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

Valerie Bostwick
The Ohio State University
vkbostwick@gmail.com

Stefanie Fischer
Cal Poly State University, San Luis Obispo
sjfische@calpoly.edu

Matthew Lang
University of California, Riverside
matthew.lang@ucr.edu

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Abstract

We examine the impact of U.S. colleges and universities switching from an academic quarter calendar to a semester calendar on student outcomes. These calendar conversions are widespread, directly affecting nearly 2 million students at 132 colleges and universities since 1987. Using panel data on the near universe of four-year nonprofit institutions in the U.S. and leveraging quasi-experimental variation in calendars across institutions and years, we show that switching from quarters to semesters negatively impacts on-time graduation rates. Using detailed administrative transcript data from one large state system, we replicate this analysis at the student-level and investigate several possible mechanisms for the reduction in on-time graduation. A switch from quarters to semesters reduces four-year graduation rates and nearly one-half of this effect is due an increase in first-year dropouts. The remaining portion of the decline in on-time graduation can be attributed to delayed time-to-degree. Event study analyses show that these negative effects persist well beyond the transition. The investigation of potential mechanisms reveals that the calendar switch: (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: I2

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1 Introduction

In the United States over the past few decades there has been a notable increase in time to complete a bachelors degree (Bound et al., 2012). At the same time, college completion rates have remained relatively low. In 2010 less than 45% of students graduated in four years and nearly 40% of students who started a bachelors degree had not completed it by the end of their sixth year. Delayed graduation is costly to students, directly and indirectly, and those who dropout are unable to realize the wage premium associate with a college degree. As such, there is a growing body of literature aimed at better understanding the causes of these recent trends. One hypothesis is that student-level factors such as socioeconomic status and preparation are key contributors ((Bailey and Dynarski, 2011; Belley and Lochner, 2007; Carneiro and Heckman, 2002). Others argue that institution-level characteristics play an important role and that it is not just the attributes of the student (Cohodes and Goodman, 2014; Bound et al., 2010; Bowen et al., 2009; Bound and Turner, 2007).[1] We add to this growing body of literature by considering a novel and potentially important institution-level characteristic: How does the academic calendar affect graduation rates and what are the underlying mechanisms?

Among U.S. postsecondary institutions, there are two predominant academic calendars: semesters and quarters. Over time the semester calendar has become more common as a large number of recent conversions have made the quarter calendar increasingly rare. These conversions are widespread, directly affecting nearly 2 million students at 132 colleges and universities since 1987.[2] Often school administrators cite cost-savings reasons for making the switch and the hopes that it will benefit students, but surprisingly little is known as to how this calendar adoption affects student outcomes. A priori, the effects are ambiguous. Semesters may be more conducive to learning and/or degree attainment as this calendar offers a longer time horizon to master complex material. On the other hand, quarters tend to allow more scheduling flexibility. Typically, more

[1]There is evidence that financial aid is effective in increasing retention rates (Singell, 2004) and improving academic performance (Glocker, 2011).

[2]These figures come from IPEDS and include entering cohorts at all four-year nonprofit institutions from 1987-2016 who participated in the IPEDS survey.

courses are offered exposing students to a greater variety of professors and subjects. Students can also more easily switch majors and recover from a poor performance in a given term.[3]

In this paper 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 U.S. 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 2.9 percentage points. An 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 as cohorts become more fully treated.

We further explore the potential mechanisms for the negative effect of semester calendars using detailed administrative transcript data from the Ohio Longitudinal Data Archive (OLDA).[4] 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. This student-level analysis confirms that switching from a quarter calendar to semesters decreases the probability of on-time graduation with an even larger estimate of -4.4 percentage points (an 18% reduction at the mean). Analysis of the transcript data further reveals that the decline in on-time graduation can be attributed to both an increase in dropout rates, particularly for first-year students, and an increase in time-to-degree. Students who enroll after the switch to a semester calendar are 2.6 percentage points more likely to drop out in their freshman year than their quarter calendar counterparts (a 13% increase from the mean). We show that switching to a semester calendar leads to lower grades for first-year students, a significant decline in the probability that students are enrolled in the recommended number of credits per

[3]We provide a more complete discussion of the costs and benefits associated with each calendar in Section 2.

[4]The 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.

year, and a delay in the timing of major choice.

To the best of our knowledge, this is the first paper to examine the consequences of changes in the academic calendar by exploiting quasi-experimental variation, and the first to analyze the near universe of institutions in the United States. The few case studies on university calendar changes that do exist focus on a small subset of schools and compare outcomes at those schools in the 1-2 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-Twin Cities changed from quarters to semesters in the fall of 1999. Coleman et al. (1984) find that switching to semesters is harmful to students in that they take fewer credit hours and are more likely to withdraw from courses, but the analysis is limited to three years of data and only ten universities across two states. These studies provide some preliminary evidence that the conversion from quarters to semesters might be harmful to certain subsets of students.[5] We add to these findings by providing a well-identified analysis of the short- and long-term effects of calendar conversion on student outcomes at a national scale, as well as a detailed, student-level view of the potential 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. The negative outcomes estimated in this study imply substantial economic costs for the affected students, on top of the considerable costs to the universities of enacting the policy. For those who fail to graduate due to the semester calendar, the cost is both the lost time and money spent taking classes as well as the unrealized wage premium associated with a postsecondary degree. For students who merely take longer to graduate, the cost includes added tuition and the lost earnings from the additional time spent enrolled. Based on data from a National Center for Education Statistics (NCES) report and the authors' own calculations, the total cost of an additional year of school for an individual student

[5] There exists a related literature on the effects of school calendars at the elementary and secondary level. Graves (2010) shows that when California schools adopt a year-round calendar to alleviate overcrowding, standardized test scores decrease. McMullen and Rouse (2012) show that the transition to year-round schooling in Wake County, North Carolina does not significantly change academic outcomes and is negatively related to home prices (Depro and Rouse, 2015). Anderson and Walker (2015) exploit changes in the weekly calendar system and find that school districts that move to a four-day school week increase academic outcomes for elementary students.

is $44,327.43.[6] These results indicate that, contrary to the hopes of the many universities that have made the shift from quarters to semesters, this change in calendar leads to worse student outcomes. 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.

2 Background

The primary differences between a semester and quarter calendar lie in 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 the average full time student takes five courses per term. In contrast, a quarter academic year includes three 10-week terms where students take three to four courses per term. Quarters systems also allow for a full 10-week summer term.

While semesters have always been more common, quarters were first introduced to the U.S. in 1891 at the University of Chicago. When the school was founded, the organizers decided to keep it open year round and divide it into four terms instead of the then-traditional two terms (Malone, 1946). In 1930, about 75% of U.S. 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 (i.e. most notably the University of California system). In 1970, 70% of schools were on a semester and approximately 30% of schools were on quarters or trimesters (Day, 1987). By 1990, approximately 87% of the institutions operated on a semester calendar. Many of the recent calendar shifts occurred in the late 1990s, but the University System of Ohio converted from quarters to semesters in 2012 and

[6] According to NCES, the cost of one year of tuition at a 4-year public institution in 2014 was $18,110 (for Education Statistics, Accessed: 2017-1-9) and the average starting salary for 2014 graduates was $26,217. (This salary was calculated using the 2014 March Current Population Survey. It includes all individuals who are age 22-24, with a 4-year degree, who are not in school, and includes those with a zero wage too.) Thus, the total cost of an additional year of school for a student is $44,327.43. This is a back-of-the-envelope calculation. We acknowledge that there are 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.

many schools in the California State University system and University of California system are considering switching to semesters in the near future (Gordon, 2016). Today, about 95% of 4-year institutions operate on a semester calendar.

