

Semesters or Quarters? The Effect of the Academic Calendar on Postsecondary Student Outcomes *

Valerie Bostwick
Kansas State University

vkpostwick@gmail.com

Stefanie Fischer
Cal Poly State University,
San Luis Obispo, Monash
University and IZA

sjfische@calpoly.edu

Matthew Lang
University of California,
Riverside

matthew.lang@ucr.edu

August 28, 2020

Abstract

There exists a long-standing debate in higher education on which academic calendar is optimal. Using panel data on the near universe of four-year nonprofit institutions and leveraging quasi-experimental variation in calendars across institutions and years, we show switching from quarters to semesters negatively impacts on-time graduation rates. Event study analyses show the negative effects persist beyond the transition. Using transcript data, we replicate this analysis at the student-level and investigate possible mechanisms. Shifting to a semester: (1) lowers first-year grades; (2) decreases the probability of enrolling in a full course load; and (3) delays the timing of major choice.

JEL Codes: I23

Keywords: Postsecondary Graduation Rates, Education Policy, Academic Calendar, Postsecondary Retention

*This paper has benefited from helpful comments from Peter Bergman, Jeff Denning, Pierre Mouganie, Bruce Weinberg, and participants at the following conferences and seminars: American Education Finance and Policy Conference in Portland, OR, Pacific Northwest Labor Day at University of Washington, Southern Economic Association Annual Meetings, Hawaii Applied Micro One-Day Conference, Society of Labor Economists Annual Meeting (Arlington), University of California Santa Barbara, Kansas State University, The Kansas City Federal Reserve Bank, Ohio State University, University of Kansas, UC Santa Cruz, Monash University, CU Denver, The College of William and Mary, UNC Chapel Hill Public Policy, Seattle University and University of Melbourne Applied Institute.

1 Introduction

There has been a long-standing debate in higher education about which academic calendar is optimal: semesters or quarters. While semesters have always been the predominant calendar, recently a large number of institutions have converted from quarters to semesters making quarters increasingly rare. These conversions have been widespread, directly affecting nearly 2 million students at 132 colleges and universities since 1987.¹ Many of these calendar adoptions are the result of state-level mandates, whereby all schools within a state system are required to convert to semesters within a specified time frame. Among schools that remain on a quarter calendar, the possibility of switching to semesters is a hotly debated issue. One such school, the University of California Los Angeles, has actively considered a calendar switch for decades. Twice since 1985, the school has moved to make the change to semesters but both times was blocked by faculty opposition. In March 2019, Chancellor Block spoke in favor of a switch to semesters stating, "The quarter system, in my view, is a failed system", in an attempt to gain support from students and faculty (Warner and Hanczor, 2018; Fitzmorris, 2019; Morris, 2019). State and university officials often assert that the reasons for adopting semesters are to improve students' academic outcomes and to increase their odds of securing summer internships; yet surprisingly little evidence exists on the effects of the academic calendar on these postsecondary student outcomes.

A priori, the effects of the calendar system on student outcomes are ambiguous. A semester calendar has longer terms, requires one to take more courses per term to remain a full-time student, and operates over a different set of months than a quarter calendar. As such, semesters may be more conducive to learning and/or degree attainment as there is a longer time horizon to master complex material. They may also provide more summer internship opportunities due to their earlier end dates in the spring term. On the other hand, it is possible that the longer terms unique to semesters may allow one to become complacent or procrastinate between exams, leading to poorer performance. Moreover, the greater number of simultaneous courses in a semester term may be difficult

¹These statistics are the authors' calculations and are generated from the Integrated Postsecondary Education Data System (IPEDS).

to juggle and/or pose scheduling challenges (Section 2 provides a more complete discussion of the costs and benefits associated with each calendar).

This paper provides the first comprehensive, at-scale analysis of this policy change using two complementary datasets: an institution-level panel of the near universe of four-year nonprofit institutions and student-level transcript data from one of the largest state public education systems. We leverage quasi-experimental variation in the timing of the adoption of semesters across institutions to causally examine the effects of switching from a quarter calendar to a semester calendar. We implement this strategy for the near universe of nonprofit, four-year, US colleges and universities, which come from the Integrated Postsecondary Education Data System (IPEDS), and find that switching to semesters reduces on-time graduation rates by 3.7 percentage points (pp). An additional event study analysis reveals that the negative effect of a semester calendar on four-year graduation rates begins to emerge in the partially treated cohorts—those students who were in their second, third, or fourth year of enrollment when the semester calendar was adopted—and grows larger and remains negative for many years thereafter among fully treated cohorts of students. This suggests that the negative impact on graduation rates is not a temporary consequence of the transition between calendars, but is rather due to some fixed characteristic of the semester calendar itself.

We further explore the potential mechanisms for this negative effect using detailed administrative transcript data from the Ohio Longitudinal Data Archive (OLDA).² The public university system in Ohio is one of the largest comprehensive postsecondary systems in the nation—serving over 300,000 students annually at 13 four-year universities and 24 regional four-year branch campuses—and provides the ideal context for this study as nearly half of the system has made the conversion from quarters to semesters since 1999. The student-level analysis of these transcript data confirms that switching from quarters to semesters decreases the probability of on-time grad-

²The Ohio Longitudinal Data Archive is a project of the Ohio Education Research Center (oerc.osu.edu) and provides researchers with centralized access to administrative data. The OLDA is managed by The Ohio State University's Center for Human Resource Research (chrr.osu.edu) in collaboration with Ohio's state workforce and education agencies (ohioanalytics.gov), with those agencies providing oversight and funding. For information on OLDA sponsors, see <http://chrr.osu.edu/projects/ohio-longitudinal-data-archive>.

uation. The mechanism analysis reveals that students on a semester calendar are more likely to earn a GPA that is below the 2.0 threshold for academic probation, are less likely to enroll in the recommended number of credits per year, and that these students are delaying the timing of major choice. These findings suggest that the longer terms and higher number of courses per term associated with a semester calendar are likely driving the estimated decline in on-time graduation.

Finally, we investigate the possibility that these negative academic outcomes are offset by an increase in summer internship employment—a benefit of semesters often touted by university administrators—by linking state unemployment records to the administrative transcript files. This analysis does not provide compelling evidence that the switch to a semester calendar improves summer employment in the types of jobs that are most likely to represent internship employment.³

To the best of our knowledge, this is the first paper to examine the effects of quasi-experimental changes in academic calendars on postsecondary students' outcomes, to analyze the longer-term effects of these changes, and the first to address this question at a large scale using the near universe of institutions in the US. The few existing case studies on university calendar changes focus on a small subset of schools and compare outcomes at those schools in the one to two year window before and after a calendar switch (Day, 1987; Matzelle et al., 1995). Gibbens et al. (2015) show that student performance in Biology coursework fell after the University of Minnesota changed from quarters to semesters in the fall of 1999. Coleman et al. (1984) find that students on semesters take fewer credit hours and are more likely to withdraw from courses, but this analysis is limited to ten universities and only three years of data. These studies provide some preliminary evidence that the conversion from quarters to semesters might be academically harmful to certain subsets of students. We add to these findings by providing a well-identified analysis of the short- and longer-term effects of a calendar conversion on student outcomes at a national scale, as well as a detailed, student-level view of the potential underlying mechanisms.

This study also relates to a literature aimed at understanding the optimal way to structure

³Because state unemployment records do not indicate whether a job is an internship, we use a proxy and define internship-type jobs as employment in non-retail and non-food service industries using the North American Industry Classification System code.

schools and academic calendars. In recent years, economists have documented the effects of several education calendar reforms on student outcomes including: the year-round academic calendar (Depro and Rouse, 2015; McMullen and Rouse, 2012; Graves, 2010); the four-day school week (Fischer and Argyle, 2018; Anderson and Walker, 2015); and adjusting school start times (Bostwick, 2018; Cortes et al., 2012; Hinrichs, 2011; Edwards, 2012; Carrell et al., 2011).⁴ For the most part, these reforms have been adopted at the elementary and secondary level in response to rapid enrollment growth and overcrowded schools. Higher education institutions face similar issues but much less is known about the optimal way to structure universities and postsecondary academic calendars.

More generally, we add to a growing body of work focused on understanding postsecondary graduation outcomes. Fewer than half of students seeking to obtain a bachelor's degree do so within four years of initial enrollment. In the 2010 entering cohort of college freshmen, only 60% had completed a bachelor's degree by the end of their sixth year. These low completion rates and the high average time-to-degree impose both direct and indirect costs on students and have thus compelled a growing body of literature aimed at better understanding the causes of these less-than-ideal graduation outcomes. One hypothesis is that student-level factors such as socioeconomic status and preparation are key contributors (e.g., Bailey and Dynarski, 2011; Belley and Lochner, 2007; Carneiro and Heckman, 2002). Another line of inquiry investigates whether institution-level characteristics such as financial aid availability and resources per student play an important role (e.g., Denning et al., 2019; Deming and Walters, 2017; Cohodes and Goodman, 2014; Bound et al., 2012, 2010; Bound and Turner, 2007; Singell, 2004).⁵ We contribute to this line of research by considering how an institution's academic calendar affects graduation rates, and investigate the underlying mechanisms.

The findings in this paper are particularly timely and policy relevant as entire university systems are currently considering switching from quarters to semesters. Contrary to the hopes of the many

⁴For more details on these reforms see Jacob and Rockoff (2011).

⁵Denning et al. (2020) show that the recent upward trend in graduation rates is correlated with standards for degree receipt. They rule out student and institutional characteristics as explanations.

universities that have made the calendar shift, we find that this change leads to significantly worse academic outcomes—implying substantial economic costs for the affected students—on top of the considerable costs to the universities of enacting the policy. While a solution to the negative impact of semesters requires much further study, our analysis of the underlying mechanisms suggests that policies aimed at increasing scheduling flexibility and easing the transition of freshmen into the demands of college study may prove effective.

The remainder of the paper is organized as follows. Section 2 provides a background of the two academic calendars and includes a discussion of the potential costs and benefits associated with each. Section 3 presents the institution-level analysis: the data; the empirical framework including a discussion of the identifying assumption; and the results. Section 4 presents the individual-level analysis: a replication of the main results; a mechanism analysis; and employment findings. Section 5 concludes.

2 Background

While semesters have always been more common, quarters were first introduced to the US in 1891 at the University of Chicago. When the school was founded, the organizers decided to make it operational year round and divide it into four terms instead of the then-traditional two terms (Malone, 1946). In 1930, 75% of US institutions reported being on a semester calendar and 22% on quarters. During the 1960s several large statewide educational systems switched from semesters to quarters to accommodate enrollment booms caused by the baby boomers; e.g., most notably the University of California system. However, starting in 1970 this trend reversed. In 1970, 70% of schools operated on semesters (Day, 1987), but by 1990 that share had increased to 87%. Many of the recent calendar shifts occurred in the late 1990s, but some universities such as the University System of Ohio converted more recently (2012), and many schools in the California State University system and University of California system are considering switching in the near future (Gordon, 2016). As of 2019, about 95% of four-year institutions operate on a semester calendar.

There are at least two main differences between the two calendars that may affect students' academic performance: the length of terms and the number of courses required per term for on-track full-time enrollment. Typically, a semester academic year comprises two 15-week terms where a student takes 5, 3-credit hour courses per term.⁶ Generally courses meet either 3 times per week for 50 minutes, 2 times per week for 75 minutes, or 2 times per week for 60 minutes with an additional 1 hour per week lab or discussion section. A typical quarter schedule includes three 10-week terms where students take 3 or 4, 4 to 5 credit hour courses per term.⁷ There are a number of ways quarter courses are configured and there is some heterogeneity across institution type; i.e., liberal arts versus research institutions. Four credit courses usually include two, 2-hour lectures per week or four, 50-minute lectures per week. It is also common for courses to meet 2 times per week for 75 minutes and include an additional hour discussion section to attain the four hours of weekly contact. Quarter systems also allow for a full 10-week summer term.

Under either regime, in order to be on track to graduate in four years, students must take on average 15 credit hours per term. As such, a minimum of 120 credit hours are required to graduate in a semester system and 180 hours in a quarter system. In summary, full-time on-track students will attend approximately 15 hours of class per week regardless of the calendar but the number of simultaneous courses is higher on a semester calendar. Scheduling five courses is likely more challenging than scheduling three or four courses and could make scheduling extracurriculars, like part-time employment, an additional challenge.

The most common reason institutions cite for making the switch to semesters is to synchronize schedules with other schools in the state including other colleges and universities, and community colleges (Smith, 2012). School administrators believe there are many benefits of a common schedule. Because a majority of schools operate on a semester calendar, institutions on quarters feel their students are disadvantaged when it comes to securing summer internships and studying abroad. A

⁶Credit hours refer to the number of instructor contact hours per week; i.e., three credit hours correspond to approximately three hours of lecture per week.

⁷There is some heterogeneity in credit hours per course across schools and disciplines. For instance, STEM courses in quarter institutions are usually five credit hours and humanities courses are usually four. As a robustness check, we conduct heterogeneity analyses by STEM and non-STEM majors and find the effects are nearly identical across the two subgroups.

semester school year typically begins in late August and concludes in early May, whereas a quarter academic year runs from late September through the middle of June. If firms center internship program dates around a semester schedule because they are more common, students who attend schools on quarters may be ineligible. Similarly, quarter system students often have to forgo a term abroad because most study abroad programs align with the semester calendar. It is also more straightforward to transfer community college credits to four-year institutions, and fewer credits are lost, when they operate on a common academic calendar.

The longer terms and more concurrent courses per term distinct to semesters may pose a cost to students in the way of scheduling flexibility. Courses may be offered less frequently and many courses are offered at less desirable times, both earlier and later class times are used by universities to accommodate the larger number of concurrent courses being offered under semesters.⁸ If a student must repeat a course, it is more likely on a semester calendar that she will have to wait until the following school year to do so. This lack of flexibility could lead students to take longer to complete their degree if they are unable to schedule the appropriate courses required for graduation within a four-year window.

These attributes of semesters may also make exploring and switching across majors more costly. Generally, there are fewer courses to choose from in a semester calendar and students are exposed to fewer professors.⁹ To highlight the added cost, consider a full-time semester student who wishes to switch majors midway through her freshman year. She spends one-eighth of her four years taking prerequisites for a major she is no longer pursuing whereas had she been on a quarter schedule, she would have only given up one-twelfth of her total time. Since approximately one-half of students report switching majors at least once during their undergraduate education, this might be an important channel through which a semester calendar increases time-to-graduation (Sklar, 2015).

In terms of learning, it is unclear whether the quarter or semester calendar is preferable. Stu-

⁸This information comes from an interview with an administrator from Ohio State University.

⁹Although descriptive in nature, a comparison of course offerings from UCLA, which is on a quarter schedule, and UC Berkeley (semester schedule) in Psychology, English and Political Science shows that UCLA offers substantially more courses in each department; 61%, 37% and 43% more, respectively (Ramzanali, 2010).

dents on semesters have to juggle more courses and the associated materials and deadlines at any given time. On the other hand, students on semesters have more time with instructors and more time to master complex material. In a similar vein, because the term is longer, it is easier for a student to ‘turn-it-around’ if she finds herself performing poorly in the first half of the course. This may be particularly beneficial to first-year students who are adjusting to college life. However, upon receiving grades at the end of a term, if a student performs poorly, it is harder for her to improve her grade point average going forward because each term carries a larger weight compared with quarter terms.

Lastly, one must consider the direct cost of switching. Switching academic calendars is often a multi-year process and can take up to four years. It is administratively costly to convert course credits from quarters to semesters and faculty have to redesign curriculum and courses to fit within the longer term. Guidance and scheduling counselors must also be re-trained to adequately advise students in the new system. Prior to their recent conversion to semesters, administrators at California State University, Los Angeles estimated that the change would cost about \$7 million. This included the cost of revamped computer systems and student records, increased counseling, and changes in faculty assignments ([Gordon, 2016](#)). Sinclair Community College budgeted \$1.8 million for their conversion to semesters and the switch from quarters to semesters cost Ohio State University \$12.6 million ([Pant, 2012](#)).

In summary, there are a multitude of costs and benefits associated with switching from a quarter to a semester academic calendar that could affect student outcomes. Ultimately it is unclear which of these effects will dominate, *ex ante*, and thus, we are presented with an empirical question.

3 Institution-Level Analysis

We begin our analysis at the institution level by employing data on the near universe of four-year nonprofit institutions. This approach is ideal because it allows us to document the causal impact of switching from quarters to semesters on student outcomes more broadly compared to the existing

case studies.

3.1 Institution-Level Data

All data for the institution-level analysis come from the Integrated Postsecondary Education Data System (IPEDS), a branch of the National Center for Education Statistics (NCES), and comprise a school-level panel that covers almost all four-year, nonprofit higher education institutions within the US. Completion of the IPEDS surveys is mandatory for all postsecondary institutions that participate in Federal financial assistance programs; consequently, there is nearly full compliance. Because we are interested in on-time graduation rates, we keep only nonprofit colleges and universities that offer comparable, traditional, four-year bachelor's degrees. This includes all schools in IPEDS defined as bachelor's, master's or doctoral degree granting institutions by the Carnegie Classification system.

The final school-level dataset includes 19 cohorts of students that entered a four-year college or university between 1991 and 2010.¹⁰ We exclude 1994 from the analysis since IPEDS did not collect four-year graduation rates for this cohort. Finally, to construct a balanced panel, we keep only institutions that report graduation rates in all 19 years (1991-2010, excluding the missing cohort of 1994). The final dataset includes 731 institutions over 19 years for a total of 13,889 observations.¹¹

The two primary variables used in our analysis are the academic calendar system variable and graduation rates. The academic calendar variable which comes from the institution files of IPEDS includes seven different mutually exclusive categories: (1) two 15 to 16 week semesters, (2) three 10 to 12 week quarters plus a summer quarter, (3) three 12 to 13 week trimesters without a summer term, (4) a 4-1-4 system consisting of two four month (semester) blocks with a one month, one course block, (5) nontraditional calendar systems used often for online courses, (6) calendar

¹⁰The most recent graduation file reported by IPEDS is for 2016, which corresponds to the 2010 entering cohort. The lag allows one to observe both four and six year graduation rates.

¹¹In Table A1 we report results using the unbalanced panel and obtain similar results. In this sample, there are 1,253 institutions for a total of 22,089 observations.

systems that differ by program, commonly used by vocational and occupational programs, and (7) a continuous academic calendar system that allows students to enroll at any time during the year.

We restrict our sample to include schools that are on semesters, quarters, trimesters or 4-1-4 academic calendar systems, and drop the small share that move from semesters to quarters as there are not enough of these types of calendar conversions over the sample frame to draw meaningful conclusions. Furthermore, 4-1-4 systems are recoded as semesters in our analysis as they are equivalent to two traditional semesters surrounding a single, one-month course. Trimesters and quarters are closely related in many cases and trimesters are recoded as quarters. Less than 1% of the institutions in our sample are on trimesters and 8% of the institutions are on a 4-1-4 schedule. Our results are not sensitive to the recoding of semesters and quarters.

The main dependent variables in our analysis are four-year and six-year graduation rates. The IPEDS provides information on the incoming cohort size at each school and the number of students in the cohort that graduate within four and six years allowing us to construct four-year and six-year graduation rates for every incoming cohort since 1991. Graduation rates only include full-time students who enrolled at the institution as a freshman, and thus exclude transfer students.

Figure 1 visually displays the policy variation that we exploit; in 1991 about 87% of schools operated on a semester calendar and this increased to 95% by 2010. Table 1 reports summary statistics for the main sample. The first column of Table 1 shows that the four-year graduation rate for all students is 36%, with women having a significantly higher rate, 40%, than men, 30%. Underrepresented minority graduation rates are just below male rates at 29%. As expected, the average six-year graduation rate is much higher, 58%. We also observe several other institution-level characteristics including cohort size, in-state tuition, the number of faculty at an institution and total annual operation expenditures. The average number of full-time faculty at a university is 340, in-state tuition (without room and board) averages \$11,088 and the average cohort size is 1,099 students.

