrics). Future research can further explore the ways in which the relative share of state funds tied to institutional performance and the specific metrics, including equity incentives, highlighted in PBF formulas affect the intended and unintended consequences of PBF adoption. As federal data continue to improve, further research can explore the impact of equity-oriented metrics on completion outcomes among low-income students, academically underprepared students, and other subgroups of students targeted in PBF formulas.

In addition, the impact of PBF policies should be considered within their larger state context. As one example, Tennessee—one of the most renowned PBF-adopting states—has been extremely active in implementing a host of initiatives focused on improving adult student completion outcomes, including a 2018 initiative titled Tennessee Reconnect that allows adult learners without an associate degree or higher to attend a technical or community college for free. States have also increased their commitment to dual enrollment programs as a way to improve college attainment (e.g., Allen & Dadgar, 2012; An, 2013), adopted or revamped merit aid programs to attract high-achieving students to attend college in their home state (e.g., Zhang & Ness, 2010), and implemented free college programs for eligible students as a way to increase the number of college graduates in a given state (e.g., Perna & Smith, 2020). Future research examining the effects of various PBF policies on college access and student success may seek to directly measure and address the different state contexts under which PBF policies are implemented.

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Figure 1. Presence of PBF dosage and PBF equity metrics across states (FY 2019)

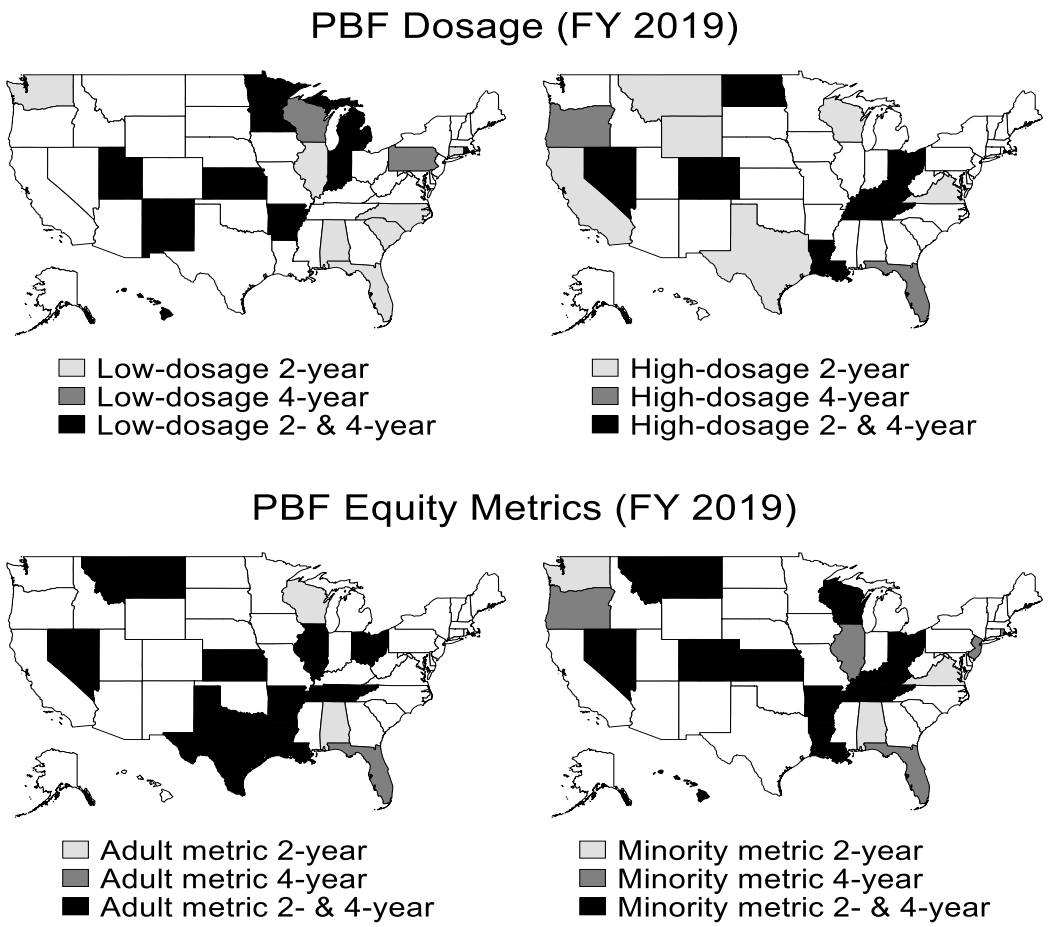

Table 1. Descriptive summary of covariates and dependent variables

	No PBF	Low PBF	High PBF	Minority metric	Adult metric