The primary motivation institutions cite for switching from quarters to semesters is to synchronize schedules with other schools in the state including other colleges and universities as well as community colleges. Because a majority of schools operate on a semester calendar, institutions on quarters often feel that their students are disadvantaged when it comes to securing summer internships and studying abroad. A semester school year typically begins in late August and concludes in early May, whereas a quarter academic year runs from late September through the beginning 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, because most study abroad programs align with a semester schedule, quarter system students often have to forgo a term abroad. It is also the case that when community colleges and 4-year schools operate on a common schedule, transferring course credits into the 4-year institution is more straightforward, and transfer students lose fewer credits in the process.

In addition to these administrative concerns, there are many other costs and benefits associated with switching to a semester calendar that could affect students' academic outcomes. Because the semester term is longer (15 weeks vs. 10 weeks) and requires students to take (and universities to offer) more concurrent courses (5 vs. 3 or 4 courses per term), semester calendars offer less scheduling flexibility. In a semester system, 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). Generally, there are fewer courses to choose from in a semester calendar and students are exposed to fewer professors.[7] This lack of flexibility could lead to students taking longer to complete their degree if they are unable to schedule the appropriate courses required for graduation within a 4-year

[7] Although descriptive in nature, a comparison of course offerings from UCLA, which is on 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, Accessed: 2016-11-9).

window.

The longer and less frequent terms associated with semesters may also make switching majors more costly. To highlight the added cost, consider a full-time student on a semester calendar who starts out as a pre-medicine major and who enrolls in the first prerequisite courses in the fall semester of her first year – i.e., General Chemistry, Biology, Calculus, and two other general education courses such as English 101 and History 101. At the start of the spring semester, she decides to switch to a business major where she must start over with the prerequisites for that major, but she has already spent 1/8 of her four years in college taking prerequisites that no longer count toward her new major. Had she been on a quarter schedule, she would have only given up 1/12 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 should be preferable. In a semester system, students have to juggle more courses and the associated materials and deadlines at any given time. One the other hand, students on semesters have more time with instructors and more time to master complex materials. In a similar vein, because the term is longer, it is easier for a student to "turn-it around" if he finds himself 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 him to improve his 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 4 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. Moreover, students caught in the transition period could be negatively impacted, as they may have trouble navigating a new system midway through their college career. 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 a staggering $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 grades, retention, graduation rates, and time-to-degree. Ultimately it is unclear which effects should dominate ex ante, and thus, this is an empirical question.

3 Institution-Level Analysis

We begin our analysis at the institution level by employing a nationally representative dataset. 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 the near universe of 4-year, non-profit higher education institutions within the U.S.. 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 4- and 6-year graduation rates, we keep only non-profit colleges and universities that offer comparable, traditional, 4-year bachelor's degrees. This includes all schools in IPEDS defined as bachelors, masters or doctoral-granting institutions by the Carnegie Classification system. We then merge this sample of institutions with IPEDS data on the calendar system, graduation rates, faculty, institution finances and tuition.

The final school-level dataset includes 19 cohorts of students that entered a 4-year college or university between 1991 and 2010.[8] We exclude 1994 from the analysis since IPEDS did not collect 4-year graduation rates for this cohort. We also drop very small schools; those that have an average cohort size less than 250 students (about 20% of all schools) as they are likely non-representative. 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).[9] The final dataset includes 635 institutions over 19 years for a total of 12,065 observations.

The two primary variables used in our analysis are the academic calendar system variable and graduation rates. The academic calendar variable 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 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. 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 below are not sensitive to the recoding of semesters and quarters.

The main dependent variables in our analysis are 4- and 6-year graduation rates. The IPEDS

[8]The 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.

[9]In Appendix Table A1 we report results using the unbalanced panel and obtain similar results. In this sample, there are 993 institutions for a total of 17,821 observations. Appendix Table A2 reports results from a more restricted sample where the number of observations are held constant across the various subgroups.

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 4-year and 6-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.

Table 1 reports summary statistics for the main sample. The first column of Table 1 shows that 93% of the observations in the dataset are on semester systems. The 4-year graduation rate for all students is 36%, with women having a significantly higher rate, 41%, than men, 30%. Underrepresented minority graduation rates are just below male rates at 29%. As expected, the average 6-year graduation rates is much higher, 59%. The analysis in this paper also controls for tuition, the number of faculty at an institution, and annual costs and revenue. The average number of full-time faculty at a university is 382, in-state tuition (without room and board) averages $10,819 and the average cohort size is 1,237 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; 77% of switchers are public compared to 48% of never-switchers. This difference also drives differences in the average cohort size (1,548 vs. 1,199) and the average in-state tuition ($6,853 vs. $11,302) between switchers and never-switchers, as public institutions typically have larger average cohorts and lower in-state tuition. Importantly, these differences do not threaten the internal validity of the regressions results presented in Section 3.3. As outlined in Section 3.2, the identifying assumption is the parallel trends assumption (see event study presented in Figure 2). Rather, we report the disaggregated summary statistics to highlight the fact that the effect of switching is, for the most part, identified off of large public universities.[10]

[10] In a heterogeneity analysis, we show that the results persist across the subset of private schools too (see Table 3, Column 9).

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 estimate an event study model using the equation:

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

where Y_{st} is either the 4-year or 6-year graduation rate for school s in year t. G_{stk} is an indicator for k years after 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 that enrolled as freshmen in the same year that a semester calendar was adopted) is $k = 0$. The cohorts who enrolled in years $k = \{-1, -2, -3\}$ are the “partially treated" cohorts (i.e., those students that are already at the institution enrolled in their second, third, or fourth year when the semester calendar is adopted). Thus, the omitted category is the last untreated cohort, $k = -4$.

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.[11] 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 such as in-state tuition, number of full time equivalent faculty, and annual operation costs and revenue. γ_s and ϕ_t are university and year fixed effects, respectively. $\rho_s * t$ is a university-specific time trend. All regressions are weighted by average cohort size and standard errors are clustered by institution.

We also estimate a difference-in-differences type model that is similar to the event study, but which groups cohorts into 3 categories (this strategy provides more power to detect average treat-

[11] For 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 A1, we show that our results are robust to dropping the first 10 years of IPEDS data where these classification errors might occur.

ment effects):

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

In this model, $G1_{st}$ is an indicator for "partially treated" cohorts ($G1_{st} = \sum_{k=-3}^{-1} G_{stk}$). The indicator $G2_{st}$ is equal to one for "fully treated" cohorts ($G2_{st} = \sum_{k=0}^{22} G_{stk}$). That is, if university s is using a semester calendar in year t. The omitted category includes all "untreated" cohorts who enroll in a university 4 or more years prior to the adoption of semesters. All other variables are the same as in Eq. (1).

The identifying assumption for estimating the effect of a semester calendar is that the adoption of the semester calendar is uncorrelated with other unobserved time-varying determinants of 4-year and 6-year graduation rates. The inclusion of institution and year fixed effects controls for time-invariant institution-level variables and overall time trends that might affect graduation rates. Moreover, by including institution-specific linear time trends, we control for differential trends in graduation rates across institutions over time. Finally, we include several institution time-varying controls to reduce concerns that unobserved characteristics, that also explain graduation rates, are correlated with the adoption of a semester calendar.