The second and third columns of Table 1 report summary statistics disaggregated by school calendar, those that do not change their calendar system between 1991 and 2010 and those that

change to semesters during the time period. The most striking difference between the two groups is the share of public institutions; 71% of switchers are public compared to 42% of never-switchers. This difference also drives differences in the average cohort size (1,376 vs. 1,066) and the average in-state tuition (\$7,240 vs. \$11,555) between switchers and never-switchers, as public institutions typically have larger average cohorts and lower in-state tuition. The disaggregated summary statistics highlight the fact that the effect of switching is, for the most part, identified off of large public universities. However, these differences in means between switchers and never-switchers do not threaten the internal validity of the estimates presented in Section 3.3, as the causal interpretation of the results does not rely on covariate similarity between the two groups.

3.2 Empirical Framework: Institution-Level

We leverage quasi-experimental variation in academic calendars across institutions and years to identify the causal relationship between semester systems and graduation rates. We first employ an event study design and estimate the following equation:

$$Y_{st} = \sum_{k=-10}^{10} \theta_k G_{stk} + X'_{st} \alpha + \gamma_s + \phi_t + \rho_s * t + \varepsilon_{st} \quad (1)$$

where Y_{st} is either the four-year or six-year graduation rate for the cohort of full-time, first-time students enrolling at school s in year t . G_{stk} is an indicator for k years from the adoption of a semester system for school s in the year t (e.g., $G_{st0} = 1$ if school s converted to semesters in year t). The first fully treated cohort (those who enrolled as freshmen in the same year that a semester calendar was first adopted) is $k = 0$. When considering four-year graduation rates as the outcome variable, the cohorts who enrolled in years $k = \{-1, -2, -3\}$ are the partially treated cohorts (i.e., those students who were already at the institution enrolled in their second, third, or fourth year when the semester calendar was first adopted). The omitted category is the last untreated cohort, $k = -4$. For estimation with six-year graduation rates as the outcome variable, the partially treated cohorts are $k = \{-1, -2, -3, -4, -5\}$ and the omitted category is $k = -6$.

We restrict the effect of treatment on all cohorts who enrolled more than 10 years before or after the calendar switch to semesters to be unchanging, so that θ_{-10} and θ_{10} represent the average

effect 10 or more years prior to or after the calendar switch, respectively.¹² There are a total of 25 pre-policy years and 22 post years in the sample. The vector X_{st} includes time-varying university level controls including: in-state tuition, number of full-time-equivalent faculty, annual operation costs, % of students female, % of students white, and % of students who are underrepresented minorities (URM).¹³ The variables γ_s and ϕ_t are university and year fixed effects, respectively. The model also includes institution-specific linear time trends, $\rho_s * t$. We discuss how the inclusion of linear time trends impacts identification in the text below, and address the results of excluding linear time trends in detail in Section 3.3. All regressions are weighted by average cohort size and standard errors are clustered by institution.¹⁴

We also employ a difference-in-differences approach and estimate a model similar to Eq. (1), but which groups cohorts into 3 categories. This strategy provides more power to detect average treatment effects. We estimate the following equation:

$$Y_{st} = \beta_1 G1_{st} + \beta_2 G2_{st} + X'_{st} \alpha + \gamma_s + \phi_t + \rho_s * t + \varepsilon_{st}. \quad (2)$$

In this model, $G1_{st}$ is an indicator for the partially treated cohorts. In specifications where the outcome variable is four-year graduation rates, this includes cohorts who enrolled at university s , one to three years before the adoption of semesters ($G1_{st} = \bigcup_{k=-3}^{-1} G_{stk}$). In specifications where the outcome variable is six-year graduation rates, this includes cohorts who enrolled one to five years before the switch to semesters ($G1_{st} = \bigcup_{k=-5}^{-1} G_{stk}$). The indicator $G2_{st}$ is equal to one for fully treated cohorts ($G2_{st} = \bigcup_{k=0}^{22} G_{stk}$); that is, if university s is using a semester calendar when the cohort first enrolls in year t . The omitted category includes all untreated cohorts. All other variables are the same as in Eq. (1).

The identifying assumption for estimating a standard difference-in-differences model in this

¹²For schools that are “always treated”, we do not observe the year of adopting a semester calendar (or if the school was ever on a quarter calendar). We include these schools in the $k = 10$ group for all years. However, this might lead to classification errors if these schools switched to semesters less than 10 years before the start of our sample. In Appendix Figure A2a and Figure A2d, we show that our results are robust to dropping the first 10 years of IPEDS data where these classification errors might occur.

¹³One could be concerned with the inclusion of time-varying controls, particularly if they are affected by the calendar switch. We show in Table 3 that the results are robust to the exclusion of these controls.

¹⁴Table A2 shows that the results are not sensitive to the inclusion of weights.

setting is that the adoption of the semester calendar is uncorrelated with other unobserved time-varying determinants of four-year and six-year graduation rates (i.e., the Parallel Trends assumption). The inclusion of institution and year fixed effects controls for time-invariant institution-level variables and overall time trends that might affect graduation rates. However, by also including institution-specific linear time trends, we control for differential trends in graduation rates across schools over time. As such, the identifying assumption in this model is that in the absence of a change in academic calendar, the switchers and the non-switchers would continue along the same differential trends in graduation rates. This Parallel Growth assumption is less restrictive than the standard Parallel Trends assumption in that we have already controlled for differences in trends across the switchers and non-switchers (with the institution-specific linear time trends) and now requires only that the difference between the growth rates of these groups is constant in the absence of a calendar conversion ([Mora and Reggio, 2019](#)).

While the identifying assumption is not directly testable, several indirect tests support its plausibility. First, the change in the four-year graduation rate precisely coincides with the timing of semester adoption. This is visually evident in the results of estimating Eq. (1), shown in Figure 2. Second, we examine whether adoption of the semester calendar is correlated with changes in other observed time-varying characteristics of universities. In Table 2, we regress institution and student-body characteristics (full-time-equivalent faculty, total operation expenditures, in-state tuition, cohort size, percent of student body white, percent URM, and percent female) on a semester calendar indicator, year and institution fixed effects, and institution-specific linear time trends. For the most part, Table 2 shows no sign of a relationship between changes in observable institution or student characteristics and the adoption of a semester calendar. Importantly, semester adoption does not appear to change the racial or gender composition of a cohort, enrollment, or the total operation expenditures. The one exception is that in-state tuition appears to increase with the calendar change. To further examine this issue we estimate an event study model with in-state tuition as the dependent variable (see Figure A3) and find that institutions are raising tuition by about 3% on average in the year prior to semester calendar adoption. This could be to help finance the

calendar conversion which can be expensive, as mentioned at the end of Section 2. Regardless, this small increase in tuition likely cannot account for the sizable decline in on-time graduation that we find in Section 3.3.¹⁵ Furthermore, [Deming and Walters \(2017\)](#) find no impact of tuition increases on degree completion providing further support that the small increase in tuition is likely not driving our main results.

A third concern that could confound the interpretation of our results is the possibility that schools enact other policies or initiatives to increase on-time graduation at the same time as an academic calendar change. If this is the case, our estimated negative effect will be a lower bound—a smaller negative effect than the true negative effect—as such initiatives would likely improve graduation rates (i.e., work against our findings).

A final concern is that institutions that change to a semester system may be inherently different from those who do not. If this is the case, it would not jeopardize the internal validity of our analysis—we include institution fixed effects to estimate a local average treatment effect—rather it would call into question the external validity of our results. That is, do our results extend to those institutions who we do not observe switching if they were to switch? First, we show in Table 1 that switchers are predominantly public institutions. Since a majority of students attend public institutions—the average cohort size at a public institution is 1,724 compared to 570 at private schools and nearly half of institutions in the dataset are public—our results are relevant to a majority of students in the US. Second, in a heterogeneity analysis, we find similar results among the subset of private schools, again suggesting that our results extend widely.

3.3 Institution-Level Results

The main results are represented in the event study in Figure 2 and come from estimating Eq. (1). Figure 2a reports the effect of policy adoption on four-year graduation rates (on-time graduation), and Figure 2b on six-year graduation rates. For four-year graduation rates the pre-treatment region,

¹⁵We also find student employment during the school year declines as a result of the calendar shift, which indicates that students are not responding to the small increase in tuition by working more; see Section 4.6

which represents all untreated cohorts, is $k < -3$. All estimates are relative to the left out group, $k = -4$, which is the last untreated cohort before policy adoption. The partially treated region includes $k \in [-3, -1]$. These cohorts were fourth, third, and second year students when semesters were implemented and, as such, were treated for one, two, or three years, respectively. Year 0 represents the first fully treated cohort because this is the group of students who were incoming freshmen in the fall that the institution adopted a semester calendar. The post-treatment region, $k \geq 0$, includes cohorts who are fully treated. For six-year graduation rates, the omitted cohort is $k = -6$ and the partially treated region is $k \in [-5, -1]$.

Figure 2a shows that on-time graduation rates fall as a result of semester calendar implementation. The negative effect begins to emerge in the partially treated cohorts, grows larger as cohorts become more fully treated (i.e., as they are exposed to more years of a semester calendar), and levels out and remains negative among the fully treated cohorts. These results indicate that the first fully treated cohort—those students who first enrolled as freshmen in the same year that the semester calendar was adopted—experienced a significant reduction in on-time graduation rates of approximately 5 pp. Furthermore, this negative effect is not isolated to this cohort or the students enrolling in the first few years following the calendar switch. Figure 2a reveals that cohorts enrolling nine or more years after the adoption of semesters experience a similar reduction in on-time graduation of approximately 5 pp. As such, the negative impact on student outcomes is not merely a short-term consequence of the calendar switch, but a longer-term effect likely driven by some characteristic of the semester calendar.

Figure 2b repeats this exercise for six-year graduation rates. After adoption of the semester calendar, there is no statistically significant impact on six-year outcomes. This smaller and statistically insignificant effect of the calendar change on six-year graduation rates suggests that students on a semester calendar are increasing their time-to-degree but not necessarily dropping out. Ideally, we would like information on retention but instead use six-year graduation rates as a proxy for whether students ever graduate because retention is not observable in the IPEDS data. In Section 4, we employ an alternative dataset to more directly address the question of whether there is an effect

on student retention.

There are at least two important takeaways from the event study figures. First, the pre-treatment regions in both panels of Figure 2 reveal that, prior to semester adoption, there are no statistically significant deviations from trends in graduation rates between institutions that switch and those that switched at different times or not at all, conditional on the included controls. This helps assuage concerns that events or policies enacted in the years prior to the calendar switch might confound the estimates. Second, the change in the outcome coincides precisely with the timing of semester adoption. This minimizes the concern that the estimated effect is driven by a trend and strongly suggests that the change in four-year graduation rates is a causal effect of the switch to semesters. Finally, since many of the calendar adoptions are a result of state-level mandates, in a robustness check, we consider the subsample of public institutions in such states (Georgia, Minnesota, North Dakota, Ohio, Texas, and Utah). The point estimates for this subset of institutions that did not select into treatment are nearly identical to the main estimates; see Figure A1.

Next, we probe the decision to include institution-specific linear time trends. To begin, consider appendix Figure A2b and Figure A2e which report event studies without controls for linear time trends. Comparing these figures to those with institution-specific linear time trends (Figure 2) highlights the importance of the inclusion of such trends in the regression analysis. Without the time trends, it is visually apparent that four-year graduation rates are differentially trending upward for the switching schools before and after the policy adoption. However, the treatment effect is still quite apparent: at the time of policy adoption there is an immediate change in graduation rates in the *opposite* direction of the trend. The trends in Figure A2e are less clear but it appears that six-year graduation rates are differentially trending upward over all periods for switching schools and, consistent with Figure 2b, there is no noticeable effect of the calendar change on this outcome.

An alternative approach to dealing with these trends is to consider a more comparable control group. In appendix Figure A2c and Figure A2f we keep only those institutions in the sample that experienced a calendar switch and estimate the event study without linear time trends. By excluding never-switchers, our estimates represent only comparisons between switchers and those

that switched at different points in time. The estimates do not represent comparisons between switchers and never-switchers. The results are nearly identical to those presented in Figure 2—even though the specification excludes linear trends—and show clearly that there are no differential pre-trends in four-year graduation rates across schools that switched to semesters in different years.

Table 3 presents results from Eq. (2) which leverages the difference-in-differences approach. Panel A presents estimates of the mean effect of switching to semesters on four-year graduation rates for the partially treated and fully treated cohorts. Following Goodman-Bacon (2018), we separately estimate the effects of the partially treated cohorts from the fully treated cohorts rather than estimating a single post period indicator because, as evident in Figure 2a, the treatment effects are heterogeneous over these cohorts. Each column within Panel A represents a separate regression. Columns 1-3 include varying levels of controls. Unsurprisingly—given the event studies discussed above—the point estimates presented in columns 1 and 2, which come from specifications that do not include institution-specific linear time trends, are small in magnitude and indistinguishable from zero. The results from the main specification (column 4), which include the full set of controls, indicate that switching from a quarter system to a semester system reduces four-year graduation rates by 3.7 pp on average for the fully treated cohorts. For context, the average four-year graduation rate is 36%, thus a 3.7 pp reduction is equivalent to a 10% reduction at the mean. The partially treated cohorts experience a smaller negative effect of 2.4 pp. These point estimates are robust to the inclusion of time-varying institution level covariates as seen by comparing columns 3 and 4.

Next, we divide the data into several subgroups: males, females, underrepresented minorities, non-underrepresented minorities, public institutions, and private institutions. We estimate the model separately for each subgroup and report these results in columns 5-10. Strikingly, there is no evidence of heterogeneity on these dimensions. The results show, across the board, declining four-year graduation rates as a result of the adoption of a semester calendar.

Panel B of Table 3 presents estimates of the mean effect of switching to semesters on six-year graduation rates. Consistent with the event study results, we find no strong evidence that the

calendar switch affects six-year graduation rates, as the estimates are small in magnitude and only marginally significant.

To provide context for the magnitudes of our estimated effects, we compare to estimates of the effects of financial aid policies on college completion rates. In a study of the West Virginia Promise program, [Scott-Clayton \(2011\)](#) finds that the large merit-based scholarship increased four-year graduation rates by 4-7 pp (from a baseline of just 27%). Using regression discontinuity analyses, [Denning et al. \(2019\)](#) find that eligibility for the maximum Pell Grant award leads to a 10% increase in the probability of graduating on-time and [Castleman and Long \(2016\)](#) find that an additional \$1,300 in need-based aid eligibility increased the probability of earning a bachelor's degree within six years by 22%.

4 Individual-Level Analysis

We next turn to a student-level analysis using detailed transcript data from all of the public bachelor's degree-granting universities in Ohio. This will allow us to explore the mechanisms underlying the drop in four-year graduation rates presented in Section 3.3. With these more nuanced data, we are able to observe term-by-term outcomes including whether or not a student drops out, what courses are taken, cumulative grade point average (GPA), and major choice. We also link these data to employment files from Ohio's Unemployment Insurance system to study the effects of the calendar conversion on student employment.

4.1 Individual-Level Data

The student-level data are provided by the Ohio Longitudinal Data Archive (OLDA) and include administrative transcript records for all students attending public colleges in Ohio between Summer 1999 and Spring 2017. These data provide student demographics, major subject identifiers, degree completions, and course-level data on enrollment and grades. The full sample is limited to all students who enroll as first-time freshmen at a bachelor's degree-granting institution in the fall

term of the years 1999-2015.¹⁶ The full sample covers 709,404 students enrolled at 37 campuses.

These data provide an ideal context in which to explore the effects of a change in the academic calendar because Ohio has one of the largest comprehensive public college systems in the US and because more than half of the schools in Ohio switched from quarters to semesters in the sample time period.¹⁷ There are 16 campuses in the data that were already on a semester calendar at the start of the sample in 1999. Four campuses switched from a quarter calendar to semesters over the course of the following decade. All of the remaining campuses in the state switched to a semester calendar in the Fall of 2012 by mandate of the Ohio Department of Higher Education.¹⁸ In total, 64% of students in the full sample first enrolled under a semester calendar while 36% first enrolled under a quarter system.

The term-by-term transcript data allow us to construct several dependent variables of interest. For each student, we create indicator variables for: (1) graduate; (2) drop out; and (3) transfer to another school (within the dataset) in year $y \in [1, 5]$ of enrollment.¹⁹ We can also aggregate these variables to create indicators for each outcome occurring anytime within four years or within five years of initial enrollment. For each student in each term we also observe cumulative GPA, the number of credits attempted, and the student's declared major.

Panel A of Table 4 displays the demographic characteristics of all students in the full sample. These summary statistics show that the sample is 53% female, predominantly white (78%) and almost entirely US-born (98%). Panel B of Table 4 shows summary statistics for the individual outcome variables in this sample. The four-year graduation rate is 23% (this is lower than the national average of 36% shown in Table 1) and the five-year graduation rate is 40%. Panel C of Table 4 displays statistics for outcomes measured at the end of each student's first year of enrollment. This panel shows that 20% of students drop out in their first year, while 8% transfer

¹⁶Students who transfer into a four-year Ohio public institution are excluded from the sample. If a student enrolls as a first-time freshman in a fall term at a four-year Ohio public institution and then transfers to another institution in this system, we will only observe them at the first institution.

¹⁷Appendix Table A3 details the variation in academic calendars within this sample.

¹⁸A driving motivator for this policy mandate was to facilitate credit transfer between institutions within the state. Additional information on the policy can be found at <https://www.ohiohighered.org/calendar-conversion>.

¹⁹We do not attempt to analyze the effect of calendar switching on six-year outcomes in this sample because we only observe 5 years of post-treatment data for the large group of schools that switch to semesters in Fall 2012.

to another public Ohio college, and only 54% of students enroll in a full-time course load.²⁰ Note that while graduation rates increase significantly from year 4 to year 5 of enrollment (shown in Panel B), drop out rates and transfer rates are largely determined in the first and second years of enrollment. This pattern is depicted in Figure 3, which plots the enrollment status measured $y \in [1, 6]$ years after initial enrollment for the subset of students in the 1999-2011 cohorts (those for whom we observe 6 years of data). This figure shows that most students who graduate do so in years 4 or 5 of enrollment and very few students in this sample take 6 years to graduate (only 4.7%).

In Section 4.3, we report estimates for separate subgroups of students who we define to be from high- or low-income backgrounds. Unfortunately, we do not observe parental income or financial aid edibility. As such, in order to identify students in the sample who are high- or low-income, we link the OLDA transcript data to the 2006-2010 American Community Survey (ACS). In the transcript data, we observe the zip code where each student's high school was located and map this to the mean household income reported for that zip code in the ACS.²¹ We then split the estimation sample in two and designate students who attended high schools in zip codes with mean household income above the median value to be higher income students.

In order to estimate the effect of the switch to semesters on student employment in Section 4.6, we link the transcript data to quarterly wage data from the Ohio Department of Job and Family Services (ODJFS). The ODJFS collects quarterly earnings data through the Unemployment Insurance (UI) system for all individuals working in Ohio who are not: (1) self-employed; or (2) employed by the Federal government. All records in the UI data include a linkage identifier that enables deterministic matching to students in the transcript data.²² The data also include the industry in which each student was employed, as categorized by the North American Industry Classification System (NAICS) code. If a student was employed by more than one employer in a given quarter,

²⁰A full course load is 15 credits per term, which totals 45 credits per year under quarters or 30 credits per year under semesters.

²¹Note that this variable is missing for approximately 7% of students in the main estimation sample.

²²Note that this linking identifier is unavailable for approximately 7% of our full estimation sample and for nearly all foreign-born students.

we assign that student to the employer from which the student received the most income.