Panel A: Institution-level covariates					
Full-time enrollment	5930.45	5835.73	6780.25	5903.49	6770.08
Percentage part-time	44.10	47.00	51.67	41.59	47.95
Percent receiving federal grants	42.09	45.55	49.68	48.12	51.73
In-state tuition	3826.46	4129.66	5010.50	5460.78	5714.04
State appropriations per FTE	6129.01	5767.18	4987.06	5554.49	4860.14
Local appropriations per FTE	2038.64	1366.54	2335.12	1515.78	2875.14
Instructional expenditures (in $1,000)	44458.71	41603.07	60191.96	58377.96	62613.26
Panel B: State-level covariates					
18-25 year-old pop with HS diploma	807421.03	617547.62	1086166.34	598193.49	1092735.62
Percent Black	8.38	8.35	8.16	8.37	8.56
Percent Hispanic	7.90	7.64	8.73	8.45	8.55
Percent American Indian or Alaska Native	6.89	7.58	9.74	8.03	7.70
Percent with baccalaureate degree	19.11	19.79	21.20	22.02	20.77
Per-capita income	36229.69	38838.04	46813.30	44890.38	45007.88
Unemployment rate	5.80	5.57	5.08	5.17	5.59
Panel C: Baccalaureate degree outcomes					
Pooled sample	1610.60	1723.80	2289.21	1856.77	2269.92
RM	321.73	271.63	516.28	334.01	636.99
RM (w/Asian)	469.28	343.77	606.96	416.61	769.62
White	1157.84	1413.66	1721.22	1450.97	1513.65
Adults	151.08	237.68	691.81	446.88	714.10
Panel D: Associate degree outcomes					
Pooled sample	472.96	625.05	800.87	559.24	684.59
RM	120.61	165.02	320.15	126.44	251.34
RM (w/Asian)	149.79	190.54	366.37	157.40	279.73
White	335.06	439.11	444.15	403.45	412.10
Adults	63.13	187.60	397.32	258.73	345.38
Panel E: Certificate outcomes					
Pooled sample	292.19	353.02	565.21	373.90	488.51
RM	89.84	103.09	203.42	74.44	168.47
RM (w/Asian)	104.21	116.01	227.87	88.42	184.93
White	202.06	248.19	366.79	304.63	327.31
Adults	51.02	125.19	277.99	169.32	251.26
Number of institutions	25887	6891	1922	2966	2736
Number of observations	1631	920	525	522	462

Note. FTE = full-time equivalent student. RM = racially minoritized.
Standard errors in parentheses