While the identifying assumption is not directly testable, several indirect tests support its plausibility. Suppose institutions enact policies such as a calendar change, aimed at improving student outcomes, in response to falling graduation rates. A pre-existing trend of this nature would undermine the causal interpretation of the treatment, as it will be impossible to distinguish the effect of a semester calendar from the pre-trend. The event study model provides a natural test for this type of pre-trend. We discuss the event study results in detail in Section 3.3 and show that it provides no empirical evidence of any confounding patterns in graduation rates in the years leading up to a calendar switch (see Figure 1).

A second concern that would confound the interpretation of the results is if other aspects of the institution or student body change as a result of the calendar adoption that also affect graduation rates. For instance, it is possible that different types of students attend the university because of the calendar change or the resources available to students is different because of the switch and this also affects graduation rates. To help rule out this concern, we regress institution and student characteristics (fulltime equivalent faculty, operation costs, cohort size, percent of student body white, percent URM, percent male, and percent female) on a semester calendar indicator and year and institution fixed effects. Table 2 shows no sign of a relationship between observable institution or student characteristics and the adoption of a semester calendar, alleviating concerns of confounding factors of this nature.

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 1,727 compared to 662 at private schools and just over 50% of institutions in the dataset are public – our results are relevant to a majority of students in the U.S. 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 1 and come from estimating Eq. (1). Figure 1a reports the effect of policy adoption on 4-year graduation rates (on-time graduation), and Figure 1b for 6-year graduation rates. The "pre-treatment" region, $k < -3$, includes untreated cohorts. 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 $k \in [-3, 0)$. 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.

The pre-treatment regions in both panels of Figure 1 reveal that prior to semester adoption, graduation rates are trending similarly across institutions that switch and those that do not. This provides some empirical evidence against pre-existing trends in graduation rates that might be driving the decision to switch calendars and thus confound our identification strategy.

Figure 1a shows that on-time graduation rates fall as a result of semester calendar implementation. The negative effect of a semester calendar on 4-year graduation rates begins to emerge in the partially treated cohorts and grows larger as cohorts become more fully treated (i.e., as they are exposed to more years of a semester calendar). This impact levels out as all entering cohorts become fully treated (i.e., the post-treatment cohorts).

Figure 1b repeats this exercise for 6-year graduation rates. Similar to 4-year graduation rates, we find no evidence of differential trends in 6-year graduation rates prior to the adoption of a semester calendar. After adoption, there is no statistically significant impact on 6-year rates. In summary, the event study suggests that the policy may not affect completion, but it decreases on-time graduation.[12]

Panel A of Table 3 presents estimates of the mean effect of switching to semesters on 4-year graduation rates for the partially treated and fully-treated cohorts. Each column within Panel A represents a separate regression and is obtained by estimating Eq. (2). The results from the main specification (Column 3) indicate that switching from a quarter system to a semester system reduces 4-year graduation rates by 2.9 percentage-points for the fully-treated cohorts. There is no significant effect on the partially treated cohorts. For context, the average 4-year graduation rate is 36%, thus a 2.9 pp reduction is equivalent to an 8% drop at the mean. This finding is robust to a variety of subgroups as reported in Columns 4-9.

Panel B of Table 3 presents estimates of the mean effect of switching to semesters on 6-year graduation rates. Consistent with the event study results, we find no strong evidence that the

[12]Ideally we would like information on retention, however, because this is not available for the universe of schools and because the majority of students who enter college and who graduate do so within six years, we use 6-year graduation rates as a proxy for whether students ever graduate. In Section 4, we will be able to more fully address the question of whether there is an effect on student retention.

calendar switch affects 6-year graduation rates, as the estimates are small in magnitude and indistinguishable from zero. Again, these results imply that while a semester calendar is not affecting completion, it is causing students to incur a cost – both a direct cost and an opportunity cost – from delayed graduation.

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 a particular state. This will allow us to explore the mechanisms underlying the drop in 4-yr graduation rates estimated in Section 3. We use this more nuanced data to look at the effect of academic calendar changes on term-by-term outcomes including: drop out, course taking, grade point average (GPA), and major choice.

4.1 Individual-Level Data

The student-level data is provided by the Ohio Longitudinal Data Archive (OLDA) and includes administrative transcript records for all students attending public colleges in Ohio between Summer 1999 and Spring 2017. This data provides 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 institutions[13] in the fall term of the years 1999-2016.[14] The full sample covers 719,268 students enrolled at 37 campuses.

The primary independent variable of interest is the academic calendar variable. Table 4 details the variation in academic calendars within this sample. There are 16 campuses 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 switched to a semester calendar in the Fall of 2012 by mandate of the Ohio Department of Higher

[13] Students who transfer from outside the state, from outside the public system, or from non-bachelor's degree-granting institutions are excluded from the sample.

[14] The sample for our primary analysis will be limited to students for whom we can observe 4-year graduation rates, which includes cohorts first enrolling between 1999 and 2013.

Education.[15] In total, 67% of students in the full sample first enrolled under a semester calendar while 33% 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; (3) or transfer to another school (within the dataset) in year $y \in [1,5]$ of enrollment.[16] We also aggregate these variables to create indicators for each outcome occurring anytime within 4 years or within 5 years of initial enrollment. For each student in each term we also observe cumulative GPA, the number of credits attempted, and the student's major.

Table 5 displays the demographic characteristics of all students in the full sample. These summary statistics show that the sample is approximately half female, predominantly white (78%) and almost entirely U.S.-born (98%). Table 6 shows summary statistics for the individual outcome variables in this sample. The first panel displays statistics for outcomes measured at the end of each student's first year of enrollment. This panel shows that nearly 20% of students drop out in their first year, while 7.6% transfer to another public Ohio college, and only 54% of students enroll in a full-time course load.[17] The second and third panels of Table 6 display statistics for outcomes measured at the end of students' fourth and fifth years, respectively. Statistics in the middle panel show that, 4 years after initial enrollment, 24% of students have graduated with a bachelor's degree, 35% have dropped out, and 15% have transferred to another school within the public system.

Note that while graduation rates increase significantly to 41% by the end of 5 years (shown in the third panel of Table 6), drop out rates and transfer rates are relatively stable as these outcomes are typically determined in the first and second year of enrollment. This pattern is also apparent in Figure 2, 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

[15] A 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

[16] We do not attempt to analyze the effect of calendar switching on 6-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.

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

figure shows that the vast majority of drop out and transferring out occurs in the first 2 years after initial enrollment. 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 4.3%).

4.2 Empirical Framework: Individual-Level

We leverage the same identification strategy as in Section 3.2 and estimate an event study model by:

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

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 year t. The vector X_i includes individual characteristics: age, age^2, sex, a foreign-born indicator, and indicators for race/ethnicity. Campus and year 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 after the adoption of a semester system.

We also estimate a difference-in-differences type model 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 partially treated students. That is, students who first enroll at a university 1 to 3 years prior to the adoption of a semester calendar. The indicator $G2_{ist}$ is equal to one if student i first enrolls at a university that is currently using a semester system. The omitted category are students who enroll in a university 4 or more years prior to the adoption of semesters. All other variables are the same as in Eq. (3).

We estimate both of the above models using Ordinary Least Squares (OLS) and 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 5-year enrollment at a given school. The errors are then assumed to have the property that for all $i \neq j$: $\mathbb{E}\left[\varepsilon_{ist}\varepsilon_{jsr}|x_{ist}, x_{jsr}\right] = 0$ 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 allows for arbitrary correlation between the errors of any 2 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 more than 4 years apart or who attend different universities.