4.2 Empirical Framework: Individual-Level

We leverage the same identification strategy as in Section 3.2 and estimate the following model:

$$Y_{ist} = \sum_{k=-10}^5 \theta_k G_{stk} + X_i' \alpha + \gamma_s + \phi_t + \rho_s * t + \varepsilon_{ist} \quad (3)$$

where Y_{ist} is an indicator that individual i enrolled at school s completes a bachelor's degree within 4 years of first enrolling in cohort t . The vector X_i includes individual characteristics: age, age², sex, a foreign-born indicator, and indicators for race/ethnicity. Campus and cohort fixed effects are captured by γ_s and ϕ_t , and $\rho_s * t$ are campus-specific linear time trends. As in Eq. (1), G_{stk} is an indicator for k years from the adoption of a semester system. We restrict the effect of the treatment on all cohorts who enrolled more than 10 years before or more than 5 years after the switch to semesters to be unchanging, so that θ_{-10} and θ_5 represent the average effect 10 or more years prior to or 5 or more years after the switch, respectively.²³

We also employ a difference-in-differences approach that is analogous to Eq. (2) for the individual-level data:

$$Y_{ist} = \beta_1 G1_{ist} + \beta_2 G2_{ist} + X_i' \alpha + \gamma_s + \phi_t + \rho_s * t + \varepsilon_{ist} \quad (4)$$

where $G1_{ist}$ is an indicator for students who are in partially treated cohorts. That is, students who first enroll at a university 1 to 3 years prior to the adoption of a semester calendar (if the outcome variable is the probability of graduating in four years) or students who enroll 1-4 years prior to the calendar change (if the outcome variable is the probability of graduation in five years). The indicator $G2_{ist}$ is equal to one if student i enrolls as a first-time freshman at a university that is currently using a semester system. The omitted category is students who are untreated. All other variables are the same as in Eq. (3).

We estimate both of the above models using Ordinary Least Squares (OLS).²⁴ In order to

²³Unlike in the institution-level analysis in Section 3, here the majority of switching occurs late in the sample (2012) so we do not attempt to separately estimate treatment effects for cohorts more than 5 years post-calendar adoption.

²⁴Estimates using a Probit Maximum Likelihood estimator are very similar.

estimate standard errors and conduct valid inference, we implement several methods to best suit the structure of the individual-level data. The full sample includes 709,404 students enrolled at 37 campuses comprising 555 school-by-year cohorts. Clustering at the level of the treatment variable, the school-by-year cohort level, assumes that there is no serial correlation in the error term that might impact two students who enroll in the same university in consecutive years. [Bertrand et al. \(2004\)](#) show that this approach can lead to under-estimated standard errors and over-rejection of standard hypothesis tests. Alternatively, clustering at the campus-level can provide broadly conservative estimates of the standard errors. We report these campus-level clustered standard error estimates in all results tables throughout Section 4.3. However, in this particular setting, campus-level clustering relies on relatively few, very large and unbalanced clusters. To account for the small number of clusters, we also estimate and report wild cluster bootstrap p-values ([Cameron et al., 2008](#)).

Finally, we note that these methods that cluster at the campus-level are most likely overly conservative in our context. This is due to the assumption that any two students who attend the same university – no matter how many years apart – may have correlated error terms. For this reason, we also estimate standard errors using multiway clustering ([Cameron et al., 2011](#)) along 5 dimensions. These dimensions correspond to the 5 overlapping peer groups that a student might be exposed to over the course of a five-year enrollment at a given school. The errors are then assumed to have the property that for all $i \neq j$: $\mathbb{E}[\epsilon_{ist}\epsilon_{jsr}|x_{ist},x_{jsr}] = 0$ unless (1) $t \in [r-4, r]$; (2) $t \in [r-3, r+1]$; (3) $t \in [r-2, r+2]$; (4) $t \in [r-1, r+3]$; or (5) $t \in [r, r+4]$. This multiway clustering structure allows for arbitrary correlation between the errors of any two students who enroll at the same campus within 4 years of each other and assumes a zero correlation between students who either attend the same university five or more years apart or who attend different universities. This creates an error covariance structure akin to Newey-West standard errors, which account for temporal autocorrelation by assuming a decay in the correlation between two observations as the time lag between them grows larger. Using the multiway standard errors, we do not impose any structure on the decay rate and allow for arbitrary correlation between students as long as they

enroll at the same university within four years of each other.

Each of these 3 methods of inference offer advantages and disadvantages and without knowledge of the true nature of the underlying error structure it is impossible to say which is best. Thus, in all of the following tables in Section 4.3 we report: (1) standard error estimates using multiway clustering; (2) standard error estimates using campus-level clustering; and (3) p-values for a Wald test estimated using wild cluster bootstrapping.

4.3 Individual-Level Results

We first focus on replicating the results shown in Figure 2 and Table 3 from the institution-level analysis. The individual-level event studies are estimated from Eq. (3) and are shown in Figure 4. Each point on the figures represent an estimate of θ_k while the dashed lines plot the 95% confidence intervals estimated using multiway clustered standard errors. In Table 5 we replicate the results from Table 3 by estimating Eq. (4) with the individual-level data.

Broadly, the results from both analyses confirm the findings from the institution-level data, albeit less precisely estimated. The switch to semesters leads to a reduction in the probability of graduating in four years (Panel A, column 1) and the effect is consistent across various sub-populations (Panel A, columns 2-7). In Panel B we report estimates of the effect of the switch to semesters on the probability of graduating in five years and find imprecisely estimated negative effects that are smaller in magnitude.²⁵ Unfortunately, we are unable to estimate the effect of switching for the six-year graduation outcome, as in the institution-level analysis, because we only observe five years of data for the large group of universities that switched to semesters in 2012.

4.4 Mechanism Exploration

Next we seek to better understand *why* a semester schedule leads to reduced on-time graduation. One possible contributing factor is that students are more likely to leave a university on semesters,

²⁵Note that Panel A includes students who enter as first-time freshmen in the F1999-F2013 cohorts and Panel B is limited to the F1999-F2012 cohorts (for whom we can observe 5 years of data).

either as a dropout or to transfer to a different institution. It is also possible that the reduction in on-time graduation is driven by an increase in time-to-degree. In the analysis that follows we probe both possibilities and the underlying channels.

There are a number of potential channels that could drive dropping out behavior and/or an increase in time-to-degree. First, students and advisors may have difficulty navigating the transition to a new calendar system. We rule out this proposed channel because the estimated effects shown in Figure 2a and Figure 4a are clearly evident in the long-term. If the reduction in on-time graduation is driven by temporary confusion following the conversion, then one would expect students and faculty to adjust to the new calendar in the medium to longer-run and for effects to fade to zero in later cohorts.

A second potential channel is that students may find it challenging to juggle more simultaneous courses per term as is required with a semester calendar. If this is a primary channel, students may earn lower grades or under-enroll—that is, take fewer credits per term than what constitutes a full load. Under-enrollment would necessarily increase time-to-degree, all else constant. Lower grades could lead to an increase in time-to-degree if students are retaking courses for a better grade. Furthermore, if a student's grades are low enough, they may face academic probation and potential dismissal from the university.

Finally, reduced scheduling flexibility associated with semesters caused by the longer term length and higher number of required courses per term may be an important channel. Students might opt to take fewer courses per term to avoid unappealing class times (e.g., early morning classes). If they must retake a course, it is possible they will have to wait an entire year before the course is offered again. Both of these factors would likely increase time-to-degree. It is also possible that scheduling flexibility impacts the timing and/or likelihood that a student switches majors, as major exploration is more costly under a semester calendar. Students who take longer to settle on a major are likely to experience a longer time-to-degree.

Mechanism Analysis for First-Year Students

We test each of these hypothesized mechanisms in turn by considering the following outcomes: drop out and transfer out behavior, course taking, grades, and major switching. To begin, we analyze the impact of the policy on first-year students. Focusing on outcomes measured in students' first year of enrollment allows us to utilize the full sample and abstract from the selection issues present in 2nd - 4th year outcomes as all follow-on years are only observed conditional on continued enrollment.²⁶ First-year students may also be the most vulnerable. More than half of all dropout and transferring out occurs in a student's freshman year (see Figure 3).

Table 6 reports the effects of the calendar switch for these first-year outcomes. Each column of this panel represents a separate regression, each estimated with a different dependent variable. Note that for outcomes measured in students' freshman year, there does not exist a partially treated group. Students who enroll at a university one or more years before the semester calendar is adopted necessarily do not experience any effect of the policy during their freshman year. Thus, when estimating Eq. (4) in Table 6, we do not include the $G1_{ist}$ variable and those students are absorbed into the omitted category of untreated students.

Taken at face value, the estimates in column 1 of Table 6 suggest that switching to a semester calendar increases freshman year dropouts by 2.0 pp. Evaluated at the mean, this is equivalent to a 10% increase in first-year dropouts. Because the OLDA data are limited to enrollment at public universities within Ohio, a dropout could include a student who is no longer enrolled in any higher education institution as well as students who transfer to private institutions, public institutions in another state or non-bachelor's degree-granting institutions. These potential misclassifications should be kept in mind when interpreting the dropout results.²⁷ Column 2 reveals no evidence of an effect of the calendar change on transfer behavior, where a transfer is defined as a student who moves to another public four-year institution in Ohio.

²⁶If the switch to semesters has an effect on the probability of remaining enrolled past the first year, then outcomes measured in enrollment years 2-4 will necessarily suffer from selection.

²⁷70% of the students who "drop out" on semesters have a GPA less than a 2.0, suggesting that they are performing poorly.

While the first two columns suggest that at least some of the reduction in on-time graduation stems from students leaving the institution, to probe the robustness of these findings, event studies for all first-year mechanism outcomes are reported in Figure 5. Figures 5a and 5b reveal suggestive evidence of preexisting differences in the dropout and transfer out outcome variables. Note that these estimates include controls for institution-specific linear time trends. Thus, the negative point estimates in the pre-treatment region suggest that the growth rates of those trends in dropping out and transferring out differ across treated and untreated cohorts. The point estimates reported in columns 1 and 2 are likely capturing, in part, these non-linearities in the trends rather than the causal effect of the calendar conversion. Moreover, there is no noticeable change in the outcome among switchers at the time of calendar adoption. In summary, we cannot provide conclusive evidence that the policy is causing an increase in dropout or transfer out behavior.

In columns 3-5 of Table 6, we investigate three additional first-year outcomes that may explain why students are dropping out or delayed in their completion as a result of the calendar switch. Column 3 reports results for course taking behavior. Taking fewer credits than the recommended course load in the first year will create a deficit for students from the onset in terms of degree progression. As such, the dependent variable in column 3 is an indicator for attempting the recommended number of credits for a full-time student to graduate in four years. This equates to 45 credits per year for students on a quarter calendar and 30 credits per year for those on a semester calendar. The results presented in column 3 are imprecisely measured, but the point estimates suggest that students on semesters may be under-enrolling in their first year.

Column 4 of Table 6 presents the estimates of the effect of a calendar switch on the probability of earning a cumulative grade point average less than 2.0 (measured at the conclusion of the spring term of a student's first year of enrollment). This threshold is meaningful because it is typically the cutoff used to place students on academic probation. Students who fail to raise their cumulative GPA above a 2.0 in subsequent terms become eligible for academic dismissal.²⁸ We estimate that the switch to a semester calendar increases the probability of earning a GPA below the 2.0

²⁸For example, see <https://advising.osu.edu/academic-status-0> for detailed information on the academic probation policy at Ohio State University.

threshold by 4.9 pp. This is equivalent to a substantial increase of 20% evaluated at the mean and is very likely a driving mechanism behind the reduction in on-time graduation.²⁹

In column 5 of Table 6, we assess the effect of switching to a semester calendar on the probability of switching one's declared major in the first year of enrollment. We do not code the 8.6% of students who enroll as an undeclared major as a switcher when they first declare a major. However, the estimates are very similar if we code those initial declarations as switches. The estimates reveal that first-year students are 7.1 pp less likely to switch majors in their first year under a semester calendar. Two possibilities emerge: (1) students are overall less likely to switch majors, or (2) they delay major switching to a later year. We investigate this at the end of the section in Table 7.

In order for any of the hypothesized mechanisms to be a good candidate, it is necessary that the effect of the calendar switch is long-lasting since the main effect on graduation rates persists well beyond the initial transition period. Figure 5 displays the event study estimates for all first-year mechanism variables. These estimates indicate that for first-year students, under-enrolling in credits, the increased probability of earning a cumulative GPA less than 2.0 and the decreased probability of switching majors are lasting effects—affecting cohorts enrolling 5 or more years after the switch—and are not merely a temporary response to the calendar change.

In order to further minimize any concern over potential bias from differential trends for these mechanism variables, we implement an alternate empirical strategy that focuses on a limited sample: cohorts entering into college in the year immediately preceding semester adoption and in the year of adoption. By restricting the sample in this way and excluding institution-specific linear time trends, we are able to home in on the effect of the calendar switch net of potential confounding trends in the outcome variable. The primary disadvantage of this strategy is that it can only be used to study outcomes measured in the first year of enrollment.

The results of this alternate approach (shown in Table A4) are consistent with the findings from our main approach, showing a negative (but not statistically significant) effect on course-taking,

²⁹We cannot identify whether the lower grades are a result of poorer performance by students or a change in the way instructors grade in the new calendar system, but regardless students are receiving lower grades which threatens degree progress.

and large negative effects on both first-year GPA and major-switching. Importantly, these results are also consistent with conclusions drawn from the event studies regarding first-year dropouts (see Figure 5a). They indicate that the estimated effect of the switch to a semester calendar on dropping out shown in Table 6 is capturing bias from differential trends. Thus, we conclude that there is no convincing evidence of an effect of the calendar change on dropout behavior.

Mechanism Analysis for Continuing Students

To further home in on the mechanisms underlying the increase in time-to-degree, we next analyze the effect of the calendar conversion on the potential mechanism variables for those students who persist past the first year of enrollment. Specifically, we restrict the sample to students who remain enrolled for at least four years and, as such, are very unlikely to ever drop out. Table 7 includes estimates of the effects of the calendar conversion on cumulative course-taking, cumulative grades, and cumulative major-switching behavior in years 1-4 of students' enrollment.³⁰ Recall that, for first-year outcome variables, there is no partially treated group. For outcomes measured in students' 2nd year, the partially treated group (represented by $G1_{ist}$ in Eq. (4)) is defined to be students who first enrolled at a given university 1 year prior to the adoption of a semester calendar. For outcomes measured in students' 3rd year, the partially treated group also includes students who enrolled 2 years prior to the switch to semesters. And for outcomes measured in students' 4th year, the partially treated group includes students who enrolled 1-3 years prior to the adoption of a semester calendar.³¹

In Panel A of Table 7, the outcome variable measures whether the student had attempted the recommended number of credits by the end of each enrollment year.³² These estimates show that, among students who do not drop out and instead persist through at least 4 years of enrollment, those

³⁰To avoid bias due to attrition, we estimate these regressions using only those students in the F1999-F2013 cohorts (those for which we observe at least 4 years of data) who remain enrolled for a minimum of 4 years. These results, however, are robust to using the full sample, see Table A6.

³¹Figure A4 presents event studies for each of the outcomes in Table 7 and overall indicates parallel pre-trends in the outcomes and a divergence from the trend for the treated cohorts at the timing of calendar adoption.

³²The outcome measures cumulative course taking at the end of each year such that a student on semesters who takes 29 credits in year 1 and 31 credits in year 2 is observed to be "on track" (total credits ≥ 60) and will have an outcome value equal to 1 in column 2.

in their 4th year on a semester calendar are 11.5 pp less likely to have attempted an on-track course load than their quarter calendar counterparts. These results suggest that students on a semester calendar fall behind in taking the recommended number of credits early on in their college careers, and then are unable to catch-up in subsequent years.

In Panel B of Table 7, we estimate the effect of the switch to a semester calendar on the probability of earning a cumulative GPA below a 2.0 in years 1-4 of enrollment. These estimates show that even among students who persist through 4 years of enrollment, the change to a semester calendar increases the probability of being below this academic probation threshold in each of the first 4 years of enrollment.

Finally, in Panel C of Table 7, we estimate the effect of calendar switching on the probability of ever having switched majors measured at the end of each year of enrollment. These estimates show that students are less likely to have switched majors by the end of their first and second year of enrollment under semesters, but no less likely to have switched majors by the end of their fourth year—supporting the hypothesis that students on a semester calendar are no less likely to switch majors overall, but are merely doing so later in their college careers.^{33 34}

With these cumulative outcome variables that are measured repeatedly for each individual student, we are able to implement an alternative empirical strategy that utilizes individual-level fixed effects. The advantage of this approach is that it relies solely on variation within an individual over time, ruling out the possibility of certain types of selection bias. The disadvantage is that the effect of the switch to a semester calendar is identified exclusively from those students who experience both calendar systems; i.e., students who are caught in the transition period. Results from this alternate approach are shown in Table A5 and indicate that the semester calendar: reduces the probability of attempting an on-track course load; increases the probability of dropping below the academic probation threshold; and has no effect on the overall probability of switching majors.

³³In a separate analysis, we find no evidence of an effect of the semester calendar on which major students choose. That is, students are no more or less likely to choose a STEM major vs. a non-STEM major after the switch to semesters.

³⁴Another possible channel is summer course-taking. It is possible that the semester calendar offers fewer opportunities for summer course-taking, as noted by the University of Chicago (see Section 2). In a separate analysis we investigate this possibility and do not find support for this mechanism.

These results support our prior findings shown in Table 7 and indicate that our results are likely not driven by preexisting trends or selection bias.

4.5 Mechanism Discussion

The switch to a semester calendar changes a student's academic experience in a number of ways, and guided by empirical evidence, we can only speculate as to which channels underlie our main findings. We posit that there are two characteristics of semesters that are particularly relevant and discuss these factors in turn.

First, the *higher number of courses per term* may produce several of our findings. Students may find it difficult to balance more courses and topics simultaneously. This could explain the increase in the probability of falling below the 2.0 GPA cutoff. At the same time, some students may simply enroll in fewer credits per term (i.e., four courses instead of five) to avoid taking too many different courses at once. These possibilities are consistent with [Buser and Peter \(2012\)](#) who show in an experimental setting that individuals perform relatively worse when assigned to a multi-tasking treatment and conclude that scheduling is a significant determinant of productivity. It is also possible that the higher number of courses in a term presents more of a scheduling challenge, particularly if a student wishes to avoid class times outside of the standard 9-5 school day. For instance, a student may prefer to enroll in fewer courses to avoid an 8 a.m. start time, especially since the cost of under-enrolling is not realized until a future period.

Second, the *increased length of the term* may be at play. Longer terms could incentivize procrastination. There are longer periods between exams and more time to put off studying. It is possible that this type of behavior leads to lower grades and an increased probability of earning a GPA below a 2.0. For instance, [Ariely and Wertenbroch \(2002\)](#) show in an experimental setting that externally imposed deadlines, such as an exam date, enhance performance more than self-imposed deadlines. In a related vein, [Beattie et al. \(2018\)](#) provides descriptive evidence showing that low performing first-year college students are more likely to cram for exams and wait longer before starting assignments compared to higher performing first-year students. The increased term

length may be particularly harmful to those lower down in the ability distribution.

Additionally, longer/fewer terms mean that experimenting with a major takes more time. If, for instance, there are a set number of courses needed to learn about the match between one's skills/interests and major, then this learning is more costly in a semester calendar as one must commit to at least half a year in a major compared to only a third of the year in a quarter system. Our findings on the timing of major switching are consistent with this proposed mechanism: students are no less likely to switch majors overall but they are doing so later on in their college careers. Delayed major switching likely results in needing more time to complete major requirements and, thus, delayed graduation.

4.6 Employment Analysis

Beyond academic outcomes, student employment may also be affected by the switch to semesters. In fact, one reason university administrators cite for making the calendar switch is to give students their best shot at obtaining a summer internship. The belief is that the majority of summer internship programs are geared towards a semester calendar—the most prevalent academic calendar—such that students at institutions on quarters are disadvantaged. One reason students and administrators care about internship opportunities is because of the immediate benefits. While some internships are unpaid, [Jaeger et al. \(2020\)](#) find that 71% of full-time internships are paid.³⁵ Perhaps more importantly, another reason is because of the expected post-graduation labor market returns. A recent study which exploits mandatory firm internships at German Universities finds post-graduation labor market returns of 6% ([Margaryan et al., 2020](#)). In a related vein, a 2017 survey of US employers reports that the most influential characteristic of an applicant in terms of obtaining an offer post-graduation at their firm is an internship at their firm or in that specific industry ([NACE, 2017](#)).