Table 2. Coefficients for PBF dosage and equity metrics on baccalaureate degrees

	One-year Lag				Two-year Lag				Three-year Lag			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A: Any PBF												
Pooled sample	0.004	0.026			0.003	0.021			0.003	0.019		
	(0.016)	(0.011)			(0.016)	(0.012)			(0.017)	(0.013)		
RM	0.050	0.069	-0.197	-0.049	0.049	0.068	-0.179	0.023	0.044	0.062	-0.203	0.025
	(0.030)	(0.031)	(0.336)	(0.231)	(0.026)	(0.029)	(0.318)	(0.222)	(0.028)	(0.031)	(0.298)	(0.224)
RM (w/Asian)	0.039	0.058	-0.329	-0.103	0.038	0.056	-0.292	-0.051	0.037	0.052	-0.270	-0.014
	(0.027)	(0.027)	(0.340)	(0.234)	(0.024)	(0.026)	(0.321)	(0.230)	(0.026)	(0.028)	(0.304)	(0.234)
White	0.018	0.033**	0.329	0.103	0.016	0.027	0.292	0.051	0.016	0.025	0.270	0.014
	(0.013)	(0.010)	(0.340)	(0.234)	(0.015)	(0.011)	(0.321)	(0.230)	(0.016)	(0.013)	(0.304)	(0.234)
Adults	0.022	0.011	-0.103	-0.204	0.030	0.020	0.286	0.137	0.034	0.021	-0.034	-0.348
	(0.010)	(0.009)	(0.375)	(0.386)	(0.014)	(0.012)	(0.352)	(0.407)	(0.018)	(0.016)	(0.429)	(0.469)
Panel B: High dosage												
Pooled sample	-0.013	0.046			-0.006	0.049			0.014	0.054		
	(0.032)	(0.019)			(0.029)	(0.020)			(0.031)	(0.022)		
RM	-0.012	0.045	-1.063	-0.631	-0.022	0.041	-1.236	-0.618	-0.031	0.026	-1.685	-0.846
	(0.053)	(0.046)	(1.004)	(0.745)	(0.048)	(0.047)	(1.015)	(0.788)	(0.056)	(0.051)	(1.041)	(0.820)
RM (w/Asian)	-0.013	0.045	-1.475	-0.829	-0.020	0.042	-1.666	-0.867	-0.017	0.032	-2.123	-1.174
	(0.045)	(0.038)	(0.979)	(0.739)	(0.041)	(0.040)	(0.972)	(0.785)	(0.047)	(0.046)	(0.983)	(0.809)
White	0.032	0.072*	1.475	0.829	0.039	0.070*	1.666	0.867	0.064**	0.076***	2.123	1.174
	(0.025)	(0.025)	(0.979)	(0.739)	(0.023)	(0.024)	(0.972)	(0.785)	(0.022)	(0.021)	(0.983)	(0.809)
Adults	0.037	0.024	0.377	0.141	0.038	0.027	0.213	-0.314	0.068	0.022	0.005	-0.514
	(0.021)	(0.017)	(0.699)	(0.738)	(0.023)	(0.021)	(0.556)	(0.674)	(0.035)	(0.025)	(0.821)	(0.825)
Panel C: Low dosage												
Pooled sample	0.006	0.023			0.004	0.018			0.002	0.017		
	(0.016)	(0.012)			(0.016)	(0.013)			(0.017)	(0.014)		
RM	0.060	0.073	-0.069	0.034	0.057	0.070	-0.065	0.090	0.050	0.064	-0.102	0.080
	(0.032)	(0.033)	(0.356)	(0.248)	(0.027)	(0.030)	(0.331)	(0.232)	(0.028)	(0.032)	(0.303)	(0.229)
RM (w/Asian)	0.046	0.060	-0.160	0.002	0.045	0.058	-0.144	0.034	0.041	0.054	-0.144	0.059
	(0.028)	(0.029)	(0.366)	(0.256)	(0.025)	(0.027)	(0.339)	(0.243)	(0.026)	(0.029)	(0.312)	(0.239)
White	0.016	0.028	0.160	-0.002	0.014	0.023	0.144	-0.034	0.013	0.022	0.144	-0.059
	(0.014)	(0.011)	(0.366)	(0.256)	(0.015)	(0.012)	(0.339)	(0.243)	(0.017)	(0.014)	(0.312)	(0.239)
Adults	0.014	0.005	-0.356	-0.384	0.026	0.017	0.318	0.331	0.024	0.020	-0.046	-0.296
	(0.012)	(0.011)	(0.548)	(0.516)	(0.014)	(0.013)	(0.357)	(0.437)	(0.020)	(0.018)	(0.413)	(0.507)
Panel D: Minority metric												
Pooled sample	0.012	0.028			0.003	0.019			0.002	0.013		

	(0.031)	(0.017)			(0.032)	(0.020)			(0.034)	(0.024)		
RM	0.057	0.062	-0.609	-0.379	0.047	0.058	-0.627	-0.280	0.041	0.051	-0.662	-0.239
	(0.043)	(0.038)	(0.623)	(0.437)	(0.042)	(0.037)	(0.611)	(0.441)	(0.044)	(0.037)	(0.609)	(0.465)
RM (w/Asian)	0.033	0.042	-0.891	-0.594	0.023	0.035	-0.914	-0.527	0.024	0.032	-0.906	-0.478
	(0.035)	(0.030)	(0.664)	(0.455)	(0.037)	(0.031)	(0.652)	(0.471)	(0.039)	(0.034)	(0.657)	(0.504)
White	0.044	0.052**	0.891	0.594	0.038	0.043	0.914	0.527	0.036	0.036	0.906	0.478
	(0.023)	(0.017)	(0.664)	(0.455)	(0.026)	(0.021)	(0.652)	(0.471)	(0.031)	(0.025)	(0.657)	(0.504)
Panel E: Adult treatment												
Adults	0.048	0.031	-0.162	-0.442	0.045	0.024	-0.461	-1.000	0.005	-0.007	-0.674	-1.306
	(0.036)	(0.015)	(0.557)	(0.690)	(0.044)	(0.028)	(0.758)	(0.922)	(0.028)	(0.018)	(0.324)	(0.593)
Two-way fixed effects	X	X	X	X	X	X	X	X	X	X	X	X
Covariates		X		X		X		X		X		X

Note. RM = racially minoritized. Standard errors in parentheses.
* p<.01, ** p<.005, *** p<.001