The use of multiway clustering to estimate the standard errors, rather than one-way clustering, is driven by the structure of the individual-level data. The primary estimation sample includes 595,502 students enrolled at 37 campuses comprising 555 school-by-year cohorts. With this type of data, it is often tempting to cluster at the cohort-level. However, cohort-level one-way clustering 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. They recommend clustering at the university-level, which provides conservative estimates of the standard errors.

However, in this particular setting, school-level one-way clustering would create relatively few, very large and unbalanced clusters. In addition to the asymptotic consistency issues presented by this clustering structure (summarized in Cameron and Miller (2015)), it is intuitively clear that clustering at the university-level will likely lead to overly conservative standard errors and under-rejection of hypothesis tests. This is due to the conservative assumption that any two students who attend the same university *no matter how many years apart* may have correlated error terms. In contrast, the multiway clustering structure that we propose allows only for correlation between error terms of students who attend the same university and have some potential overlap in their periods of enrollment.[18]

[18] Appendix Table A3 replicates the main results shown in Table 7 and displays alternate estimates of the standard errors. As expected, the standard errors estimated using multiway clustering are larger than those estimated with cohort-level clustering and are smaller than those estimated with campus-level clustering.

4.3 Individual-Level Results

The event study results from estimating Eq. (3) are shown in Figure 3. Each point on the figure represents an estimate of θ_k while the dashed lines plot the 95% confidence intervals. These results show that there were no significant trends in the graduation probabilities for cohorts who attended universities in the pre-treatment period (more than 3 years before the switch to semesters). As in the institution-level event study analysis (shown in Figure 1), the negative effect of the semester calendar begins to emerge in the partially treated cohorts and grows larger (and statistically significant) in the fully-treated cohorts.

Table 7 presents estimates of Eq. (4) for several different outcome variables of interest.[19] Columns (1) and (2) show the effects of switching to semesters on a student's probability of graduating within 4 and 5 years of initial enrollment, respectively. These estimates indicate that students in fully-treated cohorts are 4.4 percentage points less likely to graduate in 4 years and 3.6 percentage points less likely to graduate in 5 years. At the mean, this is equivalent to an 18.3% reduction in 4-year graduation rates and an 8.9% reduction for 5-year graduation rates.[20]

The smaller estimated effect on 5-year graduation rates, as compared to 4-year rates, implies that some of the negative effect of switching to semesters is due to delayed graduation.[21] However, we would like to know whether the calendar change also impacts graduation rates through an increase in dropout rates or an increase in the probability of transferring to a different university within the public state system. We estimate these effects in Columns (3)-(5) and find that students in fully-treated cohorts are 1.9 percentage point more likely to drop out in 4 years (the estimate for 5-year drop out rates is similar but statistically insignificant). We find no evidence of any effect of calendar changes on the probability of transferring to another school within the sample.[22] The

[19]Note that Columns (2) and (4) have a slightly smaller sample size as 5-year outcomes are not observed for the 2013 cohort.

[20]These estimates are somewhat larger than those estimated for the sample of all 4-year institutions in Section 3.3. This is likely due to the fact that, while the Ohio public university system is fairly representative, it is composed of mostly large, public institutions. The sample of students in the OLDA data is also slightly less female and more white than the full population of college students in the IPEDS data.

[21]Ideally, we would like to estimate the effect on 6-year graduation rates as well, but we only observe 5 years of data for the large group of universities that switched to semesters in 2012.

[22]Note that we cannot observe if a student transfers to either an out-of-state school, a non-bachelor's degree-granting

estimated increase in dropouts can explain 43% of the decline in 4-year graduation rates, implying that the remaining 57% is driven by an increase in time-to-degree. For all outcome variables in Table 7, the effects of switching to semesters on the partially treated students are small and statistically insignificant.

We further explore the timing of the effect on drop out behavior in Table 8 by estimating Eq. (4) separately for each year of enrollment. The dependent variable in each column is an indicator for whether the student drops out in year 1, 2, 3, or 4 of enrollment, respectively. For Columns 2-4, inclusion in the estimation sample is conditional on continued enrollment. Column 1 shows that the switch to a semester calendar increases the probability of first year drop out by 2.6 percentage points for fully-treated students. At the mean of 19.9%, this equates to a 13% increase in the probability of dropping out in the first year of enrollment. Columns 2-4 reveal that there is no significant impact on the likelihood of dropping out in subsequent years.

This first row of Table 8 indicates that there is no effect of the calendar switch on drop out behavior for partially treated students. Note that these estimates act as a sort of placebo test in that the “partially treated" students in Column 1 are only treated after the outcome variable has already been determined. Recall that this group is defined to be students who are in their second, third, or fourth year when the semester calendar is adopted. Thus, the outcome in Column 1, first-year drop out, should not be influenced by the calendar switch for this group, by definition. Similarly, if the effect of the semester calendar on drop out behavior occurs only during the first year of enrollment, then we would expect to see no effect on the partially treated students in the subsequent years/columns as well.

When evaluating the effects of a policy change such as this, it is important to consider whether the estimated effects are driven merely by a temporary response to the change or by a more lasting move to a new equilibrium. Both event studies provide evidence for the latter; the negative effect on 4-year graduation rates does not appear to dissipate over time in Figures 1a and 3. We examine the persistence of the estimated increase in first-year dropouts by decomposing the $G2_{ist}$ variable

institution, or a private university. These transfers will be misclassified as dropouts.

in Eq. (4) into 3 indicator variables for each of the first 3 fully treated cohorts and a 4th indicator for students who enrolled 4 or more years after the adoption of a semester calendar.

These estimates are shown in Table 9 and reveal that the first cohort of fully treated students are 1.9 percentage points more likely to drop out in the first year of enrollment. In subsequent cohorts, this effect does not dissipate, but rather grows larger so that students in the 4th full-treated cohort are 2.7 percentage points more likely than untreated students to drop out in the first year of enrollment. These results indicate that the negative effect on student outcomes from switching to a semester calendar are not attributable to a temporary adjustment period but are a lasting characteristics of the semester environment.

4.4 Mechanism Exploration

The results presented in Section 4.3 present two important questions: (1) why are students more likely to drop out in the first year of enrollment under a semester calendar?; and (2) why do students who persist past the first year take longer to graduate under a semester calendar? In Tables 10 - 12, we explore several potential mechanisms that address these questions.

We first investigate the effect of the switch to a semester calendar on students' grades. Table 10 displays estimates of Eq. (4) where the dependent variable measures cumulative grade point average measured at the end of each year of enrollment (conditional on continued enrollment). Column 1 shows that first-year GPA declines by 0.10 grade points under the semester calendar. At the mean of 2.59, this is equivalent to a 3.9% reduction in GPA. This negative effect may explain the estimated increase in first-year dropouts if students are sufficiently discouraged by the negative feedback of lower grades. However, the decline in cumulative GPA of students under semesters becomes smaller as students progress through the first 4 years of enrollment. By the end of their fourth year, the cumulative GPA of students under semesters is not statistically different from their quarter-calendar counterparts. This suggests that the impact on GPA is not a likely driver of the increase in time-to-degree.

We next explore the effect of the switch to semesters on students' course-taking behavior. Table 11 displays estimates of Eq. (4) where the dependent variable is an indicator for attempting the recommended number of credits for a full-time student to graduate in 4 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. In Columns 2-4, inclusion in the estimation sample is conditional on continued enrollment. In Panel A, the outcome variable measures whether the student attempted the appropriate number of credits in each year, regardless of the number of credits attempted in previous years. In Panel B, the outcome measures cumulative course taking at the end of each year such that a student under 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 of 1 in Column 2.