Internships are common across the distribution of institution selectivity, however there is some

³⁵They also show that internships are more likely to be paid the closer the association with a specific occupation, when there is lower unemployment, and when the local and federal minimum wage are the same.

variation in prevalence across majors. A 2018 survey conducted by the National Association of Colleges and Employers reports 60% of recent college graduates hold an internship at some point during college ([NACE, 2018](#)). This number is higher for business majors. According to Bloomberg Businessweek's 2014 Undergraduate Business School Rankings, 75% of business students have an internship during college ([Rodkin, 2018](#)). Student internships are not isolated to elite institutions. In a recent US News and World Report, Stanford University and Massachusetts Institute of Technology are among the top ten institutions with respect to internship placement as are less selective institutions including Northeastern University, University of Cincinnati, and Drexel University ([US News & World Report, Accessed: 2020-3-5](#)).

To investigate whether the calendar switch had a meaningful impact on summer internship employment, we link the transcript data to employment information from the Ohio Department of Job and Family Services (ODJFS). These data include quarterly earnings from all employers in Ohio, and allow us to construct quarterly employment indicators for each student given that they are not self-employed, employed by the Federal government, or employed outside of Ohio. We use these data to estimate the effects of the change to a semester calendar on the probability of employment in the summer following a student's 1st-3rd year of enrollment. Summer employment is coded as one if the student garnered positive earnings in the state of Ohio in Quarter 2 or 3, i.e., April-September. Ideally, we would observe summer internship employment separately from other types of summer employment (e.g., a server or barista job). In lieu of this type of data, we analyze employment in the retail and food service industries separately from all other industries, where all other industries serve as a proxy for summer internship employment.³⁶

Summary statistics for the linked employment data are reported in Table 8. Similar to the survey data described above, in the ODJFS data we find that, in any given summer, approximately 51% of students attending a public university in Ohio are employed in non-retail and non-food service sectors. Students on a semester calendar are employed in a higher share of summers in these types of positions (52.1%) compared to those on a quarter calendar (51.5%) and those two

³⁶We define retail and food service industries as those classified under NAICS codes: 451, 452, 453, 454, and 722.

means are statistically different at the 1% level. This difference is even larger (53.0% vs. 49.9%) for employment in the most critical summer: the summer following one's third year of college enrollment. On the other hand, students on semesters are much less likely to be employed during the school year in all types of jobs. The share of school years that semester students are employed in non-retail and non-food service sectors is 36.7% compared to 41.6% for quarter students. The pattern is similar for retail and food service employment. Taken together these statistics suggest that a semester calendar may slightly improve the odds of obtaining summer internship-type employment and reduce the likelihood of being employed during the school year. Next, we turn to a causal framework to further investigate this possibility.

We begin with an event study analysis by separately estimating Eq. (3) for all types of employment in each of the three summers and report the findings in Figure 6.³⁷ The vertical line at $t = 0$ indicates the first treated cohort for a given summer; e.g., in Figure 6b, $t = 0$ represents the summer following second year for the cohort of students who are in their second year when the policy is adopted. There are three key takeaways: (1) there is minimal evidence of pre-treatment trends in summer employment; (2) there is a dip in summer employment right before policy adoption due to the fact that the transition summer is one month shorter than any other summer; and (3) there is suggestive evidence of a modest increase in summer employment after a student's first year as a result of semester calendar adoption.

Next, we estimate a model similar to Eq. (4) for the summer employment outcome variables. These results are shown in Table 9. In column 1 we report the effect of the calendar change on the share of summers employed, where we allow a student to be employed in the summer after their first, second, or third year. We do not include summer employment after a student's fourth year because a substantial subset of those students will have graduated. Columns 2-4 report the effect of the switch to semesters on summer employment separately for each of those three summers.³⁸

³⁷We do not include an institution-specific linear time trend in any of the employment models since there is no evidence or reason to think that employment is trending differentially across institutions in Ohio.

³⁸Note that the partially treated group, $G1$, is defined separately for each year/column and, in all cases, includes the short summer preceding the calendar switch. In column 2, $G1$ includes students who enrolled 1 year before the switch to semesters. Column 3 includes students enrolled 1 and 2 years before, and in column 4 (and column 1) it includes those enrolled 1-3 years before. In all specifications, the fully treated group, $G2$, includes all students who first enroll

As in Table 7, we restrict the sample to students who remain enrolled for at least four years in the F1999-F2013 cohorts.³⁹

The dependent variables in Panel A of Table 9 indicate summer employment *excluding* the retail and food service industries. Overall the results confirm the findings from Figure 6; that is, there is suggestive evidence that the calendar adoption improves the probability of summer employment in non-food service and non-retail industries following one's first year. However, the point estimate for the summer employment outcome following a student's third year (column 4) is economically and statistically insignificant. An internship following one's third year is likely the most correlated with one's field of study and thus likely the most critical for improving post-graduation labor market outcomes. Panel B reports results for retail and food service employment only. These coefficients are all negative but none attain statistical significance at a conventional level when considering the two more conservative standard error estimates: campus clusters and wild cluster bootstrap p-values.

While the impetus of the employment analysis is to investigate whether semesters change summer internship employment, the calendar adoption may also affect school year employment, particularly if semesters affect scheduling flexibility. Table 10 reports results for student employment during the school year—Quarters 1 and 4 (October-March)—and Figure 7 presents the corresponding event studies. It is clear that school year employment, particularly employment in the retail and food service industries, declines substantially due to the calendar change. The calendar switch decreases the share of school years a student is employed in a retail or food service job by 4.8 pp, which is equivalent to a 23% reduction at the mean (Table 10, column 1).⁴⁰ This result is consistent with the mechanism hypothesis that the higher number of courses per term in a semester system is overwhelming for students. Students on semesters may also have more difficulty in scheduling a part-time job if they are required to take more courses in a term.

In conclusion, when considering the body of evidence (Figure 6 and Table 9), we cannot say at a university that is on a semester calendar.

³⁹Results for the unrestricted sample are very similar and are reported in Table A7.

⁴⁰Results are similar for the sample of students who continue to enroll through the year in which the outcome is measured, see Table A8.

with much certainty that the calendar switch produces meaningful improvements for non-retail and non-food service summer employment, our best proxy for summer internship employment. We do not find any evidence of an effect on this type of employment in the most crucial summer (the summer following one's third year). We do find a positive effect on non-retail and non-food service employment in the summer following students' first year. However, the results in Figure 6 reveal that this is largely driven by an isolated effect on students in the very first treated cohort. Students who enroll in subsequent cohorts one or more years after the switch to semesters do not experience a significant increase in employment during their first summer break. Furthermore, following the calendar switch, we show that students are substantially less likely to be employed during the school year in all types of jobs. This decline in school year employment might be seen as a positive outcome if it leads to improved academic outcomes; however, we do not find this to be the case. It is important to keep in mind that this analysis only includes students who are employed in the state of Ohio and earning positive wages. Our estimates will not capture any effect the calendar switch may have on out-of-state employment opportunities or the propensity to hold unpaid internships.

5 Discussion and Conclusion

The documented negative relationship between the semester calendar and on-time graduation is unexpected. Colleges and universities that have switched to semesters often cite better academic outcomes as a reason for making the shift (Burns, 2013), but we show that it is costly to students academically and does not appear to improve summer employment in a meaningful way. We find that students are 3.7-4.4 pp less likely to graduate on time.

The cost to students of this increase in time-to-degree is substantial and includes both the added tuition and the lost earnings from the additional time spent enrolled. We provide an estimate of this cost using a back-of-the-envelope calculation. Based on a National Center for Education Statistics report, the cost of one year of tuition at a four-year public institution in 2014 was \$18,110 and the

average starting salary for 2014 graduates was \$26,217.⁴¹ Thus, the total cost of an additional year of schooling for a public university student is approximately \$44,327.43.⁴² To put the total cost of the policy into context, consider that the average cohort size in our sample is 1,237 students. If we assume that the 3.7 pp decline in on-time graduation is fully due to a one-year delay in graduation for 46 students per cohort, then a lower bound estimate of the cost of the policy to students would be \$2 million per year at an average-sized university.

Our mechanism analysis suggests that the longer terms and higher number of courses per term associated with a semester calendar are likely driving the estimated increase in time-to-degree. We speculate that these features produce less scheduling flexibility, increase the cost of learning about one's optimal major match, and potentially create a suboptimal learning environment, particularly in a student's first year. As such, to combat these negative effects, higher education institutions that operate on a semester calendar might consider policies that improve scheduling flexibility and providing added academic support to first-year students in order to ease them into the demands of college.

In summary, we view this study as an important step in better understanding the optimal way to design a higher education institution. While this paper provides a thorough analysis of the effect of the conversion to a semester calendar on students' academic behaviors and outcomes, there remain many other potential effects of this policy to be considered in future work. There may be longer-term labor market effects associated with semesters. A longer post-period in administrative data is needed to investigate this possibility. The effects of switching to semesters on faculty research productivity is another factor worth considering. This paper also only addresses traditional, first-time college students and the effects on community college transfer students might differ significantly. Finally, because over the past 30 years schools are almost exclusively switching from quarters to semesters, our results do not allow one to learn about the effects of switching from semesters to quarters.

⁴¹This salary was calculated using the 2014 March Current Population Survey. It includes all individuals who are age 22-24, with a four-year degree, who are not in school, and includes those with a zero wage.

⁴²This is a rough approximation. We acknowledge that there other costs associated with delayed graduation including the year of forgone experience in the labor market. As such, our estimated cost is a lower bound.

References

- Anderson, D Mark and Mary Beth Walker**, “Does Shortening the School Week Impact Student Performance? Evidence from the Four-day School Week,” *Education Finance and Policy*, 2015.
- Ariely, Dan and Klaus Wertenbroch**, “Procrastination, Deadlines, and Performance: Self-control by Precommitment,” *Psychological Science*, 2002, 13 (3), 219–224.
- Bailey, Martha J and Susan M Dynarski**, “Gains and Gaps: Changing Inequality in US College Entry and Completion,” Technical Report, National Bureau of Economic Research 2011.
- Beattie, Graham, Jean-William P Laliberté, and Philip Oreopoulos**, “Thrivers and divers: Using non-academic measures to predict college success and failure,” *Economics of Education Review*, 2018, 62, 170–182.
- Belley, Philippe and Lance Lochner**, “The Changing Role of Family Income and Ability in Determining Educational Achievement,” *Journal of Human Capital*, 2007, 1 (1), 37–89.
- Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan**, “How Much Should We Trust Differences-In-Differences Estimates?,” *The Quarterly Journal of Economics*, 2004, 119 (1), 249–275.
- Bostwick, Valerie K**, “Saved by the Morning Bell: School Start Time and Teen Car Accidents,” *Contemporary Economic Policy*, 2018, 36 (4), 591–606.
- Bound, J, M Lovenheim, and S Turner**, “Understanding the Increased Time to the Baccalaureate Degree,” *Education Finance and Policy*, 2012.
- Bound, John and Sarah Turner**, “Cohort Crowding: How Resources Affect Collegiate Attainment,” *Journal of Public Economics*, 2007, 91 (5-6), 877–899.
- , **Michael F Lovenheim, and Sarah Turner**, “Why Have College Completion Rates Declined? An Analysis of Changing Student Preparation and Collegiate Resources,” *American Economic Journal: Applied Economics*, 2010, 2 (3), 129–57.
- Burns, G**, “Ohio Universities Still Adjusting After Switching from Quarters to Semesters,” *The Bowling Green News*, 2013.
- Buser, Thomas and Noemi Peter**, “Multitasking,” *Experimental Economics*, 2012, 15 (4), 641–655.
- Cameron, A Colin, Jonah B Gelbach, and Douglas L Miller**, “Bootstrap-based Improvements for Inference with Clustered Errors,” *The Review of Economics and Statistics*, 2008, 90 (3), 414–427.
- Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller**, “Robust Inference With Multi-way Clustering,” *Journal of Business & Economic Statistics*, 2011, 29 (2), 238–249.
- Carneiro, Pedro and James J Heckman**, “The Evidence on Credit Constraints in Post-Secondary Schooling,” *The Economic Journal*, 2002, 112 (482), 705–734.

- Carrell, Scott E, Teny Maghakian, and James E West**, “A’s from Zzzz’s? The Causal Effect of School Start Time on the Academic Achievement of Adolescents,” *American Economic Journal: Economic Policy*, 2011, 3 (3), 62–81.
- Castleman, Benjamin L. and Bridget Terry Long**, “Looking Beyond Enrollment: The Causal Effect of Need-Based Grants on College Access, Persistence, and Graduation,” *Journal of Labor Economics*, 2016, 34 (4), 1023–1073.
- Cohodes, Sarah R and Joshua S Goodman**, “Merit Aid, College Quality, and College Completion: Massachusetts’ Adams Scholarship as an In-Kind Subsidy,” *American Economic Journal: Applied Economics*, 2014, 6 (4), 251–85.
- Coleman, Daniel, John R Bolte, and Leroy Franklin**, “Academic Calendar Change Impact on Enrollment Patterns and Instructional Outcomes,” *Research in Higher Education*, 1984, 20 (2), 155–166.
- Cortes, Kalena E, Jesse Bricker, and Chris Rohlfs**, “The Role of Specific Subjects in Education Production Functions: Evidence from Morning Classes in Chicago Public High Schools,” *The BE Journal of Economic Analysis & Policy*, 2012, 12 (1).
- Day, James F**, “Student Perceptions of a University Learning Environment: Five Years After an Academic Calendar Change,” *Iowa State Digital Repository*, 1987.
- Deming, David J and Christopher R Walters**, “The Impact of Price Caps and Spending Cuts on US Postsecondary Attainment,” Technical Report, National Bureau of Economic Research 2017.
- Denning, Jeffrey T, Benjamin M Marx, and Lesley J Turner**, “ProPelled: The Effects of Grants on Graduation, Earnings, and Welfare,” *American Economic Journal: Applied Economics*, 2019.
- , **Eric R Eide, Kevin J Mumford, Richard W Patterson, and Merrill Warnick**, “Why Have College Completion Rates Increased,” Technical Report 2020.
- Depro, Brooks and Kathryn Rouse**, “The Effect of Multi-Track Year-Round Academic Calendars on Property Values: Evidence from District Imposed School Calendar Conversions,” *Economics of Education Review*, 2015, 49, 157–171.
- Edwards, Finley**, “Early to Rise? The Effect of Daily Start Times on Academic Performance,” *Economics of Education Review*, 2012, 31 (6), 970–983.
- Fischer, Stefanie and Daniel Argyle**, “Juvenile Crime and the Four-Day School Week,” *Economics of Education Review*, 2018, 64, 31–39.
- Fitzmorris, Olivia**, *Throwback Thursday: Quarter or Semester System? The Debate UCLA Has Been Having for Decades* 2019. <https://dailybruin.com/2019/04/25/throwback-thursday-quarter-or-semester-system-the-debate-ucla-has-been-having-for-decades/>.
- Gibbens, Brian, Mary A Williams, Anna K Strain, and Courtney DM Hoff**, “Comparison Of Biology Student Performance in Quarter and Semester Systems,” *College and University*, 2015, 90 (3), 12.

- Goodman-Bacon, Andrew**, “Difference-in-Differences with Variation in Treatment Timing,” Technical Report, National Bureau of Economic Research 2018.
- Gordon, L**, “Cal State Joins National Trend to Switch to 15-Week Semesters,” *EdSource*, 2016.
- Graves, Jennifer**, “The Academic Impact of Multi-Track Year-Round School Calendars: A Response to School Overcrowding,” *Journal of Urban Economics*, 2010, 67 (3), 378–391.
- Hinrichs, Peter**, “When the Bell Tolls: The Effects of School Starting Times on Academic Achievement,” *Education Finance and Policy*, 2011, 6 (4), 486–507.
- Jacob, Brian A and Jonah E Rockoff**, *Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments*, Brookings Institution, Hamilton Project Washington, DC, 2011.
- Jaeger, David, John Nunley, Alan Seals, and Eric Wilbrandt**, “The Demand for Interns,” Technical Report, National Bureau of Economic Research 2020.
- Malone, Kemp**, “Semester,” *American Speech*, 1946, 21 (4), 264–269.
- Margaryan, Shushanik, Nils Saniter, Mathias Schumann, and Thomas Siedler**, “Do Internships Pay Off: The Effects of Student Internships on Earnings,” *Journal of Human Resources*, 2020.
- Matzelle, Raymond, Gael Grossman, Michele Lawlor, Benjamin Rosenberger, Lou Ann Smacchi, and Mark Orr**, “A Study of the Term and Semester Calendars in a Two Year Community College,” Technical Report 1995.
- McMullen, Steven C and Kathryn E Rouse**, “The Impact of Year-round Schooling on Academic Achievement: Evidence from Mandatory School Calendar Conversions,” *American Economic Journal: Economic Policy*, 2012, 4 (4), 230–252.
- Mora, Ricardo and Iliana Reggio**, “Alternative Diff-in-Diffs Estimators with Several Pretreatment Periods,” *Econometric Reviews*, 2019, 38 (5), 465–486.
- Morris, Melissa**, *Chancellor Gene Block Supports Switching UCLA to Semester System* 2019. <https://dailybruin.com/2019/04/02/chancellor-gene-block-supports-switching-ucla-to-semester-system/>.
- NACE**, “Job Outlook 2018 Technical Report,” Technical Report 2017.
- , “Student Survey Report: Attitudes and Preferences of Bachelor’s Degree Students,” Technical Report 2018.
- Pant, Meagan**, “Colleges Spend Millions to Switch to Semesters,” *Dayton Daily News*, Mar 2012.
- Ramzanali, Asad**, *Quarter System Better for Students and Faculty* 2010. https://dailybruin.com/2010/09/19/quarter_system_better_for_students_and_faculty/.

Rodkin, Jonathan, “Skipped Your College Internship? You’re Far Less Likely to Get a Job in Business,” *Bloomberg Business Week*, 2018.

Scott-Clayton, Judith, “On Money and Motivation: A Quasi-experimental Analysis of Financial Incentives for College Achievement,” *Journal of Human Resources*, 2011, 46 (3), 614–646.

Singell, Larry D, “Come and Stay a While: Does Financial Aid Effect Retention Conditioned on Enrollment at a Large Public University?,” *Economics of Education Review*, 2004, 23 (5), 459–471.

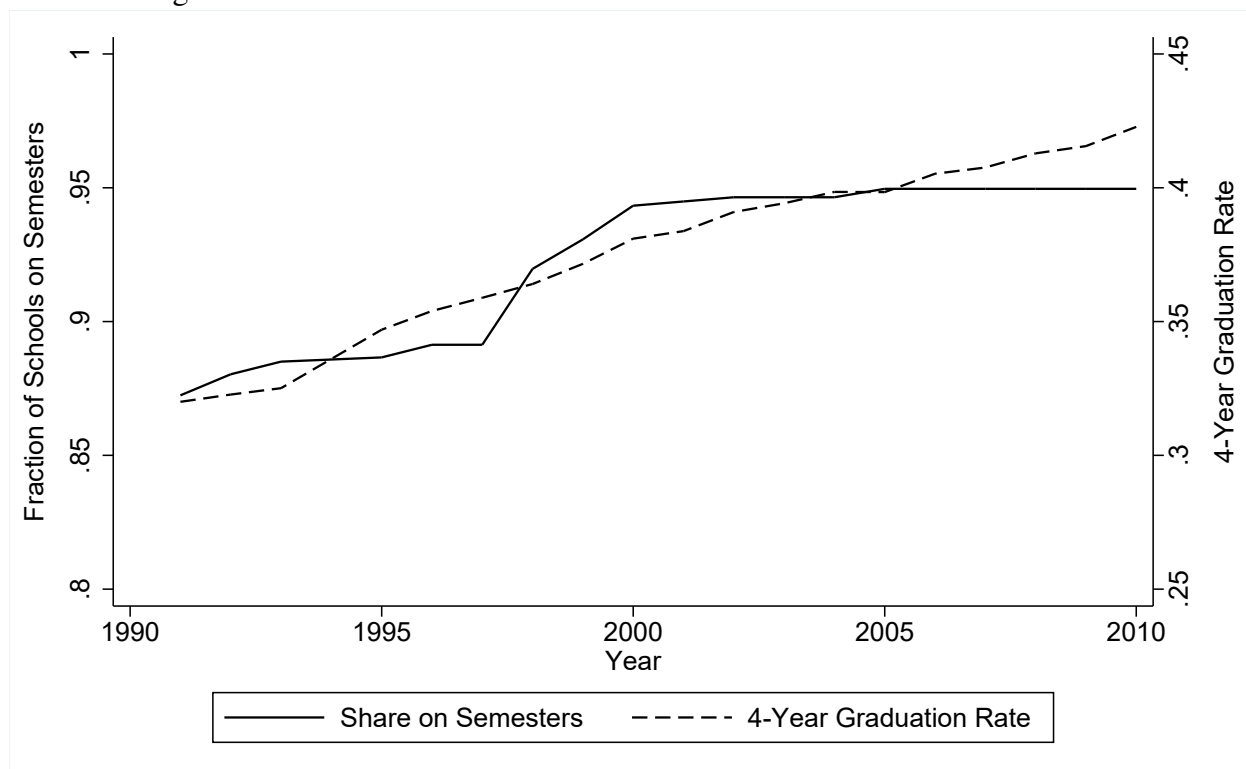
Sklar, Jeffrey, “The Impact of Change of Major on Time to Bachelors Degree Completion with Special emphasis on STEM disciplines: A Multilevel Discrete-Time Hazard Modeling Approach,” 2015.