Table 2. *continued*

	Four-year Lag				Five-year Lag				Six-year Lag			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A: Any PBF												
Pooled sample	0.000	0.013			-0.008	0.001			-0.014	-0.006		
	(0.018)	(0.015)			(0.020)	(0.018)			(0.020)	(0.019)		
RM	0.038	0.054	-0.164	0.030	0.023	0.034	-0.031	0.105	0.022	0.034	0.140	0.233
	(0.029)	(0.032)	(0.293)	(0.230)	(0.032)	(0.035)	(0.325)	(0.258)	(0.034)	(0.036)	(0.391)	(0.283)
RM (w/Asian)	0.033	0.047	-0.213	0.009	0.021	0.031	-0.067	0.077	0.024	0.034	0.149	0.235
	(0.028)	(0.029)	(0.307)	(0.244)	(0.030)	(0.033)	(0.347)	(0.274)	(0.031)	(0.034)	(0.427)	(0.302)
White	0.008	0.016	0.213	-0.009	-0.005	0.001	0.067	-0.077	-0.014	-0.010	-0.149	-0.235
	(0.019)	(0.016)	(0.307)	(0.244)	(0.022)	(0.020)	(0.347)	(0.274)	(0.022)	(0.021)	(0.427)	(0.302)
Adults	0.005	0.000	-1.280	-1.413	0.021	0.021	0.230	0.395	-0.061	-0.059*	-1.438	-0.889
	(0.017)	(0.019)	(0.702)	(0.705)	(0.024)	(0.021)	(0.457)	(0.480)	(0.036)	(0.022)	(0.593)	(0.539)
Panel B: High dosage												
Pooled sample	0.009	0.052			-0.005	0.046			-0.017	0.025		
	(0.027)	(0.022)			(0.026)	(0.022)			(0.025)	(0.025)		
RM	-0.089	-0.021	-2.538*	-1.621	-0.135*	-0.050	-3.350***	-2.325***	-0.163***	-0.060	-3.392***	-2.181***
	(0.052)	(0.050)	(0.904)	(0.722)	(0.048)	(0.056)	(0.718)	(0.661)	(0.043)	(0.058)	(0.695)	(0.596)
RM (w/Asian)	-0.062	-0.007	-2.939**	-1.963*	-0.100	-0.030	-3.762***	-2.695***	-0.116*	-0.030	-3.610***	-2.384**
	(0.047)	(0.046)	(0.843)	(0.708)	(0.043)	(0.050)	(0.680)	(0.698)	(0.041)	(0.058)	(0.668)	(0.705)
White	0.066**	0.085***	2.939**	1.963*	0.066*	0.094***	3.762***	2.695***	0.044	0.056	3.610***	2.384**
	(0.021)	(0.020)	(0.843)	(0.708)	(0.024)	(0.020)	(0.680)	(0.698)	(0.022)	(0.021)	(0.668)	(0.705)
Adults	0.044	0.012	-0.064	-0.481	0.124***	0.136**	2.457**	2.066				
	(0.035)	(0.031)	(0.977)	(0.928)	(0.024)	(0.039)	(0.834)	(1.074)				
Panel C: Low dosage												
Pooled sample	0.000	0.012			-0.008	0.000			-0.014	-0.006		
	(0.018)	(0.015)			(0.020)	(0.018)			(0.020)	(0.019)		
RM	0.043	0.056	-0.087	0.074	0.025	0.035	0.012	0.128	0.022	0.034	0.141	0.224
	(0.029)	(0.032)	(0.296)	(0.233)	(0.032)	(0.035)	(0.326)	(0.264)	(0.034)	(0.036)	(0.391)	(0.288)
RM (w/Asian)	0.036	0.048	-0.124	0.062	0.022	0.032	-0.018	0.103	0.024	0.034	0.150	0.225
	(0.028)	(0.030)	(0.311)	(0.246)	(0.030)	(0.033)	(0.348)	(0.280)	(0.031)	(0.034)	(0.427)	(0.307)
White	0.006	0.014	0.124	-0.062	-0.006	0.000	0.018	-0.103	-0.014	-0.010	-0.150	-0.225
	(0.020)	(0.017)	(0.311)	(0.246)	(0.022)	(0.020)	(0.348)	(0.280)	(0.022)	(0.021)	(0.427)	(0.307)
Adults	-0.003	-0.002	-1.503	-1.603	0.005	-0.000	-0.136	0.082	-0.061	-0.059*	-1.438	-0.889
	(0.018)	(0.019)	(0.703)	(0.727)	(0.024)	(0.019)	(0.400)	(0.486)	(0.036)	(0.022)	(0.593)	(0.539)
Panel D: Minority metric												