Column 1 of Table 11 shows that the switch to semesters decreases full-time course taking for first-year students by 8.6 percentage points. Furthermore, Columns 2-4 of Panel A reveal that students who do not drop out are similarly less likely to enroll in a full course load in their second, third, and fourth years. These results suggest that students under 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. Panel B confirms this by showing that fully-treated students in their 4th year of enrollment are 12 percentage points less likely to be “on-track" to graduate after the switch to semesters. Furthermore, the negative effects estimated for the partially treated students indicate that, unlike with drop out behavior, the impact on course-taking is not isolated to first-year students. This decline in students attempting a full course load is clearly a driving force in the increased time-to-degree under the semester system and may also help to explain the increase in first-year dropout (if students are sufficiently discouraged by falling “behind schedule" in the first year).

Finally, in Table 12, we assess the effect of switching to a semester calendar on the probability of switching one’s declared major in each year of enrollment (conditional on continued enrollment).[23] Note that the dependent variables in these columns are not cumulative, so the outcome in Column 2 is equal to one only if the student changes his or her major in the second year of

[23]This excludes the switch to first declared major for those students who enroll as undeclared. The estimates are very similar if we include those initial switches in the dependent variables.

enrollment. These estimates show that fully-treated, first-year students are 7.7 percentage points less likely to switch majors under a semester calendar. Conversely, students in a semester system are 4.3 percentage points more likely to switch their major choices in the third year of enrollment. There is no discernible effect on the probability of switching majors for fully-treated second- and fourth-year students. This implies that students under a semester calendar take longer to settle on a major choice.

A descriptive regression of on-time graduation on each of the indicators for switching majors in a particular year of enrollment (estimated using students in the untreated cohorts only) reveals a significant positive correlation between switching majors as a first-year student and on-time graduation. Unsurprisingly, there is a large and significant negative correlation between switching majors as a third- or fourth-year student and on-time graduation. This suggests that the increase in time-to-degree caused by the semester calendar may be partially due to a delay in settling on a major.

The results in Tables 10 - 12 suggest several mechanisms for the increases in first-year dropouts and in time-to-degree. We find that a drop in first-year GPA and reduced course-taking may be causing the increase in dropouts. This could be because the recommended course load for a semester calendar of 5 classes is simply overwhelming for first-time freshmen students. For students who advance beyond the first year of enrollment, we find that there is a continued propensity to take less than the recommended 15 credits per term under semesters and that these students are more likely to switch majors late in their college careers. This suggests that the less flexible scheduling associated with a semester calendar may be causing the increase in time-to-degree.

5 Discussion and Conclusion

The documented negative relationship is unexpected. Colleges and universities that have switched to semesters often cite higher graduation rates as a reason for making the calendar shift (Burns, 2013), but we show that the switch is costly to students. We find not only that students are between 2.9-4.4 percentage points less likely to graduate on-time, but also that nearly one-half of this negative effect is due to an increase in first-year dropouts.

To put the policy into context, based on an National Center for Education Statistics report, the cost of one year of tuition at a 4-year public institution in 2014 was $18,110[24] and the average starting salary for 2014 graduates was $26,217.[25] Thus, the total cost of an additional year of school for a student is $44,327.43.[26] Further, the average cohort size in our sample is 1,237 students. Even if we were to ignore the estimated drop in retention and assume that the 2.9 percentage point decline in on-time graduation was fully due to a one-year delay in graduation for 36 students per cohort, then a back-of-the-envelope estimate of the lower bound on the cost of the policy to students would be $1.6 million per year at an average-sized university.

Our mechanism analysis suggests that the lack of flexibility in scheduling under a semester calendar and the larger number of courses per term are likely driving the estimated increases in dropouts and time-to-degree. First-year students experience lower grades and are more likely to exhibit under-enrollment after the switch from quarters to semesters. This suggests that the strain of juggling 5 courses simultaneously and/or the inability to enroll in one's preferred set of classes leads to an increased probability of dropout among freshmen on a semester calendar. Furthermore we find that students who persist past their first year continue to under-enroll and are more likely to switch majors as upperclassmen. This implies that the less flexible schedule of a semester calendar is also a driver of the increase in time-to-degree after schools switch from a quarter calendar to semesters.

In summary, this paper examines the impact of the widespread trend in colleges and universities in the U.S. moving from quarters to semesters. No previous study to our knowledge has examined the effect of postsecondary calendar shifts on such a large scale. Using a panel of the near universe of 4-year, non-profit institutions, we find that on-time graduation rates decrease af-

[24] NCESstats

[25] This salary was calculated using the 2014 March Current Population Survey. It includes all individuals who are age 22-24, with a 4-year degree, who are not in school, and includes those with a zero wage too.

[26] This is a back of the envelope calculation. 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.

ter a school moves from quarters to semesters. This result is consistent across several subsets of the data including women, men, whites, underrepresented minorities, public institutions and private institutions. Further analysis using detailed individual-level student transcripts reveals that students are also more likely to drop out after a school moves from quarters to semesters. While the majority of colleges and universities in the U.S. are already on semesters, the results of this study are very timely as large state systems, such as the University of California system and the California State University system, continue to make the transition.

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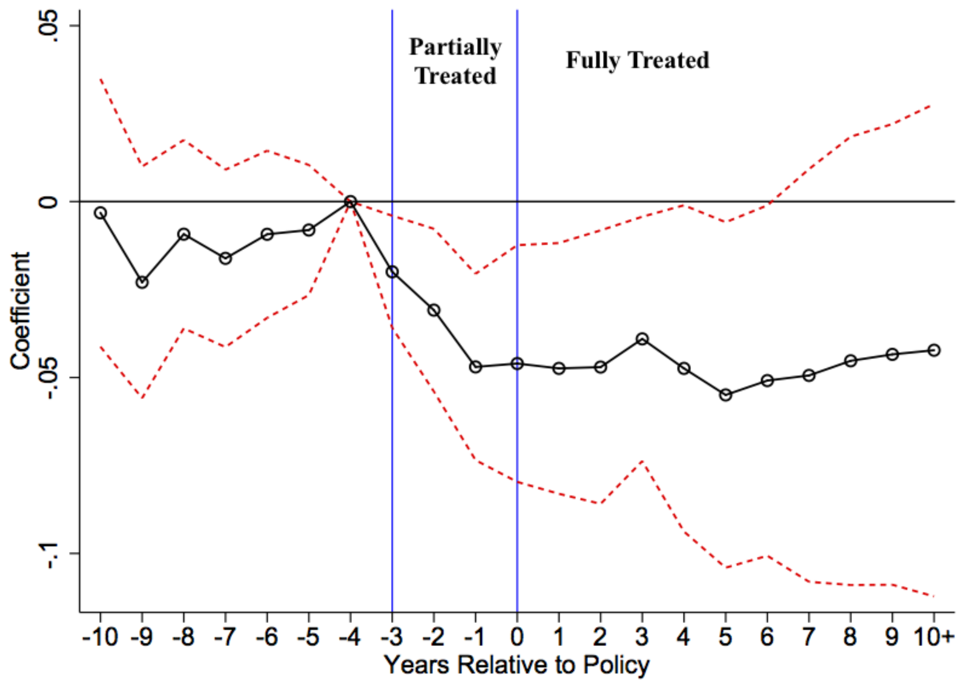
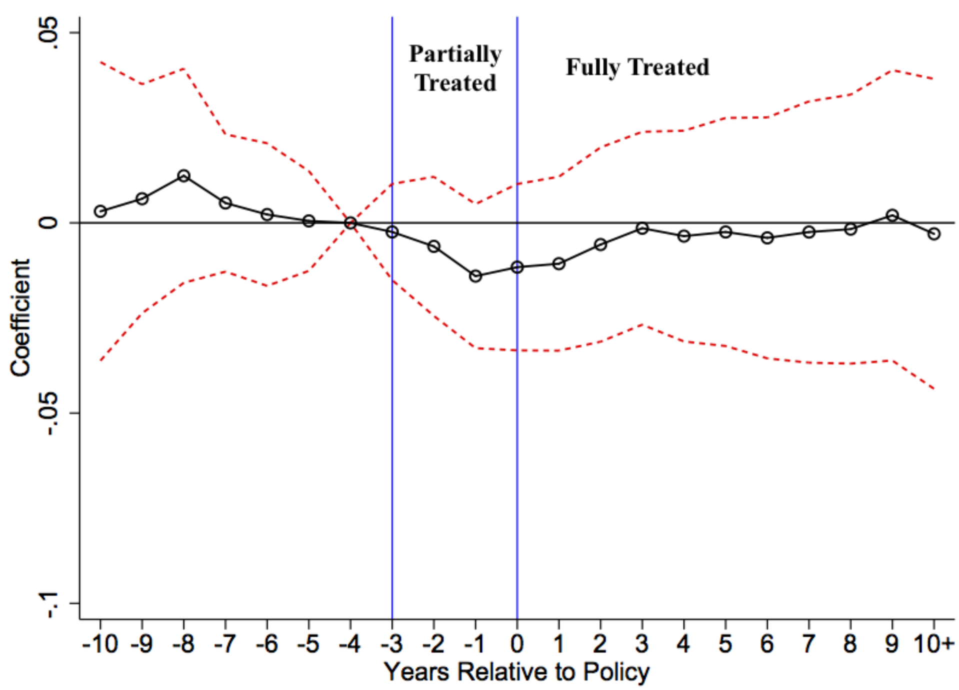
Figure 1: Event Study: Institution-Level Analysis