Smith, Mitch, “Strength in Numbers,” *Inside Higher Ed*, 2012.

US News & World Report, “Co-ops/Internships in U.S. New Best Colleges,” Accessed: 2020-3-5. <https://www.usnews.com/best-colleges/rankings/internship-programs>.

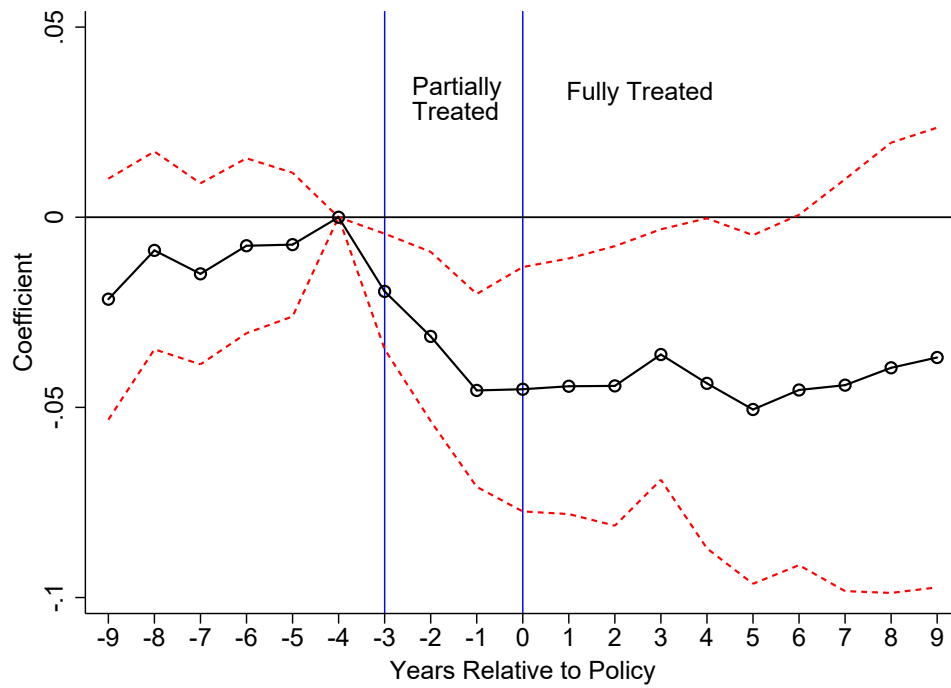
Warner, Andrew and Elizabeth Hanczor, *The Quad: The Long, Convoluted History that Entrenches the Quarter System at UCLA* 2018. <https://dailybruin.com/2018/06/08/the-quad-the-long-convoluted-history-that-entrenches-the-quarter-system-at-ucla/>.

Figure 1: Fraction of Schools on Semesters and Four-Year Graduation Rates

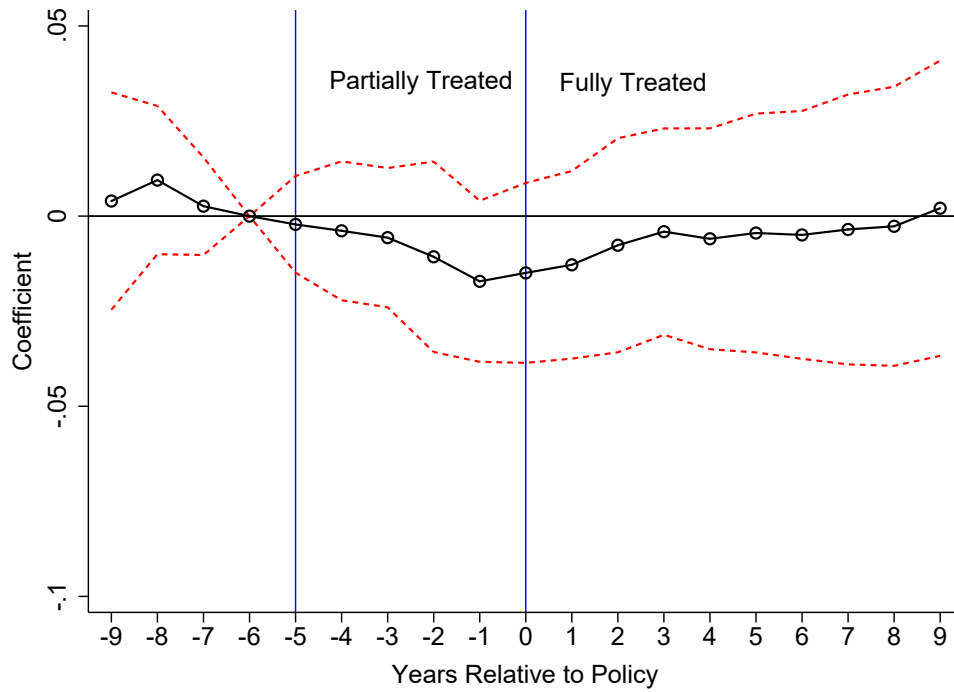


Data Source: IPEDS. Data on graduation rates are for the 1991-2010 cohorts.

Figure 2: Event Study: Institution-Level Analysis
(a) 4-year Graduation Rates

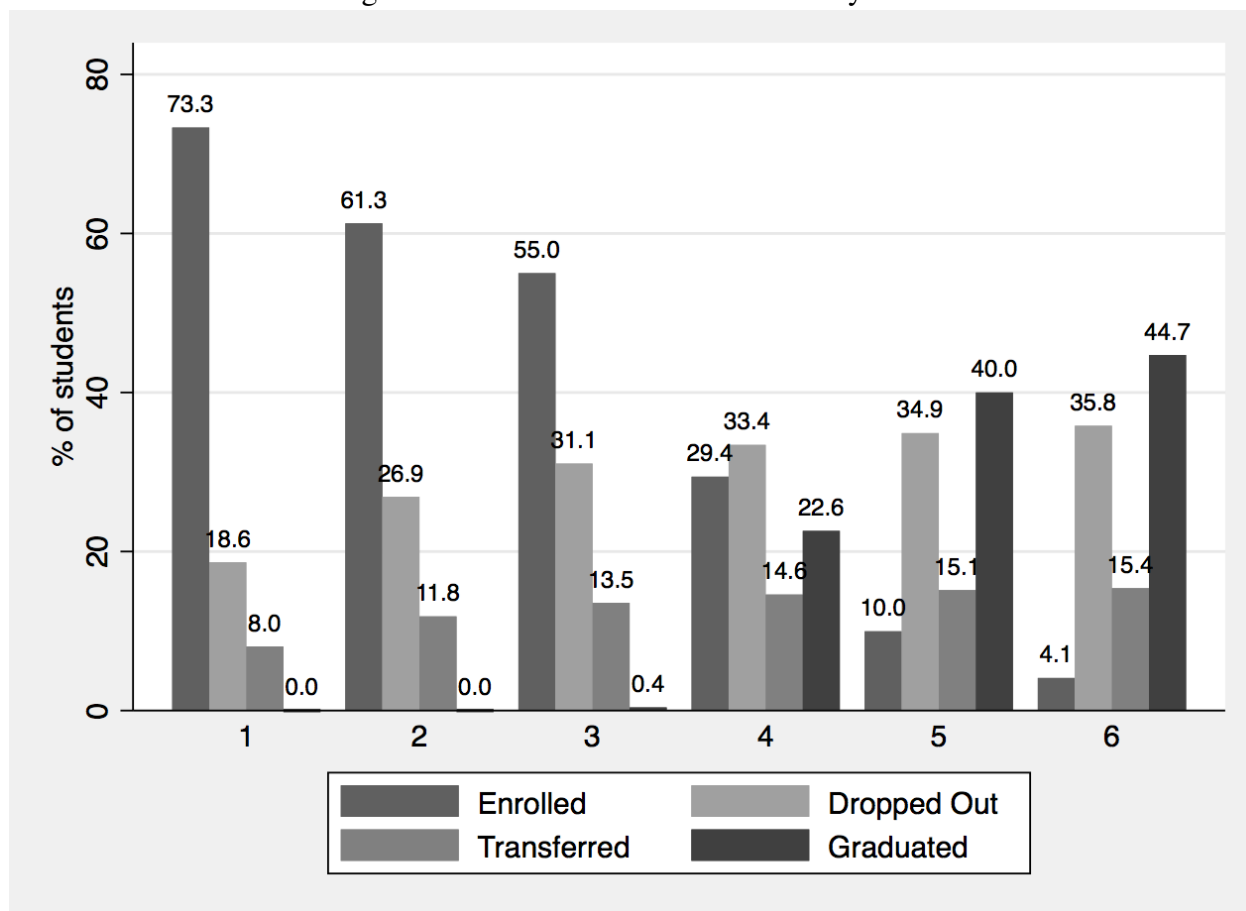


(b) 6-year Graduation Rates



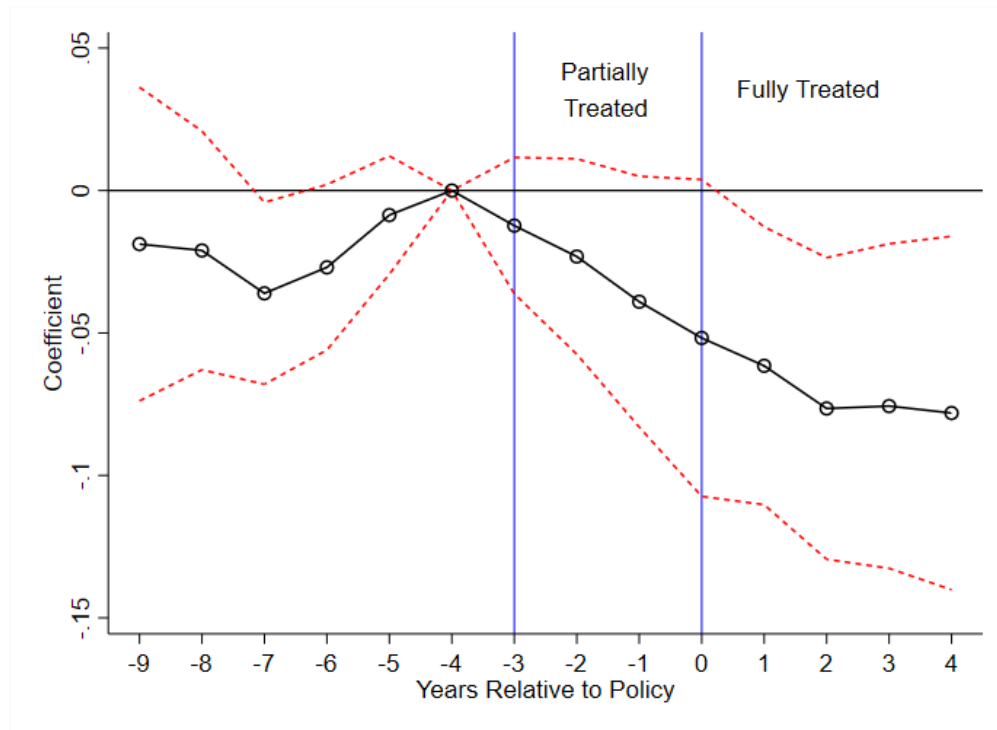
Data Source: IPEDS. Notes: The sample includes 731 institutions for 19 years (13,889 observations). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (1). Year and institution fixed effects, institution-specific linear time trends, and time varying controls are included. See Figure A1 and Figure A2 for various robustness checks. Standard errors are clustered at the institution level.

Figure 3: Students' Enrollment Status By Year

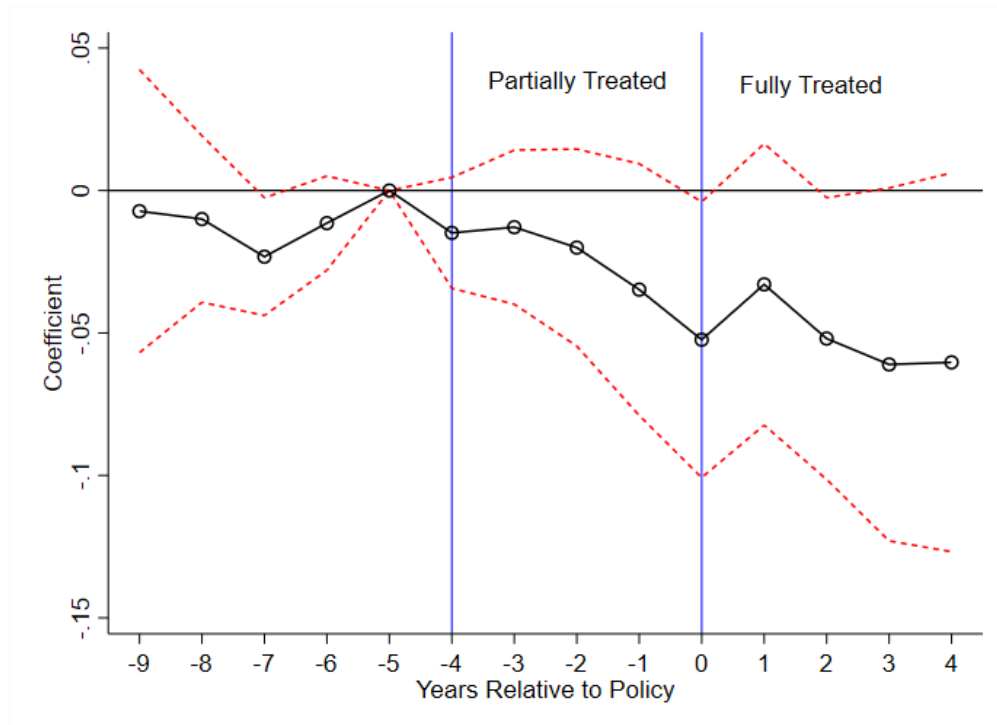


Data Source: OLDA. Notes: X-axis measures years since initial matriculation. Sample includes all students who enroll as first-time freshmen at a bachelor's degree-granting public Ohio institution in the Fall terms of 1999-2011.

Figure 4: Event Study: Individual-Level Analysis
(a) 4-year Graduation Rates



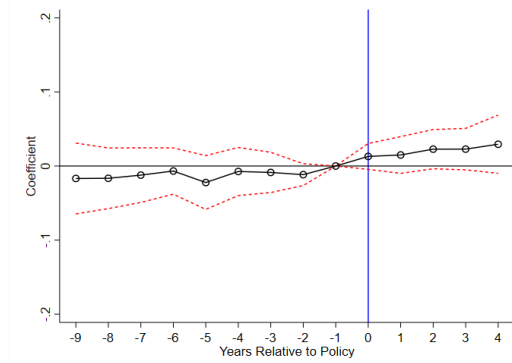
(b) 5-year Graduation Rates



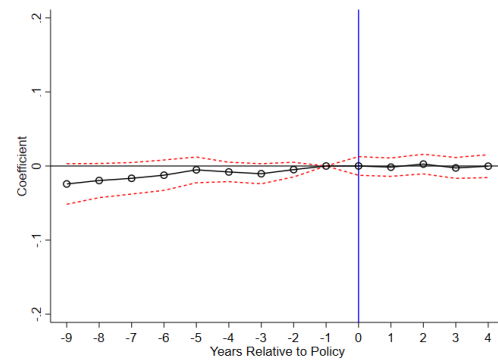
Data Source: OLDA. Notes: In (a) the sample includes students who enter as first-time freshmen in the F1999-F2013 cohorts (627,988 observations). In (b) it includes students who enter as first-time freshmen in the F1999-F2012 cohorts (585,935 observations). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (3). Year and institution fixed effects, institution linear time trends, and student-level controls are included. Standard errors are estimated using multiway clustering.

Figure 5: Event Study: Mechanism Analysis—First-Year Outcomes

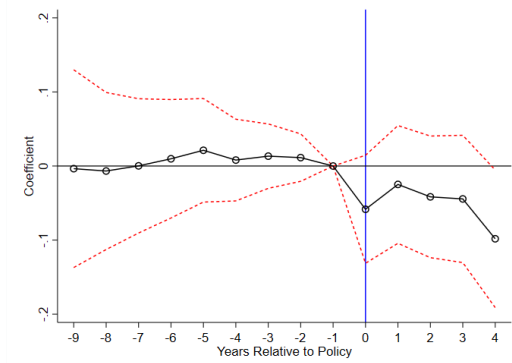
(a) Dropout End of Yr. 1



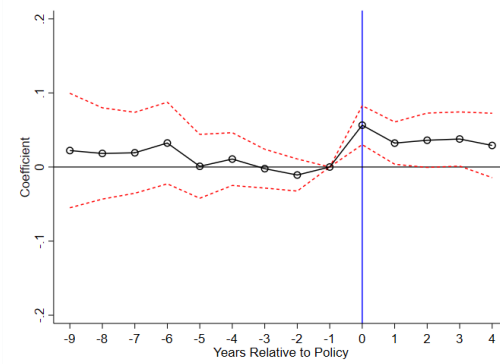
(b) Transfer End of Yr. 1



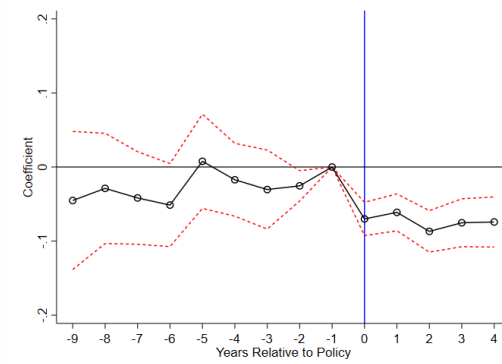
(c) Full Course Load in Yr. 1



(d) Academic Probation in Yr. 1



(e) Switch Major in Yr. 1

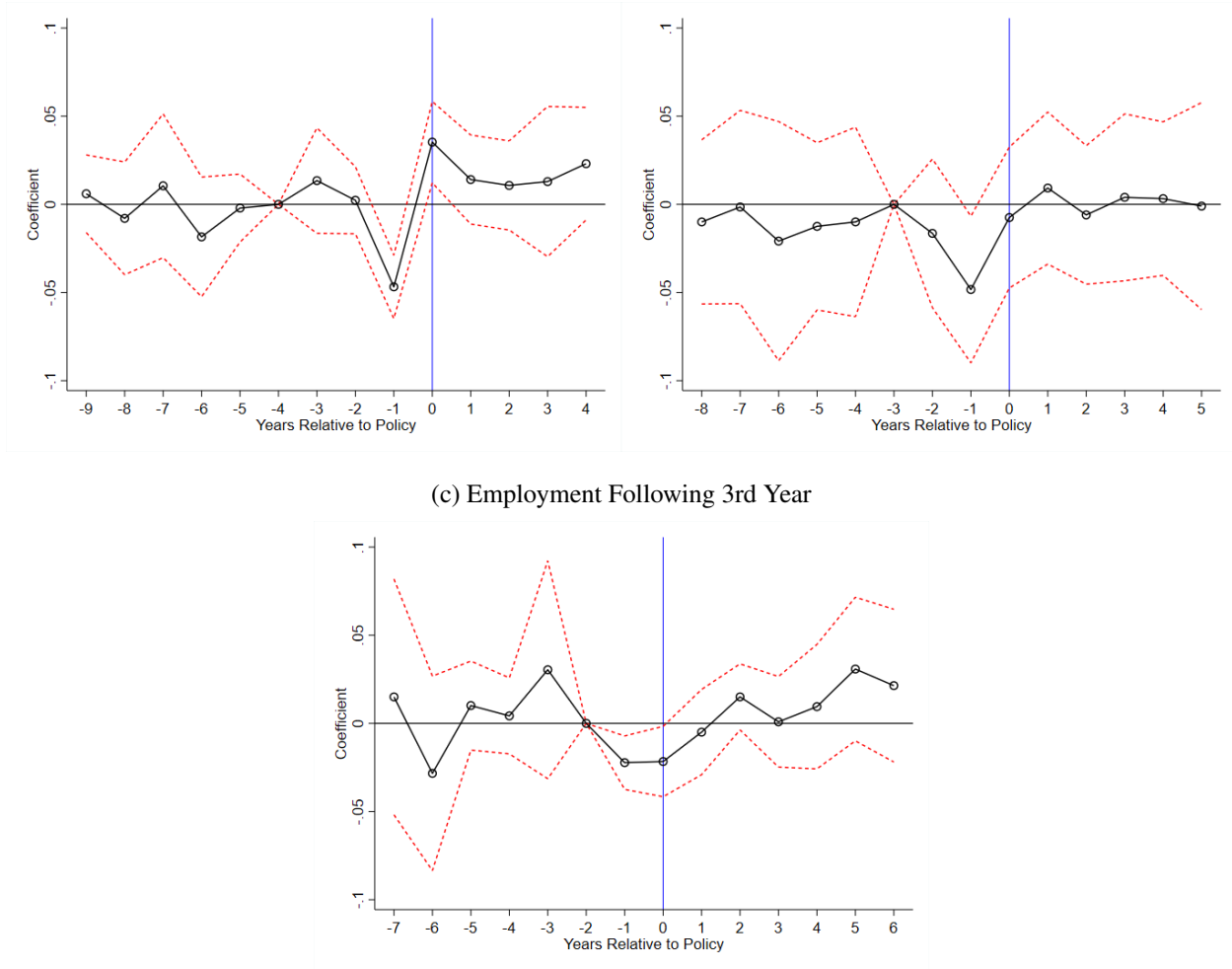


Data Source: OLDA. Notes: The sample includes students who enter as first-time freshmen in the F1999-F2015 cohorts (709,404 observations). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (3). The vertical line at $t = 0$ indicates the year of semester adoption; i.e., $t = 0$ represents the cohort of students who are in their first year in the year of adoption. Year and institution fixed effects, institution linear time trends, and student-level controls are included. Standard errors are estimated using multiway clustering.