Pooled sample	-0.008	0.003			-0.022	-0.012			-0.022	-0.016		
	(0.037)	(0.029)			(0.041)	(0.034)			(0.033)	(0.027)		
RM	0.026	0.039	-0.698	-0.276	0.022	0.034	-0.512	-0.185	0.031	0.041	-0.390	-0.088
	(0.050)	(0.039)	(0.640)	(0.500)	(0.052)	(0.042)	(0.652)	(0.507)	(0.046)	(0.040)	(0.589)	(0.454)
RM (w/Asian)	0.014	0.024	-0.913	-0.498	0.013	0.021	-0.684	-0.381	0.025	0.032	-0.520	-0.250
	(0.046)	(0.037)	(0.694)	(0.538)	(0.048)	(0.041)	(0.691)	(0.530)	(0.043)	(0.040)	(0.620)	(0.471)
White	0.016	0.017	0.913	0.498	-0.001	0.001	0.684	0.381	-0.007	-0.006	0.520	0.250
	(0.037)	(0.033)	(0.694)	(0.538)	(0.040)	(0.037)	(0.691)	(0.530)	(0.031)	(0.030)	(0.620)	(0.471)
Panel E: Adult treatment												
Adults	0.010	0.007	-1.027	-0.864	0.091***	0.094***	0.503	0.345				
	(0.023)	(0.027)	(0.581)	(0.730)	(0.016)	(0.013)	(0.739)	(0.553)				
Two-way fixed effects	X	X	X	X	X	X	X	X	X	X	X	X
Covariates		X		X		X		X		X		X

Note. RM = racially minoritized. Standard errors in parentheses.
* p<.01, ** p<.005, *** p<.001

Table 3. Coefficients for PBF dosage and equity metrics on associate degrees

	No Lag				One-year Lag				Two-year Lag				Three-year Lag			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A: Any PBF																
Pooled sample	-0.009	-0.008			-0.028	-0.021			-0.028	-0.018			-0.036	-0.017		
	(0.032)	(0.026)			(0.037)	(0.032)			(0.035)	(0.031)			(0.035)	(0.028)		
RM	0.016	0.015	0.072	-0.062	0.011	0.017	-0.249	-0.296	0.012	0.014	-0.246	-0.352	0.012	0.018	-0.209	-0.292
	(0.041)	(0.041)	(0.685)	(0.513)	(0.044)	(0.044)	(0.821)	(0.608)	(0.042)	(0.042)	(0.750)	(0.541)	(0.041)	(0.040)	(0.647)	(0.442)
RM (w/Asian)	-0.001	-0.002	0.008	-0.123	-0.007	0.001	-0.168	-0.217	-0.007	-0.003	-0.105	-0.235	-0.010	-0.004	-0.091	-0.194
	(0.041)	(0.040)	(0.690)	(0.497)	(0.043)	(0.042)	(0.769)	(0.561)	(0.040)	(0.040)	(0.700)	(0.510)	(0.038)	(0.036)	(0.616)	(0.428)
White	-0.011	-0.007	-0.008	0.123	-0.017	-0.009	0.168	0.217	-0.017	-0.005	0.105	0.235	-0.025	-0.005	0.091	0.194
	(0.028)	(0.025)	(0.690)	(0.497)	(0.024)	(0.023)	(0.769)	(0.561)	(0.023)	(0.022)	(0.700)	(0.510)	(0.026)	(0.021)	(0.616)	(0.428)
Adults	0.054	0.037	1.160	1.317	0.005	0.010	1.491*	1.535**	0.008	0.008	0.703	0.887	-0.011	-0.009	-0.113	0.032
	(0.027)	(0.023)	(0.660)	(0.661)	(0.037)	(0.020)	(0.510)	(0.472)	(0.035)	(0.024)	(0.526)	(0.477)	(0.033)	(0.026)	(0.534)	(0.449)
Panel B: High dosage																
Pooled sample	0.084	0.078			0.040	0.040			0.052	0.064			0.051	0.081		
	(0.073)	(0.049)			(0.090)	(0.066)			(0.092)	(0.070)			(0.095)	(0.073)		
RM	0.026	0.024	-0.015	-0.166	-0.007	0.009	-0.796	-0.618	0.016	0.028	-0.609	-0.536	0.016	0.037	-0.593	-0.500
	(0.074)	(0.057)	(1.759)	(1.239)	(0.087)	(0.066)	(2.255)	(1.612)	(0.085)	(0.065)	(2.217)	(1.581)	(0.092)	(0.070)	(2.269)	(1.540)
RM (w/Asian)	0.054	0.051	0.028	-0.090	0.031	0.043	-0.431	-0.232	0.052	0.066	-0.244	-0.132	0.051	0.074	-0.212	-0.072
	(0.073)	(0.055)	(1.864)	(1.321)	(0.082)	(0.062)	(2.251)	(1.606)	(0.079)	(0.060)	(2.206)	(1.582)	(0.086)	(0.066)	(2.303)	(1.585)
White	0.063	0.060	-0.028	0.090	0.044	0.042	0.431	0.232	0.051	0.060	0.244	0.132	0.048	0.074	0.212	0.072
	(0.044)	(0.034)	(1.864)	(1.321)	(0.040)	(0.033)	(2.251)	(1.606)	(0.040)	(0.035)	(2.206)	(1.582)	(0.040)	(0.035)	(2.303)	(1.585)
Adults	0.112	0.095*	1.466	1.473	0.024	0.047	1.197	1.027	0.042	0.064	0.274	0.476	0.008	0.024	-0.917	-0.565
	(0.045)	(0.033)	(0.707)	(0.593)	(0.059)	(0.024)	(0.627)	(0.527)	(0.059)	(0.030)	(0.705)	(0.581)	(0.062)	(0.041)	(0.713)	(0.592)
Panel C: Low dosage																
Pooled sample	-0.037	-0.033			-0.045	-0.036			-0.046	-0.035			-0.051	-0.033		
	(0.026)	(0.027)			(0.028)	(0.030)			(0.027)	(0.028)			(0.030)	(0.025)		
RM	0.014	0.012	0.099	-0.030	0.015	0.019	-0.111	-0.217	0.011	0.011	-0.167	-0.314	0.012	0.014	-0.142	-0.257
	(0.045)	(0.049)	(0.640)	(0.495)	(0.045)	(0.049)	(0.673)	(0.522)	(0.041)	(0.045)	(0.618)	(0.477)	(0.040)	(0.042)	(0.529)	(0.399)
RM (w/Asian)	-0.018	-0.018	0.003	-0.132	-0.016	-0.010	-0.102	-0.214	-0.019	-0.017	-0.075	-0.257	-0.020	-0.017	-0.071	-0.215
	(0.043)	(0.048)	(0.613)	(0.463)	(0.043)	(0.047)	(0.624)	(0.490)	(0.039)	(0.044)	(0.575)	(0.465)	(0.036)	(0.039)	(0.498)	(0.399)