(a) 4-year Graduation Rates

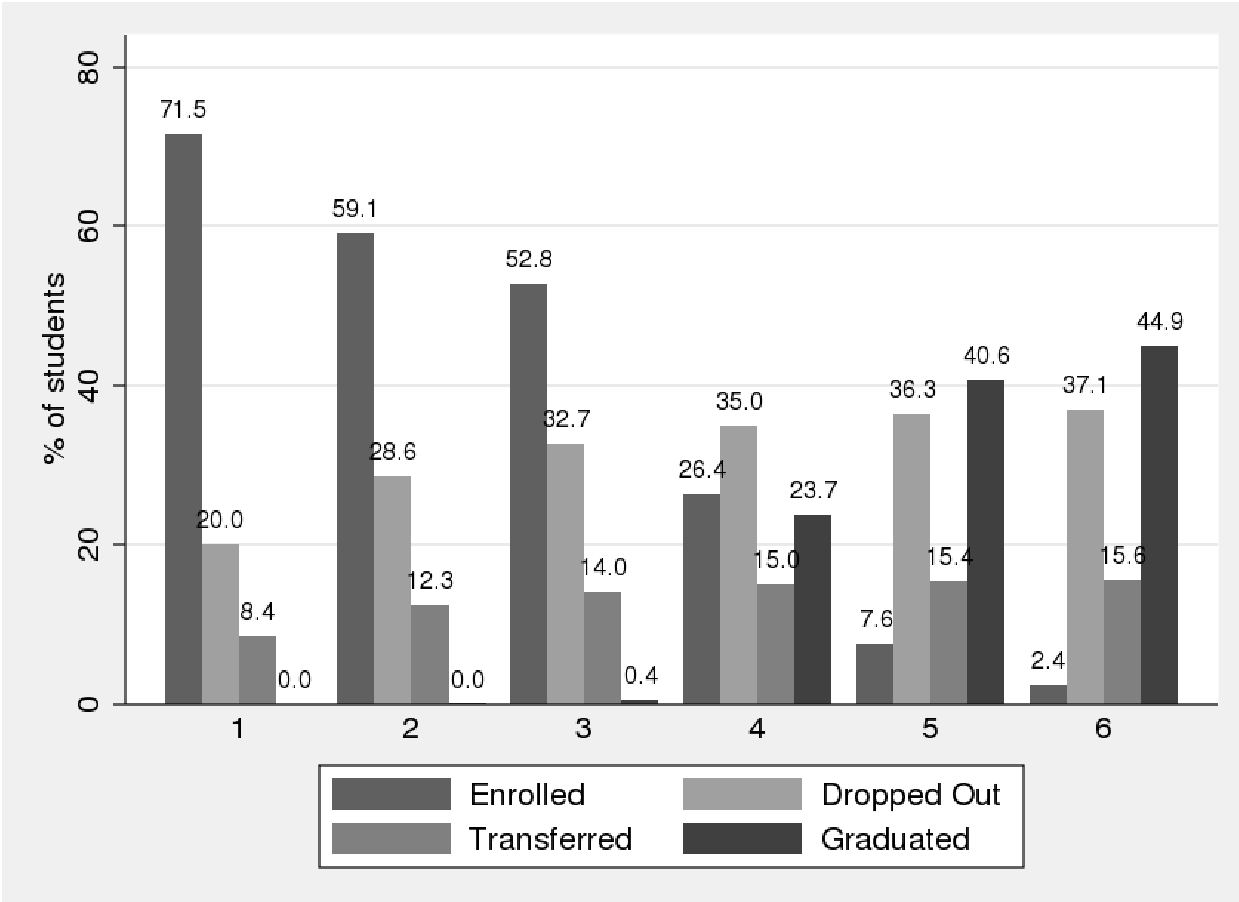


(b) 6-year Graduation Rates



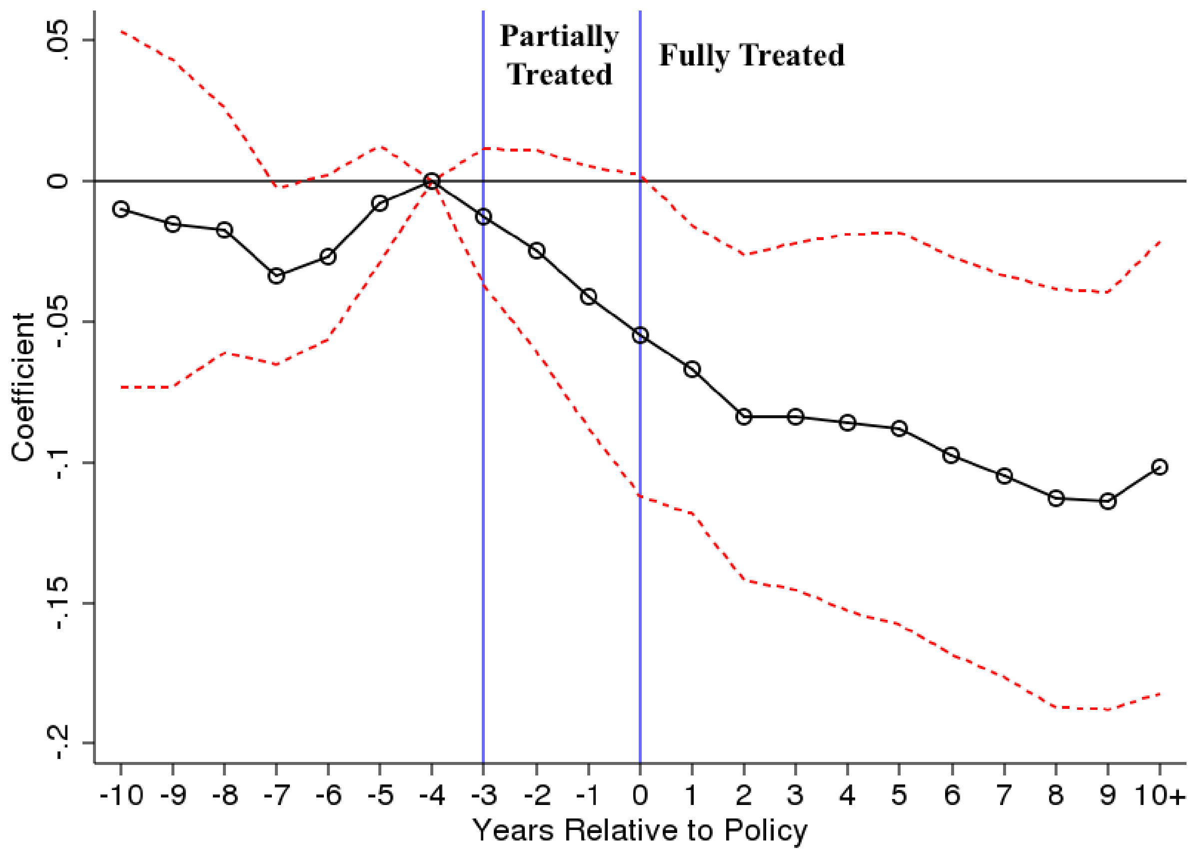
Data Source: IPEDS. Notes: This figure plots θ_k, and 95% confidence intervals in dashed pink lines, from estimating Eq. (1). Year and institution fixed effects, institution linear time trends, and time varying controls are included.