Figure 6: Event Study: Summer Employment (Q2 and Q3)

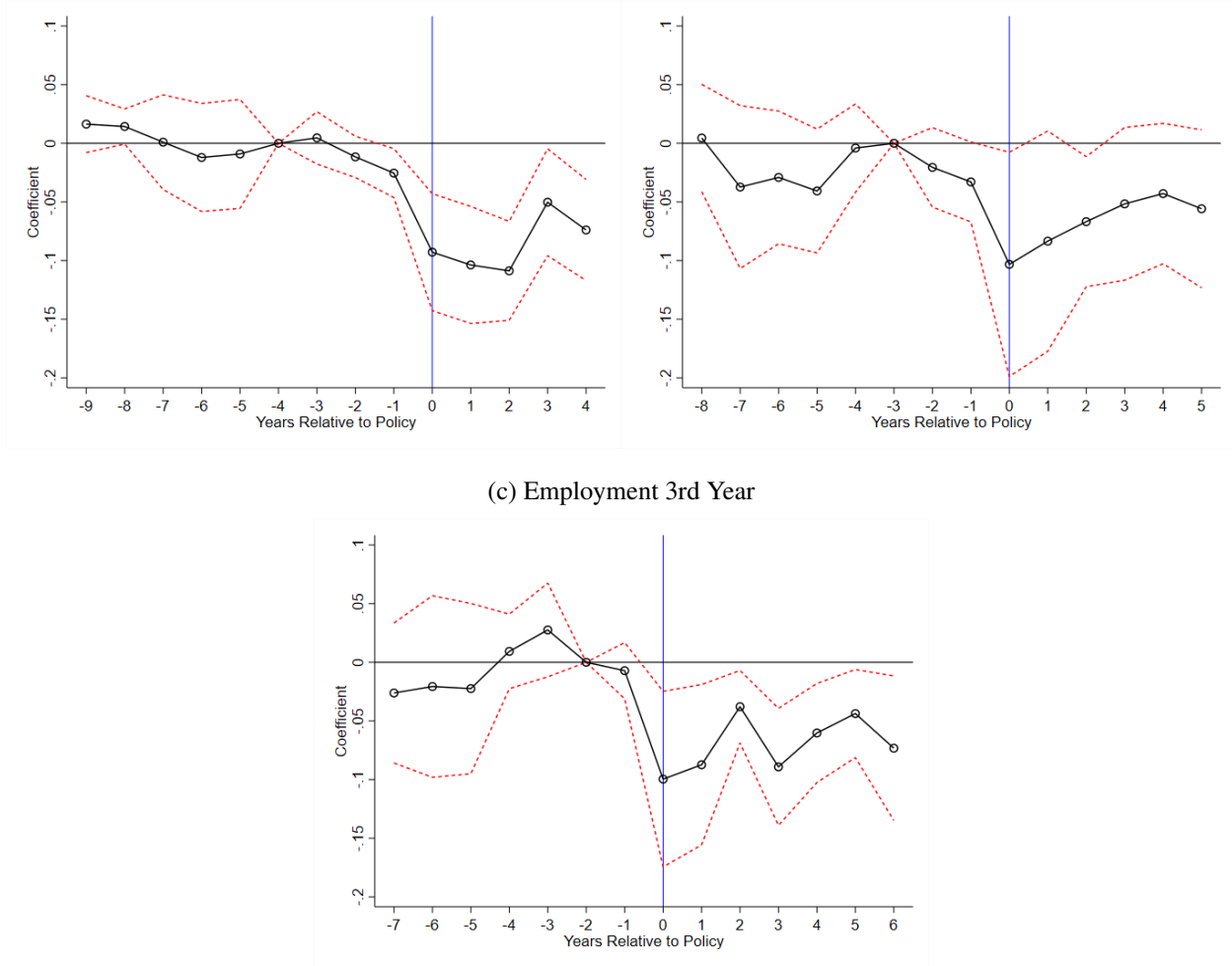
(a) Employment Following 1st Year

(b) Employment Following 2nd Year



Data Source: OLDA merged with employment data from ODJFS. Notes: The sample includes students who enter as first-time freshmen in the F2000-F2013 cohorts who remain enrolled for 4+ years and can be linked to ODJFS employment data (296,416 obs). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (3). The vertical line at $t = 0$ indicates the first treated cohort for a given summer; e.g., in Figure 6b, $t = 0$ represents the summer following second year for the cohort of students who are in their second year when the policy is adopted. Year and institution fixed effects and student-level controls are included. Standard errors are estimated using multiway clustering.

Figure 7: Event Study: School Year Employment (Q1 and Q4)
 (a) Employment 1st Year (b) Employment 2nd Year



Data Source: OLDA merged with employment data from ODJFS. Notes: The sample includes students who enter as first-time freshmen in the F2000-F2013 cohorts who remain enrolled for 4+ years and can be linked to ODJFS employment data (296,416 obs). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (3). The vertical line at $t = 0$ indicates the first treated cohort for a given school year; e.g., in Figure 7b, $t = 0$ represents the cohort of students who are in their second year when the policy is adopted. Year and institution fixed effects and student-level controls are included. Standard errors are estimated using multiway clustering.

Table 1: Institution-Level Summary Statistics

	All	Never Switchers	Switchers
	(1)	(2)	(3)
Semester calendar	0.93 (0.25)	0.96 (0.20)	0.72 (0.46)
Four-yr grad rate	0.36 (0.22)	0.37 (0.22)	0.28 (0.16)
Four-yr women grad rate	0.40 (0.22)	0.42 (0.23)	0.34 (0.18)
Four-yr men grad rate	0.30 (0.21)	0.31 (0.22)	0.23 (0.15)
Four-yr URM grad rate	0.29 (0.20)	0.30 (0.21)	0.21 (0.14)
Four-yr non URM grad rate	0.37 (0.22)	0.39 (0.23)	0.30 (0.17)
Six-yr grad rate	0.58 (0.18)	0.59 (0.18)	0.54 (0.17)
Six-yr women grad rate	0.61 (0.17)	0.62 (0.17)	0.57 (0.17)
Six-yr men grad rate	0.55 (0.19)	0.55 (0.19)	0.51 (0.18)
Six-yr URM grad rate	0.51 (0.19)	0.51 (0.19)	0.46 (0.17)
Six-yr non URM grad rate	0.60 (0.18)	0.61 (0.18)	0.56 (0.17)
Public	0.46 (0.50)	0.42 (0.49)	0.71 (0.45)
FTE faculty	340.00 (382.59)	330.24 (372.32)	420.58 (450.77)
Cohort size	1,099.45 (1,183.03)	1,065.99 (1,148.55)	1,375.54 (1,406.74)
In-state tuition	11,088.47 (9,181.55)	11,554.71 (9,298.51)	7,240.46 (7,063.64)
Total expenditures (\$/1M)	192.10 (400.54)	185.14 (390.65)	249.54 (470.59)
Observations	13,889	12,388	1,501

Data Source: IPEDS. Notes: The balanced panel dataset includes the 1991-2010 entering cohorts. There are 731 institutions and 19 years. An observation is an institution-year. Standard deviations are reported in parentheses.

Table 2: Effect of Switching to Semesters on Institution and Student Characteristics

	<u>Institution Characteristics</u>				<u>Student Characteristics</u>		
	FTE Faculty (1)	Costs (2)	In-State Tuition (3)	Cohort Size (4)	% URM (5)	% White (6)	% Female (7)
Semester	-0.282 (6.733)	6.435 (7.961)	346.717*** (115.741)	-33.185 (40.368)	0.009 (0.008)	-0.011 (0.008)	-0.005 (0.004)
Mean of outcome	340.00	192.10	11,088.47	1,099.45	0.25	0.71	0.56
Observations	13,889	13,889	13,889	13,889	13,889	13,889	13,889

Data Source: IPEDS. Notes: Each column represents a separate regression, where different pre-treatment characteristics are the outcomes. All regressions include a dummy for being on a semester calendar, year fixed effects, institution fixed effects and institution-specific linear time trends. Standard errors are reported in parentheses and are clustered at the institution level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Effect of Switching to Semesters on Graduation Rates—Institution-Level Analysis

	All (1)	All (2)	All (3)	All (4)	Women (5)	Men (6)	URM (7)	Non-URM (8)	Public (9)	Private (10)
Panel A: Effect on 4-year Grad. Rates										
G1 - partially treated	-0.003 (0.016)	-0.013 (0.010)	-0.021** (0.009)	-0.024*** (0.009)	-0.023** (0.010)	-0.025*** (0.008)	-0.022** (0.011)	-0.024** (0.010)	-0.022** (0.010)	-0.015 (0.015)
G2 - fully treated	-0.009 (0.020)	-0.015 (0.017)	-0.035*** (0.012)	-0.037*** (0.012)	-0.037*** (0.014)	-0.038*** (0.012)	-0.028* (0.017)	-0.039*** (0.013)	-0.032** (0.014)	-0.036* (0.020)
Panel B: Effect on 6-year Grad. Rates										
G1 - partially treated	0.010 (0.019)	0.002 (0.013)	-0.011 (0.009)	-0.013 (0.008)	-0.014 (0.009)	-0.011 (0.008)	-0.020 (0.013)	-0.010 (0.009)	-0.013 (0.009)	-0.011 (0.007)
G2 - fully treated	0.024 (0.018)	0.016 (0.014)	-0.012 (0.010)	-0.014 (0.010)	-0.017 (0.012)	-0.009 (0.010)	-0.027 (0.019)	-0.013 (0.010)	-0.012 (0.011)	-0.019* (0.011)
Observations	13,889	13,889	13,889	13,889	13,865	13,824	13,883	13,799	6,365	7,524
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institution-Specific Time Trends	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Notes: The sample includes 731 institutions for 19 years. All regressions are weighted by average cohort size. Within each panel and column, point estimates come from the same regression. The left out category is G0, the pre-treatment years, and is defined as ($k \leq -4$) for the four-year graduation outcome and ($k \leq -6$) for the six-year graduation outcome. Standard errors are reported in parentheses and are clustered at the institution level. Results are robust to holding constant the sample size across the columns. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Individual-Level Summary Statistics

	Mean	Std. Dev.	N
<u>Panel A: Characteristics - First-Year Students</u>			
Female	0.53	0.50	709,404
White	0.78	0.41	709,404
Black	0.11	0.31	709,404
Hispanic	0.02	0.15	709,404
Asian	0.02	0.14	709,404
Other race	0.07	0.25	709,404
Foreign-born	0.02	0.13	709,404
Age	19.03	3.18	709,404
<u>Panel B: Graduation Outcomes</u>			
Four-yr grad rate	0.23	0.42	627,988
Five-yr grade rate	0.40	0.49	585,935
<u>Panel C: First-Year Academic Outcomes</u>			
Drop out	0.20	0.40	709,404
Transfer out	0.08	0.27	709,404
Full course load	0.54	0.50	709,404
Cummulative GPA	2.53	1.06	709,404
Cumm. GPA <2.0	0.24	0.43	709,404
Switch major	0.11	0.32	709,404

Data Source: OLDA. Notes: Observation counts in Panels A and C include all students who enroll as first-time freshmen at a bachelor's degree-granting public institution in the fall term of the years 1999-2015. In Panel B, 4-yr graduation rates are measured only for the F1999-F2013 cohorts and 5-yr graduation rates are measured only for the F1999-F2012 cohorts.

Table 5: Effect of Switching to Semesters on Graduation Rates—Individual-Level Analysis

	All (1)	Women (2)	Men (3)	URM (4)	Non- URM (5)	Low- Income (6)	Higher- Income (7)
Panel A: Effect on 4-year Grad. Rates							
G1 - partially treated	-0.010	-0.004	-0.017	-0.007	-0.011	-0.015	-0.006
SE multi-way clustered	(0.013)	(0.014)	(0.014)	(0.019)	(0.013)	(0.012)	(0.018)
SE clustered by campus	(0.016)	(0.017)	(0.016)	(0.025)	(0.016)	(0.015)	(0.021)
Wild cluster bootstrap p-value	[0.64]	[0.78]	[0.48]	[0.64]	[0.62]	[0.51]	[0.81]
G2 - fully treated	-0.044	-0.044	-0.045	-0.026	-0.050	-0.039	-0.045
SE multi-way clustered	(0.021)**	(0.021)**	(0.022)**	(0.030)	(0.021)**	(0.017)**	(0.023)*
SE clustered by campus	(0.030)	(0.031)	(0.029)	(0.044)	(0.030)*	(0.024)	(0.033)
Wild cluster bootstrap p-value	[0.35]	[0.41]	[0.32]	[0.53]	[0.21]	[0.24]	[0.44]
Mean of Outcome Variable	0.23	0.28	0.18	0.11	0.25	0.18	0.29
Observations	627,988	333,163	294,825	82,423	545,565	292,380	298,730
Panel B: Effect on 5-year Grad. Rates							
G1 - partially treated	-0.007	-0.007	-0.008	-0.009	-0.007	-0.005	-0.004
SE multi-way clustered	(0.012)	(0.012)	(0.013)	(0.022)	(0.012)	(0.011)	(0.018)
SE clustered by campus	(0.015)	(0.015)	(0.016)	(0.028)	(0.014)	(0.014)	(0.021)
Wild cluster bootstrap p-value	[0.70]	[0.70]	[0.73]	[0.75]	[0.71]	[0.70]	[0.85]
G2 - fully treated	-0.034	-0.025	-0.043	-0.011	-0.042	-0.020	-0.035
SE multi-way clustered	(0.018)*	(0.017)	(0.020)**	(0.033)	(0.017)**	(0.014)	(0.024)
SE clustered by campus	(0.028)	(0.024)	(0.033)	(0.051)	(0.027)	(0.021)	(0.035)
Wild cluster bootstrap p-value	[0.44]	[0.47]	[0.38]	[0.83]	[0.20]	[0.52]	[0.55]
Mean of Outcome Variable	0.40	0.43	0.37	0.23	0.43	0.33	0.49
Observations	585,935	310,836	275,099	76,528	509,407	274,577	277,320

Data Source: OLDA linked to Mean Household Income by Zip Code from the 2006-2010 American Community Survey (<https://www.psc.isr.umich.edu/dis/census/Features/tract2zip/>). Notes on Panel A: Includes students who enter as first-time freshmen in the F1999-F2013 cohorts. The partially treated group, G1, includes students who first enroll at a university 1 to 3 years prior to the adoption of a semester calendar and the omitted category includes all students who enroll more than 3 years prior to the calendar switch. Notes on Panel B: Includes student who enter in the F1999-F2012 cohorts. The partially treated group includes students who first enroll 1 to 4 years prior to the switch to semesters and the omitted category includes all students who enrolled more than 4 years prior to the switch. In both panels, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, campus and year fixed-effects, and campus-specific linear time trends. ***p<0.01, **p<0.05, *p<0.10.

Table 6: Effect of Switching to Semesters on First-Year Outcomes

	Drop Out (1)	Transfer Out (2)	On-Track Course Taking (3)	Cum. GPA <2.0 (4)	Switch Major (5)
G2 - fully treated	0.020	0.001	-0.068	0.049	-0.071
SE multi-way clustered	(0.007)***	(0.005)	(0.036)*	(0.010)***	(0.007)***
SE clustered by campus	(0.009)**	(0.007)	(0.044)	(0.013)***	(0.009)***
Wild cluster bootstrap p-value	[0.05]**	[0.95]	[0.25]	[0.01]***	[0.00]***
Mean of Outcome	0.20	0.08	0.54	0.24	0.11
Observations	709,404	709,404	709,404	709,404	709,404

Data Source: OLDA. Notes: The sample includes students who enter as first-time freshmen in the F1999-F2015 cohorts. The omitted category includes all students who enroll prior to the adoption of semesters. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, campus and year fixed-effects, and campus-specific linear time trends. ***p<0.01, **p<0.05, *p<0.10.