White	-0.034	-0.027	-0.003	0.132	-0.033	-0.022	0.102	0.214	-0.032	-0.019	0.075	0.257	-0.038	-0.018	0.071	0.215
	(0.026)	(0.026)	(0.613)	(0.463)	(0.024)	(0.025)	(0.624)	(0.490)	(0.022)	(0.023)	(0.575)	(0.465)	(0.026)	(0.021)	(0.498)	(0.399)
Adults	0.015	-0.001	0.963	1.217	-0.004	-0.007	1.634*	1.764**	-0.006	-0.013	0.875	1.038	-0.017	-0.018	0.121	0.190
	(0.027)	(0.020)	(0.752)	(0.808)	(0.029)	(0.021)	(0.591)	(0.517)	(0.027)	(0.021)	(0.594)	(0.553)	(0.028)	(0.026)	(0.494)	(0.445)
Panel D: Minority metric																
Pooled sample	-0.088	-0.066			-0.104	-0.072			-0.105	-0.072			-0.103	-0.065		
	(0.037)	(0.035)			(0.044)	(0.043)			(0.045)	(0.047)			(0.046)	(0.048)		
RM	-0.023	-0.020	-0.901	-0.915	-0.019	-0.008	-0.793	-0.738	-0.021	-0.014	-0.683	-0.622	-0.008	-0.001	-0.465	-0.352
	(0.056)	(0.051)	(1.246)	(0.860)	(0.061)	(0.056)	(1.355)	(0.930)	(0.062)	(0.061)	(1.370)	(0.937)	(0.062)	(0.061)	(1.387)	(0.927)
RM (w/Asian)	-0.061	-0.057	-1.090	-1.104	-0.055	-0.045	-0.885	-0.839	-0.058	-0.051	-0.809	-0.783	-0.049	-0.044	-0.630	-0.586
	(0.045)	(0.045)	(1.159)	(0.740)	(0.048)	(0.048)	(1.224)	(0.784)	(0.048)	(0.053)	(1.242)	(0.821)	(0.049)	(0.056)	(1.255)	(0.827)
White	-0.048	-0.028	1.090	1.104	-0.067	-0.039	0.885	0.839	-0.070	-0.044	0.809	0.783	-0.072	-0.042	0.630	0.586
	(0.043)	(0.034)	(1.159)	(0.740)	(0.044)	(0.038)	(1.224)	(0.784)	(0.047)	(0.043)	(1.242)	(0.821)	(0.048)	(0.046)	(1.255)	(0.827)
Panel E: Adult treatment																
Adults	0.060	0.071	1.789	2.084*	0.059	0.060	1.666	1.193	0.074	0.082	0.170	0.208	0.042	0.042	-1.178	-0.742
	(0.067)	(0.043)	(0.896)	(0.717)	(0.068)	(0.031)	(0.728)	(0.692)	(0.060)	(0.033)	(0.941)	(0.815)	(0.049)	(0.030)	(1.000)	(1.005)
Two-way fixed effects	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Covariates		X		X		X		X		X		X		X		X