Figure 2: 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 3: Event Study: Individual-Level Analysis



Data Source: OLDA. Notes: 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.

Table 1: Institution-Level Summary Statistics

	All	Never Switchers	Switchers
	(1)	(2)	(3)
Semester calendar	0.93	0.95	0.69
	(0.26)	(0.21)	(0.46)
Four-yr grad rate	0.36	0.37	0.28
	(0.22)	(0.22)	(0.16)
Four-yr women grad rate	0.41	0.42	0.34
	(0.22)	(0.23)	(0.18)
Four-yr men grad rate	0.30	0.32	0.23
	(0.22)	(0.22)	(0.15)
Four-yr URM grad rate	0.29	0.30	0.21
	(0.20)	(0.21)	(0.14)
Four-yr non URM grad rate	0.37	0.39	0.30
	(0.22)	(0.23)	(0.17)
Six-yr grad rate	0.59	0.59	0.54
	(0.18)	(0.18)	(0.17)
Six-yr women grad rate	0.62	0.62	0.57
	(0.17)	(0.17)	(0.17)
Six-yr men grad rate	0.55	0.56	0.51
	(0.19)	(0.19)	(0.18)
Six-yr URM grad rate	0.51	0.52	0.46
	(0.19)	(0.19)	(0.16)
Six-yr non URM grad rate	0.60	0.61	0.56
	(0.18)	(0.18)	(0.17)
Public	0.51	0.48	0.77
	(0.50)	(0.50)	(0.42)
FTE faculty	381.78	370.63	473.24
	(393.71)	(383.53)	(459.01)
Cohort size	1,236.64	1,198.89	1,548.01
	(1,211.28)	(1,177.05)	(1,424.94)
In-state tuition	10,818.93	11,302.44	6,852.70
	(9,549.79)	(9,699.73)	(7,065.06)
Costs ($ per 1M)	215.42	207.15	283.30
	(418.82)	(407.89)	(494.52)
Observations	12,065	10,754	1,311

Data Source: IPEDS. Note: The balanced panel dataset includes the 1991-2010 entering cohorts. There are 635 institutions and 19 years. An observation is an institution-year. Standard deviations are reported in parentheses.

Table 2: The Effect of Semesters on Institution and Student Characteristics

	Institution Characteristics			Student Characteristics		
	FTE Faculty	Costs	Cohort Size	% URM	% White	% Female
	(1)	(2)	(3)	(4)	(5)	(6)
Semester	2.299	18.757	9.203	-0.002	-0.004	-0.004
	(10.450)	(33.304)	(59.688)	(0.009)	(0.008)	(0.004)
Mean of outcome	381.78	215.42	1,236.64	0.25	0.70	0.56
Observations	12,065	12,065	12,065	12,065	12,065	12,065

Data Source: IPEDS. Note: 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, and institution fixed effects. 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 Institution-Level Graduation Rates

	All (1)	All (2)	All (3)	Women (4)	Men (5)	URM (6)	Non-URM (7)	Public (8)	Private (9)
<u>Panel A: Effect on 4-year Grad. Rates</u>									
G1 - partially treated	0.006	0.005	-0.013	-0.015	-0.013	-0.016	-0.012	-0.010	-0.012
	(0.021)	(0.021)	(0.010)	(0.011)	(0.009)	(0.011)	(0.011)	(0.011)	(0.024)
G2 - fully treated	-0.004	-0.007	-0.029	-0.030	-0.030	-0.025	-0.031	-0.024	-0.033
	(0.021)	(0.021)	(0.013)**	(0.014)**	(0.013)**	(0.016)	(0.014)**	(0.014)*	(0.027)
<u>Panel B: Effect on 6-year Grad. Rates</u>									
G1 - partially treated	0.005	-0.001	-0.012	-0.014	-0.009	-0.019	-0.009	-0.010	-0.013
	(0.015)	(0.011)	(0.009)	(0.010)	(0.009)	(0.012)	(0.009)	(0.010)	(0.012)
G2 - fully treated	0.020	0.014	-0.012	-0.016	-0.005	-0.024	-0.012	-0.010	-0.019
	(0.016)	(0.014)	(0.010)	(0.012)	(0.011)	(0.018)	(0.011)	(0.012)	(0.016)
Observations	12,065	12,065	12,065	12,041	12,052	12,064	11,989	6,194	5,871
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trends	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Note: The sample includes 635 institutions for 19 years. All regressions are weighted by average cohort size. In Panel A within each column, point estimates in rows 1 and 2 come from the same regression. In Panel B within each column, point estimates in rows 3 and 4 come from the same regression. The left out category is G0 ($k \leq -4$), which are the pre-treatment years. Standard errors are reported in parentheses and are clustered at the institution level. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Timing of Calendar Switch for Ohio Campuses