Table 7: Effect of Switching to Semesters on Student-Level Cumulative Outcomes by Year in School

	Year 1 (1)	Year 2 (2)	Year 3 (3)	Year 4 (4)
Panel A: Outcome - Cumulative # of Credits is On-Track				
G1 - partially treated		-0.069	-0.053	-0.051
SE multi-way clustered		(0.014)***	(0.021)**	(0.018)***
SE clustered by campus		(0.014)***	(0.026)**	(0.023)**
Wild cluster bootstrap p-value		[0.00]***	[0.17]	[0.15]
G2 - fully treated	-0.083	-0.112	-0.108	-0.115
SE multi-way clustered	(0.042)*	(0.026)***	(0.031)***	(0.026)***
SE clustered by campus	(0.048)*	(0.032)***	(0.041)**	(0.040)***
Wild cluster bootstrap p-value	[0.26]	[0.01]***	[0.06]*	[0.03]**
Mean of Outcome	0.73	0.68	0.64	0.62
Panel B: Outcome - Cum. GPA < 2.0				
G1 - partially treated		0.013	0.015	0.018
SE multi-way clustered		(0.003)***	(0.004)***	(0.005)***
SE clustered by campus		(0.004)***	(0.005)***	(0.006)***
Wild cluster bootstrap p-value		[0.02]**	[0.03]**	[0.02]**
G2 - fully treated	0.013	0.009	0.014	0.012
SE multi-way clustered	(0.006)**	(0.005)*	(0.004)***	(0.005)**
SE clustered by campus	(0.008)	(0.006)	(0.006)**	(0.006)*
Wild cluster bootstrap p-value	[0.24]	[0.29]	[0.15]	[0.14]
Mean of Outcome	0.06	0.04	0.03	0.04
Panel C: Outcome - Has Ever Switched Major				
G1 - partially treated		-0.030	0.005	0.040
SE multi-way clustered		(0.028)	(0.033)	(0.028)
SE clustered by campus		(0.034)	(0.039)	(0.034)
Wild cluster bootstrap p-value		[0.43]	[0.91]	[0.35]
G2 - fully treated	-0.064	-0.082	-0.052	-0.022
SE clustered by campus	(0.011)***	(0.025)***	(0.036)	(0.033)
SE clustered by campus	(0.011)***	(0.032)**	(0.043)	(0.041)
Wild cluster bootstrap p-value	[0.00]***	[0.00]***	[0.33]	[0.62]
Mean of Outcome	0.13	0.40	0.55	0.61

Data Source: OLDA. Notes: Sample includes first-time freshmen in the F1999-F2013 cohorts who remain enrolled for 4+ years (341,646 obs). The partially treated group is defined separately for each year/column. In column (2), G1 includes students who enrolled 1 year before the switch to semesters. In columns (3) and (4), G1 also includes student who enroll 2 and 3 years before the calendar switch, respectively. In all specifications, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, campus and year fixed-effects, and campus-specific linear time trends. ***p<0.01, **p<0.05, *p<0.10.

Table 8: Employment Summary Statistics

	All Students (1)	Students on Quarters (2)	Students on Semesters (3)
<u>Panel A: Excluding Retail and Food Service Employment</u>			
Share of Summers Employed	0.512 (0.388)	0.515 (0.381)	0.521 (0.393)
Employed Summer After Y1	0.508 (0.500)	0.532 (0.499)	0.509 (0.500)
Employed Summer After Y2	0.514 (0.500)	0.514 (0.500)	0.524 (0.499)
Employed Summer After Y3	0.514 (0.500)	0.499 (0.500)	0.530 (0.499)
Share of School-Years Employed	0.379 (0.355)	0.416 (0.356)	0.367 (0.356)
Employed During SY1	0.310 (0.462)	0.366 (0.482)	0.289 (0.453)
Employed During SY2	0.371 (0.483)	0.415 (0.493)	0.358 (0.479)
Employed During SY3	0.405 (0.491)	0.437 (0.496)	0.397 (0.489)
Employed During SY4	0.429 (0.495)	0.448 (0.497)	0.423 (0.494)
<u>Panel B: Retail and Food Service Employment Only</u>			
Share of Summers Employed	0.228 (0.334)	0.212 (0.322)	0.240 (0.342)
Employed Summer After Y1	0.235 (0.424)	0.222 (0.415)	0.246 (0.430)
Employed Summer After Y2	0.229 (0.420)	0.215 (0.411)	0.241 (0.428)
Employed Summer After Y3	0.219 (0.413)	0.200 (0.400)	0.234 (0.423)
Share of School-Years Employed	0.210 (0.308)	0.210 (0.306)	0.214 (0.311)
Employed During SY1	0.197 (0.398)	0.209 (0.407)	0.193 (0.395)
Employed During SY2	0.215 (0.411)	0.220 (0.415)	0.217 (0.412)
Employed During SY3	0.216 (0.412)	0.213 (0.409)	0.224 (0.417)
Employed During SY4	0.211 (0.408)	0.199 (0.399)	0.223 (0.416)
Observations	296,416	92,679	171,746

Data Source: OLDA linked to ODJFS Unemployment Insurance Quarterly Wage data. Notes: Sample includes first-time freshmen in the F2000-F2013 cohorts who remain enrolled for 4+ years and can be linked to ODJFS employment data. 31,991 “partially treated” observations are not included in columns 2 and 3.

Table 9: Effect of Switching to Semesters on Summer Employment (Q2 or Q3)

	Share of Summers Employed	Employed Summer After:		
		1st Year	2nd Year	3rd Year
	(1)	(2)	(3)	(4)
Panel A: Excluding Retail and Food Service Employment				
G2 - fully treated	0.022	0.026	0.022	0.013
SE multi-way clustered	(0.011)*	(0.009)***	(0.013)*	(0.014)
SE clustered by campus	(0.015)	(0.012)**	(0.016)	(0.019)
Wild cluster bootstrap p-value	[0.25]	[0.11]	[0.29]	[0.66]
Mean of Outcome	0.51	0.51	0.51	0.51
Panel B: Retail and Food Service Employment Only				
G2 - fully treated	-0.017	-0.002	-0.021	-0.021
SE multi-way clustered	(0.010)*	(0.006)	(0.010)**	(0.012)*
SE clustered by campus	(0.013)	(0.008)	(0.013)	(0.015)
Wild cluster bootstrap p-value	[0.38]	[0.85]	[0.27]	[0.38]
Mean of Outcome	0.23	0.23	0.23	0.22

Data Source: OLDA linked to ODJFS Unemployment Insurance Quarterly Wage data. Notes: Sample includes first-time freshmen in the F2000-F2013 cohorts who remain enrolled for 4+ years and can be linked to ODJFS employment data (296,416 obs). The partially treated group (not reported) is defined separately for each year/column and always includes the short summer preceding the calendar switch. In column 2, G1 includes students who enrolled 1 year before the switch to semesters. In column 2 it includes student enrolled 1 and 2 years before, and in column 3 (and column 1) it includes those enrolled 1-3 years before. In all specifications, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, and campus and year fixed-effects. ***p<0.01, **p<0.05, *p<0.10.

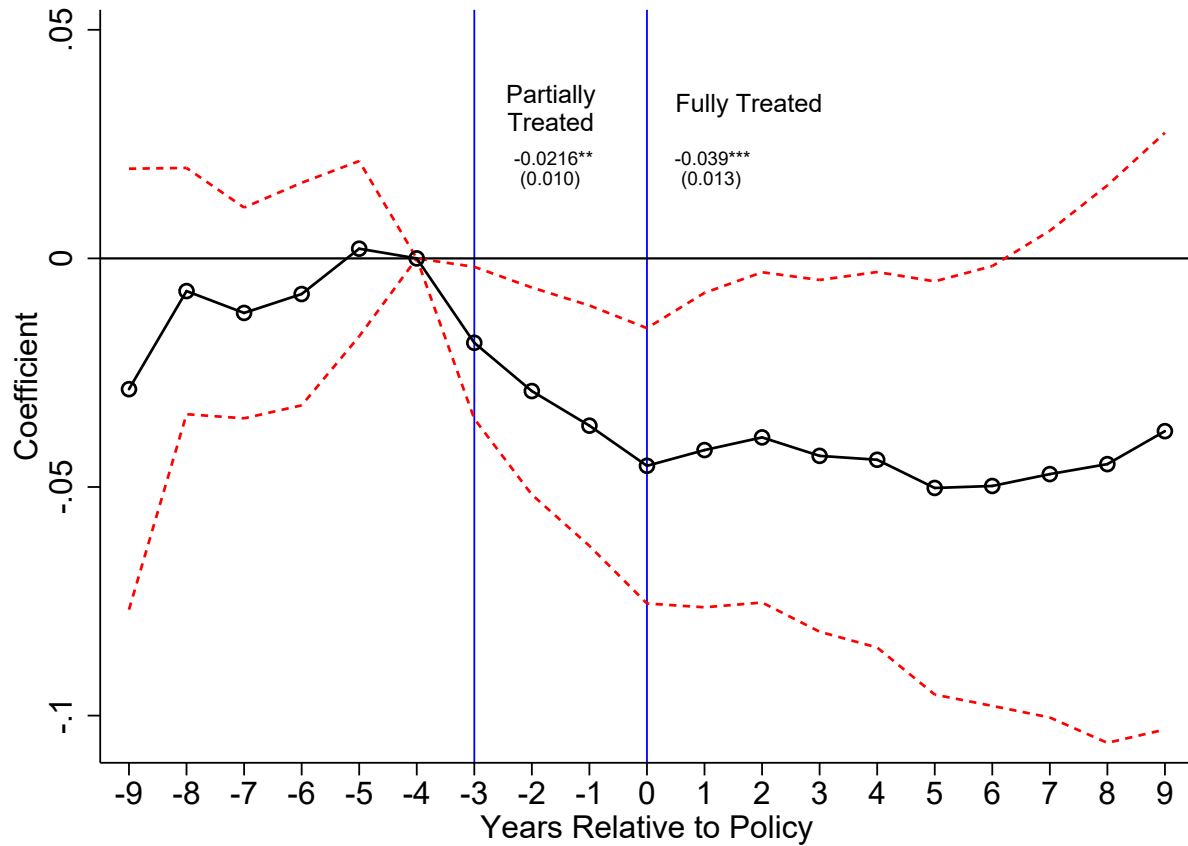
Table 10: Effect of Switching to Semesters on School-Year Employment (Q4 or Q1)

	Share of School-Years Employed	Employed During:			
		1st Year	2nd Year	3rd Year	4th Year
	(1)	(2)	(3)	(4)	(5)
Panel A: Excluding Retail and Food Service Employment					
G2 - fully treated	-0.032	-0.056	-0.016	-0.021	-0.037
SE multi-way clustered	(0.015)**	(0.022)**	(0.017)	(0.009)**	(0.023)
SE clustered by campus	(0.019)	(0.024)**	(0.019)	(0.014)	(0.028)
Wild cluster bootstrap p-value	[0.14]	[0.01]***	[0.43]	[0.21]	[0.22]
Mean of Outcome	0.38	0.31	0.37	0.41	0.43
Panel B: Retail and Food Service Employment Only					
G2 - fully treated	-0.048	-0.041	-0.047	-0.049	-0.040
SE multi-way clustered	(0.010)***	(0.007)***	(0.010)***	(0.011)***	(0.011)***
SE clustered by campus	(0.012)***	(0.009)***	(0.013)***	(0.015)***	(0.013)***
Wild cluster bootstrap p-value	[0.01]***	[0.00]***	[0.01]***	[0.02]**	[0.03]**
Mean of Outcome	0.21	0.20	0.22	0.22	0.21

Data Source: OLDA linked to ODJFS Unemployment Insurance Quarterly Wage data. Notes: Sample includes first-time freshmen in the F2000-F2013 cohorts who remain enrolled for 4+ years and can be linked to ODJFS employment data (296,416 obs). The partially treated group (not reported) is defined separately for each year/column. In column (3), G1 includes students who enrolled 1 year before the switch to semesters. In columns (4) and (5), G1 also includes student who enroll 2 and 3 years before the calendar switch, respectively. In column (1), G1 includes student who enrolled 1-3 years before the calendar switch. In all specifications, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, and campus and year fixed-effects. ***p<0.01, **p<0.05, *p<0.10.

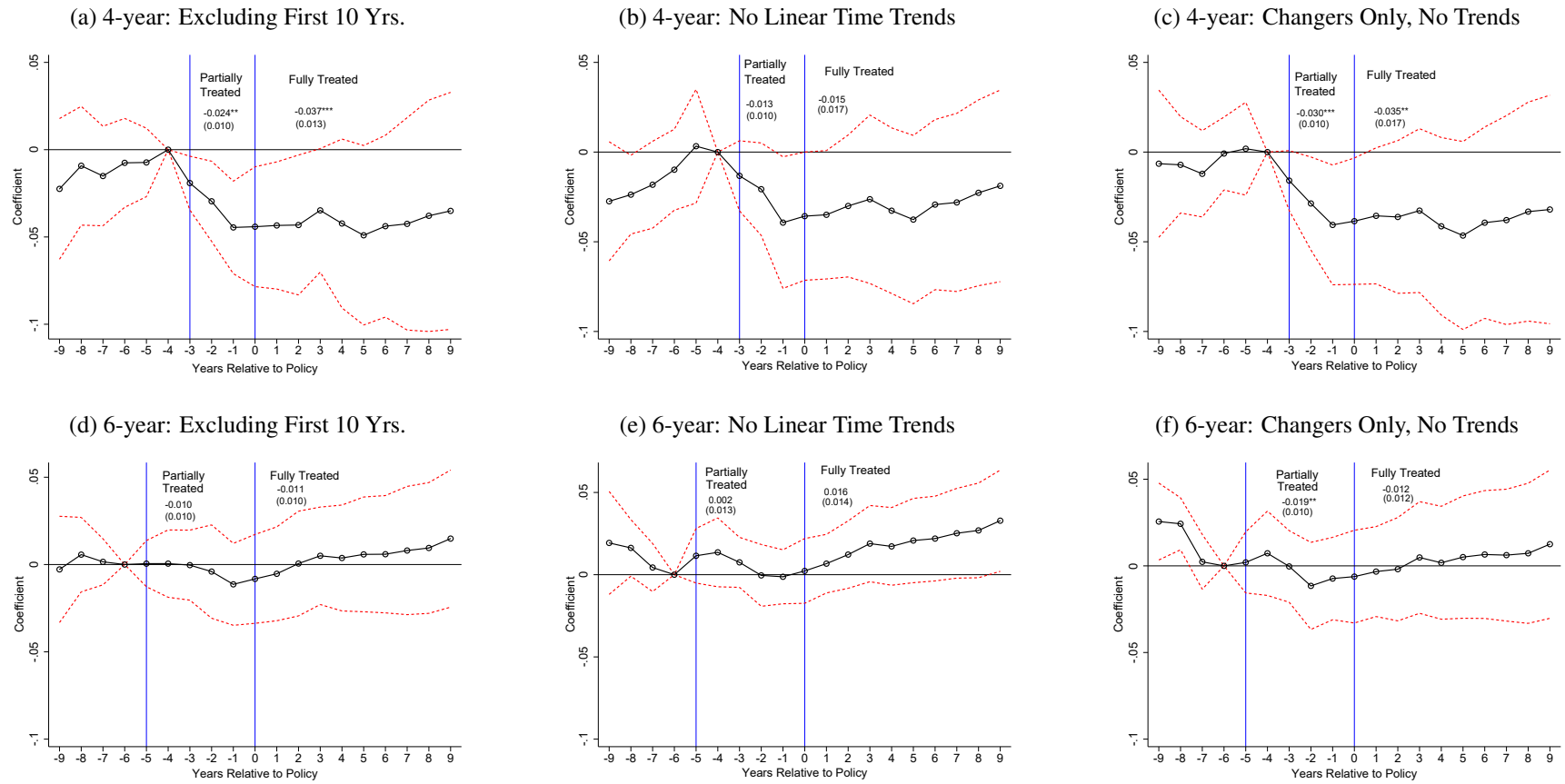
Appendix

Figure A1: Event Study: 4-Year Graduation Rates for Institutions with State-Level Mandates to Adopt a Semester Calendar



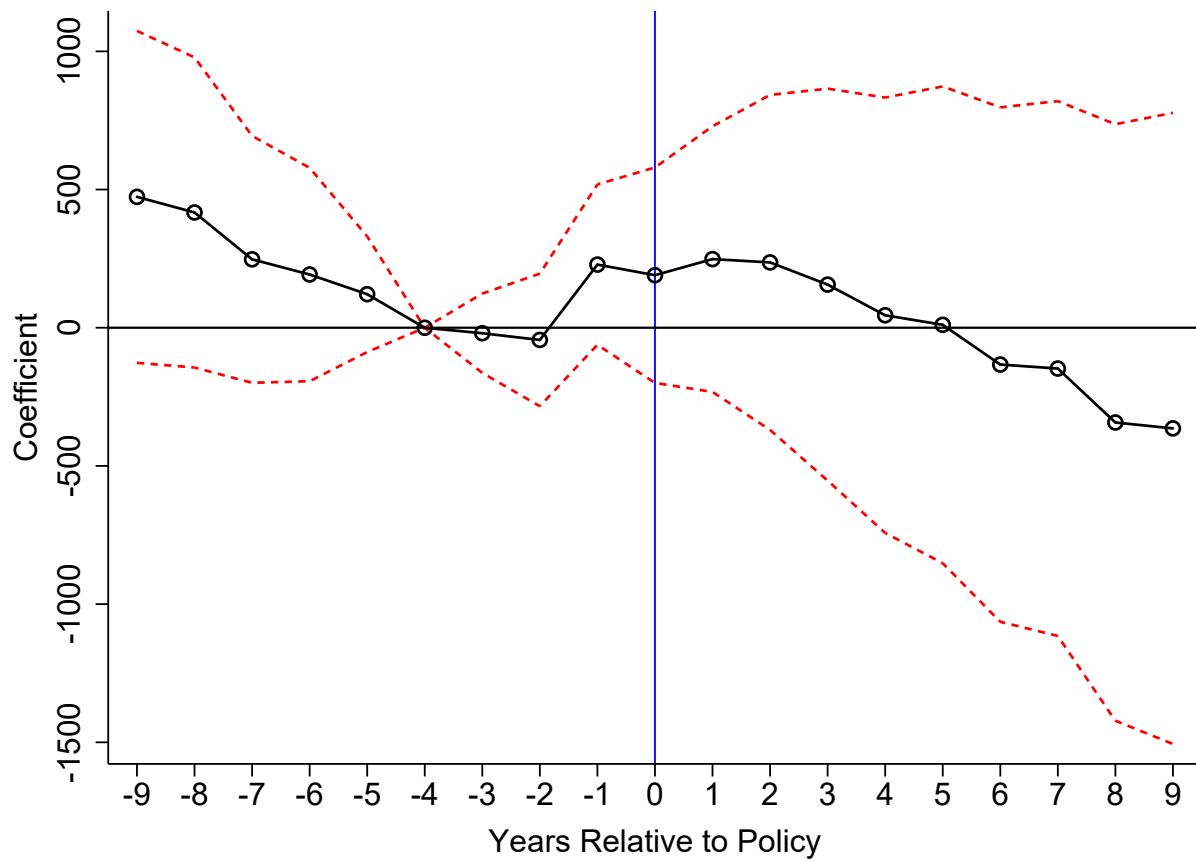
Data Source: IPEDS. Notes: This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (1). The sample includes 2,071 observations from 109 institutions. Year and institution fixed effects and institution-specific linear time trends are included. Standard errors are clustered at the institution level.

Figure A2: Institution-Level Event Study Robustness Checks



Data Source: IPEDS. Notes: The sample includes 13,889 observations for (a) and (d), 13,836 observations for (b) and (e), and 1,501 observations for (c) and (f). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (1). Year and institution fixed effects, institution-specific linear time trends, and time varying controls are included unless otherwise noted. Standard errors are clustered at the institution level.

Figure A3: Event Study: In-State Tuition—Institution-Level Analysis



Data Source: IPEDS. The sample includes 731 institutions for 19 years (13,889). Notes: This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (1). Year and institution fixed effects and institution-specific linear time trends are included. Standard errors are clustered at the institution level.