Note. RM = racially minoritized. Standard errors in parentheses.
* p<.01, ** p<.005, *** p<.001

Table 4. Coefficients for PBF dosage and equity metrics on certificates

	No Lag				One-year Lag				Two-year Lag				Three-year Lag			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A: Any PBF																
Pooled sample	0.009	0.010			-0.028	-0.022			-0.031	-0.025			-0.056	-0.050		
	(0.039)	(0.038)			(0.046)	(0.041)			(0.049)	(0.045)			(0.055)	(0.049)		
RM	0.027	0.027	0.382	0.299	-0.005	-0.002	0.181	0.180	-0.008	-0.008	0.344	0.317	-0.028	-0.033	0.346	0.147
	(0.051)	(0.054)	(0.664)	(0.539)	(0.054)	(0.048)	(0.754)	(0.529)	(0.052)	(0.044)	(0.678)	(0.482)	(0.055)	(0.046)	(0.629)	(0.456)
RM (w/Asian)	0.020	0.021	0.378	0.311	-0.001	0.002	0.325	0.293	-0.009	-0.011	0.470	0.384	-0.036	-0.041	0.408	0.152
	(0.045)	(0.048)	(0.626)	(0.525)	(0.046)	(0.043)	(0.665)	(0.500)	(0.046)	(0.040)	(0.610)	(0.475)	(0.049)	(0.040)	(0.589)	(0.467)
White	0.001	0.004	-0.378	-0.311	-0.027	-0.021	-0.325	-0.293	-0.035	-0.026	-0.470	-0.384	-0.056	-0.050	-0.408	-0.152
	(0.039)	(0.038)	(0.626)	(0.525)	(0.042)	(0.038)	(0.665)	(0.500)	(0.046)	(0.042)	(0.610)	(0.475)	(0.051)	(0.047)	(0.589)	(0.467)
Adults	0.040	0.024	0.951	0.960	-0.062	-0.052	1.148	1.335	-0.022	-0.012	0.528	0.847	-0.003	-0.003	1.293	1.493
	(0.041)	(0.041)	(0.841)	(0.798)	(0.043)	(0.034)	(0.779)	(0.739)	(0.043)	(0.037)	(0.826)	(0.818)	(0.044)	(0.043)	(0.944)	(0.838)
Panel B: High dosage																
Pooled sample	0.182	0.176			0.104	0.116			0.106	0.132			0.085	0.116		
	(0.099)	(0.091)			(0.099)	(0.095)			(0.097)	(0.094)			(0.096)	(0.100)		
RM	0.154	0.148	0.740	0.430	0.071	0.089	-0.349	-0.378	0.080	0.098	0.039	0.030	0.023	0.035	0.158	0.080
	(0.109)	(0.096)	(1.403)	(1.018)	(0.108)	(0.099)	(1.946)	(1.345)	(0.103)	(0.096)	(1.881)	(1.353)	(0.095)	(0.093)	(1.872)	(1.339)
RM (w/Asian)	0.158	0.154	0.546	0.298	0.093	0.108	-0.188	-0.239	0.091	0.107	0.248	0.207	0.036	0.048	0.312	0.247
	(0.104)	(0.091)	(1.404)	(1.032)	(0.100)	(0.093)	(1.797)	(1.248)	(0.093)	(0.087)	(1.745)	(1.259)	(0.086)	(0.085)	(1.735)	(1.271)
White	0.154	0.155	-0.546	-0.298	0.100	0.117	0.188	0.239	0.095	0.127	-0.248	-0.207	0.071	0.106	-0.312	-0.247
	(0.112)	(0.100)	(1.404)	(1.032)	(0.111)	(0.101)	(1.797)	(1.248)	(0.110)	(0.099)	(1.745)	(1.259)	(0.109)	(0.106)	(1.735)	(1.271)
Adults	0.093	0.067	0.914	0.691	-0.034	-0.019	0.718	1.087	0.020	0.042	0.154	0.964	0.046	0.050	0.137	1.004
	(0.068)	(0.056)	(1.069)	(1.009)	(0.058)	(0.035)	(0.898)	(0.844)	(0.058)	(0.040)	(0.863)	(0.868)	(0.059)	(0.053)	(1.553)	(1.404)
Panel C: Low dosage																
Pooled sample	-0.045	-0.040			-0.062	-0.056			-0.061	-0.058			-0.081	-0.077		
	(0.048)	(0.047)			(0.054)	(0.047)			(0.055)	(0.049)			(0.059)	(0.051)		
RM	-0.013	-0.010	0.271	0.260	-0.025	-0.025	0.317	0.319	-0.028	-0.031	0.412	0.378	-0.037	-0.044	0.379	0.158
	(0.063)	(0.065)	(0.653)	(0.525)	(0.060)	(0.054)	(0.600)	(0.429)	(0.056)	(0.049)	(0.551)	(0.399)	(0.058)	(0.048)	(0.549)	(0.413)
RM (w/Asian)	-0.023	-0.019	0.326	0.314	-0.026	-0.025	0.458	0.425	-0.031	-0.036	0.519	0.421	-0.048	-0.056	0.425	0.136
	(0.055)	(0.057)	(0.602)	(0.512)	(0.052)	(0.049)	(0.543)	(0.436)	(0.049)	(0.045)	(0.516)	(0.431)	(0.051)	(0.043)	(0.530)	(0.450)

White	-0.047	-0.042	-0.326	-0.314	-0.060	-0.055	-0.458	-0.425	-0.063	-0.059	-0.519	-0.421	-0.078	-0.075	-0.425	-0.136
	(0.045)	(0.045)	(0.602)	(0.512)	(0.050)	(0.046)	(0.543)	(0.436)	(0.053)	(0.049)	(0.516)	(0.431)	(0.056)	(0.050)	(0.530)	(0.450)
Adults	0.005	-0.004	0.976	1.135	-0.076	-0.068	1.365	1.450	-0.040	-0.033	0.685	0.802	-0.018	-0.017	1.649	1.627
	(0.048)	(0.046)	(1.055)	(1.025)	(0.042)	(0.040)	(0.903)	(0.846)	(0.042)	(0.040)	(0.950)	(0.933)	(0.043)	(0.045)	(0.899)	(0.825)
Panel D: Minority metric																
Pooled sample	0.119	0.144			0.048	0.071			0.029	0.043			-0.001	0.009		
	(0.076)	(0.076)			(0.100)	(0.097)			(0.102)	(0.102)			(0.102)	(0.099)		
RM	0.144	0.152	-0.422	-0.385	0.080	0.084	-0.293	-0.272	0.060	0.049	-0.201	-0.190	0.030	0.010	-0.109	-0.120
	(0.090)	(0.085)	(1.177)	(0.818)	(0.111)	(0.106)	(1.222)	(0.857)	(0.109)	(0.107)	(1.187)	(0.834)	(0.108)	(0.104)	(1.156)	(0.817)
RM (w/Asian)	0.129	0.134	-0.283	-0.295	0.073	0.075	-0.059	-0.140	0.051	0.036	-0.011	-0.141	0.017	-0.008	0.105	-0.097
	(0.075)	(0.074)	(1.055)	(0.718)	(0.093)	(0.092)	(1.087)	(0.758)	(0.090)	(0.090)	(1.088)	(0.808)	(0.089)	(0.087)	(1.094)	(0.841)
White	0.135	0.158	0.283	0.295	0.068	0.089	0.059	0.140	0.042	0.056	0.011	0.141	0.009	0.016	-0.105	0.097
	(0.073)	(0.074)	(1.055)	(0.718)	(0.091)	(0.091)	(1.087)	(0.758)	(0.095)	(0.098)	(1.088)	(0.808)	(0.094)	(0.095)	(1.094)	(0.841)
Panel E: Adult treatment																
Adults	0.072	0.054	1.227	1.458	-0.015	-0.042	1.273	1.483	0.023	0.033	0.177	1.269	0.029	0.011	0.552	1.067
	(0.078)	(0.066)	(1.461)	(1.204)	(0.068)	(0.041)	(0.791)	(0.683)	(0.058)	(0.043)	(1.196)	(1.077)	(0.060)	(0.051)	(1.625)	(1.799)
Two-way fixed effects	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Covariates		X		X		X		X		X		X		X		X

Note. RM = racially minoritized. Standard errors in parentheses.
* p<.01, ** p<.005, *** p<.001