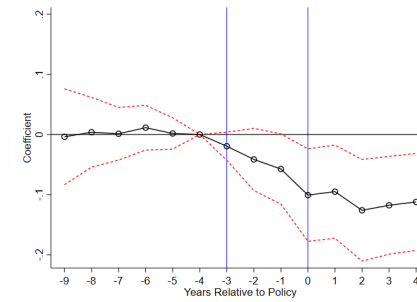
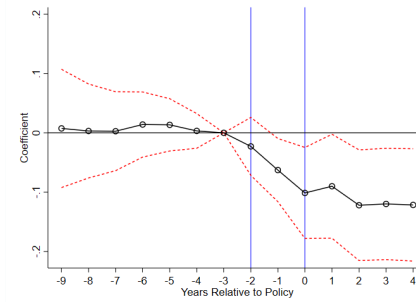
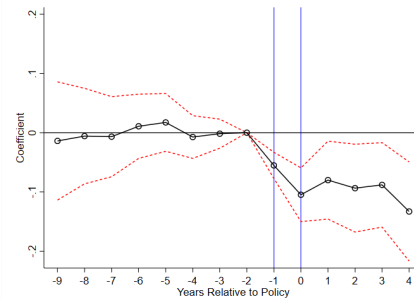
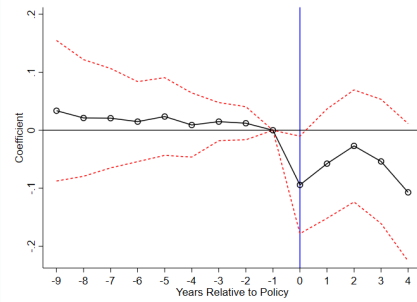
Figure A4: Event Study: Mechanism Analysis–Effect of Switching to Semesters on Cumulative Outcomes by Year in School

(a) No. Credits On-Track, Yr. 1

(b) No. Credits On-Track, Yr. 2

(c) No. Credits On-Track, Yr. 3

(d) No. Credits On-Track, Yr. 4

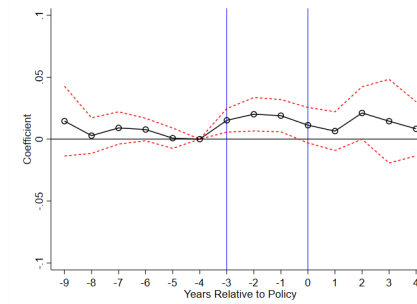
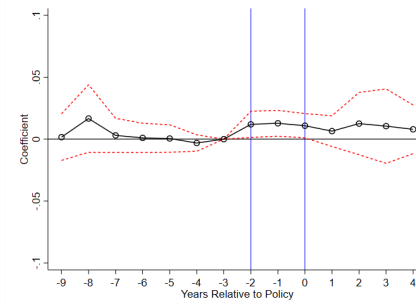
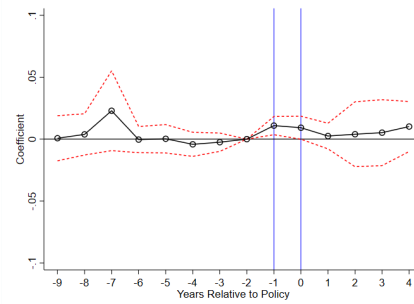
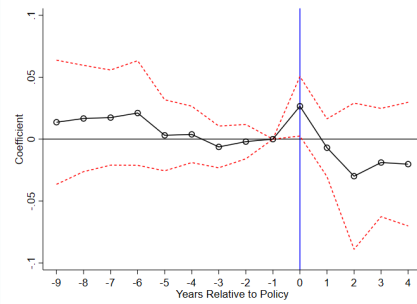


(e) Cum. GPA < 2.0, Yr. 1

(f) Cum. GPA < 2.0, Yr. 2

(g) Cum. GPA < 2.0, Yr. 3

(h) Cum. GPA < 2.0, Yr. 4

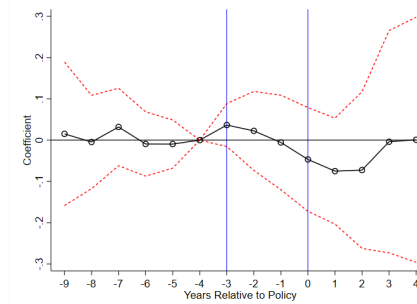
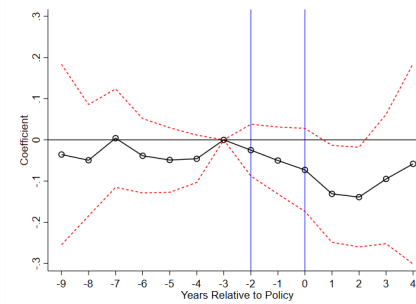
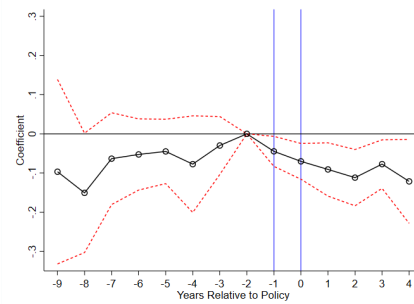
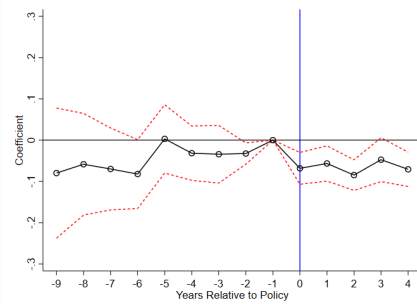


(i) Ever Switch Major, Yr. 1

(j) Ever Switch Major, Yr. 2

(k) Ever Switch Major, Yr. 3

(l) Ever Switch Major, Yr. 4



Data Source: OLDA. Notes: Sample includes first-time freshmen in the F1999-F2013 cohorts who remain enrolled for 4+ years (341,646 obs). This figure plots θ_k , and 95% confidence intervals in dashed lines, from estimating Eq. (3). Year and institution fixed effects, institution linear time trends, and student-level controls are included. The vertical line at $t = 0$ indicates the first fully treated cohort, that is students who first enroll at a university in the year of semester calendar adoption. The additional vertical line indicates the first partially treated cohort; e.g., in Figure A4f, the line at $t = -1$ indicates students who enrolled 1 year before the switch to semesters. Standard errors are estimated using multiway clustering.

Table A1: Effect of Switching to Semesters on Graduation Rates (Unbalanced Panel)—Institution-Level Analysis

	All (1)	All (2)	All (3)	All (4)	Women (5)	Men (6)	URM (7)	Non-URM (8)	Public (9)	Private (10)
<u>Panel A: Effect on 4-year Grad. Rates</u>										
G1 - partially treated	0.004 (0.014)	-0.003 (0.010)	-0.006 (0.011)	-0.008 (0.011)	-0.006 (0.012)	-0.009 (0.011)	-0.006 (0.011)	-0.007 (0.012)	-0.004 (0.013)	-0.017* (0.010)
G2 - fully treated	-0.013 (0.016)	-0.015 (0.013)	-0.020* (0.011)	-0.021* (0.011)	-0.019 (0.012)	-0.022** (0.011)	-0.014 (0.014)	-0.024** (0.012)	-0.016 (0.013)	-0.021 (0.013)
<u>Panel B: Effect on 6-year Grad. Rates</u>										
G1 - partially treated	0.019 (0.016)	0.012 (0.012)	0.001 (0.010)	-0.001 (0.009)	-0.002 (0.010)	0.001 (0.009)	-0.006 (0.015)	-0.000 (0.009)	0.001 (0.011)	-0.003 (0.008)
G2 - fully treated	0.028* (0.015)	0.024* (0.012)	0.006 (0.011)	0.006 (0.011)	0.005 (0.012)	0.010 (0.011)	-0.004 (0.020)	0.005 (0.011)	0.010 (0.013)	-0.004 (0.012)
Observations	22,089	22,089	22,089	22,089	22,010	21,489	22,074	21,528	8,845	13,244
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institution-Specific Time Trends	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Notes: The sample includes 1,253 institutions over 19 years. Not all institutions are observed in each year. All regressions are weighted by average cohort size. Within each panel and column, point estimates come from the same regression. The left out category comprises the pre-treatment years, and is defined as ($k \leq -4$) for the four-year graduation outcome and ($k \leq -6$) for the six-year graduation outcome. Standard errors are clustered at the institution level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2: Effect of Switching to Semesters on Graduation Rates (Unweighted)—Institution-Level Analysis

	All (1)	Women (2)	Men (3)	URM (4)	Non-URM (5)	Public (6)	Private (7)
<u>Panel A: Effect on 4-year Grad. Rates</u>							
G1 - partially treated	-0.021*** (0.008)	-0.016 (0.011)	-0.023*** (0.008)	-0.021** (0.011)	-0.017* (0.010)	-0.017* (0.009)	-0.013 (0.016)
G2 - fully treated	-0.034*** (0.010)	-0.029** (0.014)	-0.033*** (0.010)	-0.035** (0.014)	-0.030** (0.012)	-0.023** (0.011)	-0.035* (0.021)
<u>Panel B: Effect on 6-year Grad. Rates</u>							
G1 - partially treated	-0.012 (0.008)	-0.009 (0.009)	-0.012 (0.009)	-0.025* (0.013)	0.000 (0.011)	-0.011 (0.011)	-0.005 (0.011)
G2 - fully treated	-0.007 (0.011)	-0.004 (0.013)	-0.003 (0.013)	-0.028* (0.017)	0.004 (0.020)	-0.000 (0.014)	-0.009 (0.014)
Observations	13,889	13,865	13,824	13,883	13,799	6,365	7,524
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institution-Specific Time Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Notes: The sample includes 731 institutions for 19 years. Within each panel and column, point estimates come from the same regression. The left out category comprises the pre-treatment years, and is defined as ($k \leq -4$) for the four-year graduation outcome and ($k \leq -6$) for the six-year graduation outcome. Standard errors are clustered at the institution level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3: Timing of Calendar Switch for Ohio Campuses

Institution	Year of Switch to Semesters	Total # Obs	% of Obs on Semesters
Kent State University - Ashtabula Campus	1979	3,584	100%
Kent State University - East Liverpool Campus	1979	1,468	100%
Kent State University - Geauga Campus	1979	2,545	100%
Kent State University - Main Campus	1979	56,134	100%
Kent State University - Salem Campus	1979	3,117	100%
Kent State University - Stark Campus	1979	9,727	100%
Kent State University - Trumbull Campus	1979	5,126	100%
Kent State University - Tuscarawas Campus	1979	4,957	100%
Bowling Green State University - Firelands Campus	1982	4,463	100%
Bowling Green State University - Main Campus	1982	51,081	100%
Miami University - Hamilton Campus	Before 1987	9,732	100%
Miami University - Main Campus	Before 1987	48,914	100%
Miami University - Middletown Campus	Before 1987	6,025	100%
University of Akron - Main Campus	Before 1987	53,784	100%
University of Akron - Wayne Campus	Before 1987	4,830	100%
University of Toledo	1997	50,344	100%
Cleveland State University	1999	18,180	100%
Youngstown State University	2000	32,925	95%
Central State University	2005	7,926	71%
Shawnee State University	2007	13,738	61%
Ohio State University - Agricultural Technical Institute	2012	5,126	24%
Ohio State University - Lima Campus	2012	6,067	25%
Ohio State University - Main Campus	2012	94,822	24%
Ohio State University - Mansfield Campus	2012	6,977	28%
Ohio State University - Marion Campus	2012	6,410	25%
Ohio State University - Newark Campus	2012	14,673	31%
Ohio University - Chillicothe Campus	2012	4,471	28%
Ohio University - Eastern Campus	2012	1,793	22%
Ohio University - Lancaster Campus	2012	5,338	27%
Ohio University - Main Campus	2012	54,890	23%
Ohio University - Southern Campus	2012	3,978	22%
Ohio University - Zanesville Campus	2012	4,111	20%
University of Cincinnati - Clermont Campus	2012	8,216	26%
University of Cincinnati - Main Campus	2012	54,972	23%
University of Cincinnati - Raymond Walters Campus	2012	10,729	36%
Wright State University - Lake Campus	2012	2,640	31%
Wright State University - Main Campus	2012	35,591	23%
Total		709,404	64%

Data Source: OLDA. Notes: Sample includes all students enrolling as first-time freshmen at a bachelor's degree-granting public Ohio institution in the Fall terms of 1999-2015.

Table A4: Effect of Switching to Semesters on First-Year Outcomes with Limited Cohorts

	Drop Out (1)	Transfer Out (2)	On-Track Course Taking (3)	Cum. GPA <2.0 (4)	Switch Major (5)
Semester	0.005	-0.010	-0.063	0.027	-0.060
SE clustered by campus	(0.005)	(0.007)	(0.040)	(0.006)***	(0.009)***
Wild cluster bootstrap p-value	[0.39]	[0.17]	[0.16]	[0.01]**	[0.00]***
Observations	47,372	47,372	47,372	47,372	47,372

Data Source: OLDA. Notes: This is a companion table to Table 6 but instead of the full sample, there are only two cohorts in this subsample: those that enter the year before the calendar switch and those that enter the year of the calendar switch. *Semester* is an indicator variable that takes the value of 1 if institution *s* operates on a semester calendar in year *t*, and 0 if it operates on a quarter calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity and campus and year fixed-effects. There are no campus-specific linear time trends included because there are only two cohorts per campus. Multiway clustering is equivalent to campus clustering when there are only two cohorts per institution. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A5: Effect of Switching to Semesters on Student-Level Cumulative Outcomes with Individual Fixed Effects

	Cum. # of Credits is On-Track (1)	Cum. GPA <2.0 (2)	Has Ever Switched Major (3)
Semester	-0.073	0.028	-0.014
SE multi-way clustered	(0.025)***	(0.006)***	(0.029)
SE clustered by campus	(0.021)***	(0.006)***	(0.028)
Wild cluster bootstrap p-value	[0.02]**	[0.00]***	[0.68]
Observations	1,998,766	1,998,766	1,998,766

Data Source: OLDA.

Notes: Point estimates come from estimating the following equation:

$$Y_{ist} = \beta \text{Semesters}_{st} + D_t + D_i + \text{Status}_{it} + u_{ist}$$

Where *i* is an individual, *s* is an institution, and *t* is the year. *Semester* is an indicator variable that takes the value of 1 if institution *s* operates on a semester calendar in year *t*, and 0 if it operates on a quarter calendar. *Status_{it}* are indicator variables for the student's current year in school ($\in [1, 6]$).

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A6: Effect of Switching to Semesters on Student-Level Cumulative Outcomes by Year in School (Full Sample)

	Year 1 (1)	Year 2 (2)	Year 3 (3)	Year 4 (4)
Panel A: Outcome - Cumulative # of Credits is On-Track				
G1 - partially treated		-0.052	-0.044	-0.051
SE multi-way clustered		(0.017)***	(0.022)**	(0.018)***
SE clustered by campus		(0.017)***	(0.026)*	(0.023)**
Wild cluster bootstrap p-value		[0.02]**	[0.31]	[0.15]
G2 - fully treated	-0.068	-0.103	-0.106	-0.115
SE multi-way clustered	(0.036)*	(0.029)***	(0.031)***	(0.026)***
SE clustered by campus	(0.044)	(0.040)**	(0.043)**	(0.040)***
Wild cluster bootstrap p-value	[0.23]	[0.02]**	[0.06]*	[0.03]**
Mean of Outcome	0.54	0.57	0.59	0.62
Panel B: Outcome - Cum. GPA < 2.0				
G1 - partially treated		0.034	0.023	0.018
SE multi-way clustered		(0.009)***	(0.006)***	(0.005)***
SE clustered by campus		(0.009)***	(0.007)***	(0.006)***
Wild cluster bootstrap p-value		[0.01]***	[0.02]**	[0.02]**
G2 - fully treated	0.049	0.038	0.026	0.012
SE multi-way clustered	(0.010)***	(0.012)***	(0.007)***	(0.005)**
SE clustered by campus	(0.013)***	(0.016)**	(0.010)**	(0.006)*
Wild cluster bootstrap p-value	[0.01]***	[0.10]*	[0.08]*	[0.14]
Mean of Outcome	0.24	0.12	0.06	0.04
Panel C: Outcome - Has Ever Switched Major				
G1 - partially treated		-0.032	-0.000	0.040
SE multi-way clustered		(0.026)	(0.033)	(0.028)
SE clustered by campus		(0.029)	(0.039)	(0.034)
Wild cluster bootstrap p-value		[0.36]	[1.00]	[0.35]
G2 - fully treated	-0.071	-0.107	-0.070	-0.022
SE clustered by campus	(0.007)***	(0.023)***	(0.034)**	(0.033)
SE clustered by campus	(0.009)***	(0.030)***	(0.044)	(0.041)
Wild cluster bootstrap p-value	[0.00]***	[0.00]***	[0.16]	[0.62]
Mean of Outcome	0.11	0.38	0.54	0.61
Obs	709,404	515,629	405,488	341,646

Data Source: OLDA. Note: Sample includes first-time freshmen in the F1999-F2013 cohorts and is conditional on continued enrollment through the year in which the outcome variable is measured. The partially treated group is defined separately for each year/column. In column (2), G1 includes students who enrolled 1 year before the switch to semesters. In columns (3) and (4), G1 also includes student who enroll 2 and 3 years before the calendar switch, respectively. In all specifications, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, campus and year fixed-effects, and campus-specific linear time trends. ***p<0.01, **p<0.05, *p<0.10.

Table A7: Effect of Switching to Semesters on Summer Employment (Full Sample)

	Share of Summers Employed	Employed Summer After:		
		1st Year	2nd Year	3rd Year
	(1)	(2)	(3)	(4)
Panel A: Excluding Retail and Food Service Employment				
G2 - fully treated	0.024	0.016	0.021	0.015
SE multi-way clustered	(0.009)**	(0.005)***	(0.009)**	(0.012)
SE clustered by campus	(0.013)*	(0.007)**	(0.011)*	(0.016)
Wild cluster bootstrap p-value	[0.14]	[0.05]**	[0.10]	[0.49]
Mean of Outcome	0.52	0.52	0.53	0.52
Observations	351,643	619,491	446,569	351,643
Panel B: Retail and Food Service Employment Only				
G2 - fully treated	-0.018	-0.007	-0.023	-0.023
SE multi-way clustered	(0.009)*	(0.007)	(0.009)**	(0.010)**
SE clustered by campus	(0.012)	(0.009)	(0.012)*	(0.013)
Wild cluster bootstrap p-value	[0.31]	[0.51]	[0.15]	[0.24]
Mean of Outcome	0.23	0.27	0.25	0.22
Observations	351,643	619,491	446,569	351,643

Data Source: OLDA linked to ODJFS Unemployment Insurance Quarterly Wage data. Notes: Sample includes first-time freshmen in the F2000-F2013 cohorts and is conditional on continued enrollment through the year in which the outcome variable is measured, and can be linked to ODJFS employment data. The partially treated group (not reported) is defined separately for each year/column and always includes the short summer preceding the calendar switch. In column 2, G1 includes students who enrolled 1 year before the switch to semesters. In column 2 it includes student enrolled 1 and 2 years before, and in column 3 (and column 1) it includes those enrolled 1-3 years before. In all specifications, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, and campus and year fixed-effects. ***p<0.01, **p<0.05, *p<0.10.

Table A8: Effect of Switching to Semesters on School-Year Employment (Full Sample)

	Share of School-Years Employed	Employed During:			
		1st Year	2nd Year	3rd Year	4th Year
	(1)	(2)	(3)	(4)	(5)
Panel A: Excluding Retail and Food Service Employment					
G2 - fully treated	-0.032	-0.042	-0.031	-0.023	-0.037
SE multi-way clustered	(0.015)**	(0.012)***	(0.016)*	(0.010)**	(0.023)
SE clustered by campus	(0.019)	(0.015)***	(0.021)	(0.016)	(0.028)
Wild cluster bootstrap p-value	[0.15]	[0.05]***	[0.23]	[0.21]	[0.20]
Mean of Outcome	0.38	0.34	0.39	0.41	0.43
Observations	296,452	619,491	446,569	351,643	296,452
Panel B: Retail and Food Service Employment Only					
G2 - fully treated	-0.048	-0.037	-0.048	-0.049	-0.040
SE multi-way clustered	(0.010)***	(0.008)***	(0.010)***	(0.010)***	(0.011) ***
SE clustered by campus	(0.012)***	(0.011) ***	(0.013) ***	(0.013) ***	(0.013) ***
Wild cluster bootstrap p-value	[0.01]**	[0.02]**	[0.01]**	[0.00]***	[0.04]**
Mean of Outcome	0.21	0.24	0.24	0.22	0.21
Observations	296,452	619,491	446,569	351,643	296,452

Data Source: OLDA linked to ODJFS Unemployment Insurance Quarterly Wage data. Notes: Sample includes first-time freshmen in the F2000-F2013 cohorts and is conditional on continued enrollment through the year in which the outcome variable is measured. The partially treated group (not reported) is defined separately for each year/column. In column (3), G1 includes students who enrolled 1 year before the switch to semesters. In columns (4) and (5), G1 also includes student who enroll 2 and 3 years before the calendar switch, respectively. In column (1), G1 includes student who enrolled 1-3 years before the calendar switch. In all specifications, the fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. All regressions include age, age-squared, sex, a foreign-born indicator, indicators for race/ethnicity, and campus and year fixed-effects. ***p<0.01, **p<0.05, *p<0.10.