Institution	Switch to Semesters	# Obs	% of Obs on Semesters
Kent State University - Ashtabula Campus	1979	3,521	100%
Kent State University - East Liverpool Campus	1979	1,428	100%
Kent State University - Geauga Campus	1979	2,703	100%
Kent State University - Main Campus	1979	57,988	100%
Kent State University - Salem Campus	1979	3,087	100%
Kent State University - Stark Campus	1979	9,671	100%
Kent State University - Trumbull Campus	1979	5,039	100%
Kent State University - Tuscarawas Campus	1979	4,808	100%
Bowling Green State University - Firelands Campus	1982	4,519	100%
Bowling Green State University - Main Campus	1982	52,442	100%
Miami University - Hamilton Campus	Before 1987	9,659	100%
Miami University - Main Campus	Before 1987	50,678	100%
Miami University - Middletown Campus	Before 1987	5,937	100%
University of Akron - Main Campus	Before 1987	53,087	100%
University of Akron - Wayne Campus	Before 1987	4,786	100%
University of Toledo	1997	49,144	100%
Cleveland State University	1999	19,274	100%
Youngstown State University	2000	33,278	95%
Central State University	2005	8,280	73%
Shawnee State University	2007	14,117	65%
Ohio State University - Agricultural Technical Institute	2012	5,317	29%
Ohio State University - Lima Campus	2012	6,346	30%
Ohio State University - Main Campus	2012	98,155	29%
Ohio State University - Mansfield Campus	2012	7,280	32%
Ohio State University - Marion Campus	2012	6,561	30%
Ohio State University - Newark Campus	2012	15,650	37%
Ohio University - Chillicothe Campus	2012	4,513	34%
Ohio University - Eastern Campus	2012	1,835	27%
Ohio University - Lancaster Campus	2012	5,328	33%
Ohio University - Main Campus	2012	56,826	28%
Ohio University - Southern Campus	2012	3,936	27%
Ohio University - Zanesville Campus	2012	4,036	25%
University of Cincinnati - Clermont Campus	2012	8,257	33%
University of Cincinnati - Main Campus	2012	50,801	30%
University of Cincinnati - Raymond Walters Campus	2012	11,448	45%
Wright State University - Lake Campus	2012	2,855	38%
Wright State University - Main Campus	2012	36,678	28%
Total		**719,268**	**67%**

Data Source: OLDA. Notes: Sample includes all students who enroll as first-time freshmen at a bachelor's degree-granting public institutions in Fall terms of 1999-2016.

Table 5: Summary Statistics - Individual Characteristics

	Mean	**SD**	**Min**	**Max**
Age at Enrollment	19.017	3.13	9	89
Female	0.533	0.50	0	1
Foreign-Born	0.018	0.13	0	1
White	0.777	0.42	0	1
Black	0.109	0.31	0	1
Hispanic	0.025	0.16	0	1
Asian	0.021	0.14	0	1
Other/Unknown	0.069	0.25	0	1
Enroll Undeclared	0.098	0.30	0	1
Enroll as STEM Major	0.313	0.46	0	1
Obs	719,268			

Data Source: OLDA. Notes: Sample includes all students who enroll as first-time freshmen at a bachelor's degree-granting public institutions in Fall terms of 1999-2016.

Table 6: Summary Statistics - Individual Outcome Variables

	Outcomes Measured in Spring of 1st Year		Outcomes Measured in Spring of 4th Year		Outcomes Measured in Spring of 5th Year	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Earned BA	--	--	0.240	0.43	0.406	0.49
Dropout	0.199	0.40	0.354	0.48	0.367	0.48
Transfer to other OH university	0.076	0.26	0.146	0.35	0.152	0.36
Switch Majors	0.111	0.31	0.400	0.49	0.410	0.49
STEM Major	0.309	0.46	0.162	0.37	0.150	0.36
Complete Full Course-Load	0.544	0.50	0.347	0.48	0.446	0.50
Cumulative GPA*	2.591	1.01	3.098	0.52	2.946	0.50
Obs	719,268		595,502		557,122	

*Only observed for students who remain enrolled through the Spring of 1st year (N=704,909) or Spring of 4th year (N=313,247) or Spring of 5th year (N=144,052)

Data Source: OLDA.

Table 7: The Effect of Switching to Semester Calendar on 4- and 5-Year Student-Level Outcomes

	Graduate in 4 Yrs (1)	Graduate in 5 Yrs (2)	Drop Out in 4 Yrs (3)	Drop Out in 5 Yrs (4)	Transfer Out in 4 Yrs (5)
G1 - partially treated	-0.009	-0.010	-0.004	-0.006	0.003
	(0.014)	(0.011)	(0.008)	(0.008)	(0.009)
G2 - fully treated	-0.044	-0.036	0.019	0.015	0.004
	(0.022) **	(0.018) **	(0.010) *	(0.011)	(0.011)
Mean of Outcome	0.240	0.406	0.354	0.367	0.146
Obs	595,502	557,122	595,502	557,122	595,502

Data Source: OLDA. Note: 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. The fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. The omitted category includes all students who enroll more than 3 years 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. Standard errors are estimated using multiway clustering by 5 overlapping peer groups. ***p$<$0.01, **p$<$0.05, *p$<$0.10.

Table 8: The Effect of Switching to Semester Calendar on Dropping Out

	Drop Out in (Conditional on Enrollment):			
	Year 1	Year 2	Year 3	Year 4
G1 - partially treated	0.000	-0.001	-0.007	-0.006
	(0.010)	(0.008)	(0.005)	(0.003) **
G2 - fully treated	0.026	0.011	0.009	-0.002
	(0.011) **	(0.007)	(0.005) *	(0.003)
Mean of Outcome	0.199	0.119	0.070	0.042
Obs	719,268	483,246	374,549	313,545

Data Source: OLDA. Note: 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. The fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. The omitted category includes all students who enroll more than 3 years 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. Standard errors are estimated using multiway clustering by 5 overlapping peer groups. ***p$<$0.01, **p$<$0.05, *p$<$0.10.

Table 9: The Effect of Switching to Semester Calendar on First-Year Drop Out

	Drop Out in Year 1	
First fully-treated cohort (k=0)	0.019	
	(0.009)	**
Second fully-treated cohort (k=1)	0.019	
	(0.009)	**
Third fully-treated cohort (k=2)	0.029	
	(0.008)	***
Fourth fully-treated cohort (k=3)	0.027	
	(0.008)	***
Future fully-treated cohorts (k>=4)	0.043	
	(0.015)	***
Obs	719,268	

Data Source: OLDA. Note: 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. Standard errors are estimated using multiway clustering by 5 overlapping peer groups. ***p$<$0.01, **p$<$0.05, *p$<$0.10.

Table 10: The Effect of Switching to Semester Calendar on Grades

	Cumulative GPA (Conditional on Continued Enrollment) By Spring of:			
	Year 1	Year 2	Year 3	Year 4
G1 - partially treated	0.028	-0.007	-0.013	-0.008
	(0.030)	(0.024)	(0.024)	(0.027)
G2 - fully treated	-0.100	-0.075	-0.051	-0.037
	(0.044) **	(0.038) *	(0.031)	(0.027)
Mean of Outcome	2.59	2.87	3.02	3.09
Obs	704,909	483,038	374,517	313,247

Data Source: OLDA. Note: 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. The fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. The omitted category includes all students who enroll more than 3 years 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. Standard errors are estimated using multiway clustering by 5 overlapping peer groups. ***p$<$0.01, **p$<$0.05, *p$<$0.10.

Table 11: The Effect of Switching to Semester Calendar on Course-Taking Behavior

	Full-Time Course Load (Conditional on Enrollment) in:			
	Year 1	Year 2	Year 3	Year 4
Panel A: Outcome measures credits attempted in each year separately				
G1 - partially treated	-0.015	-0.025	-0.040	-0.071
	(0.017)	(0.015) *	(0.026)	(0.028) **
G2 - fully treated	-0.086	-0.061	-0.050	-0.036
	(0.032) ***	(0.027) **	(0.027) *	(0.019) *
Mean of Outcome	0.544	0.579	0.617	0.572
Panel B: Outcome measures cumulative credits attempted over all years				
G1 - partially treated	-0.015	-0.010	-0.027	-0.051
	(0.017)	(0.015)	(0.015) *	(0.018) ***
G2 - fully treated	-0.086	-0.091	-0.102	-0.120
	(0.032) ***	(0.029) ***	(0.027) ***	(0.025) ***
Mean of Outcome	0.544	0.583	0.624	0.657
Obs	719,268	483,246	374,549	313,545

Data Source: OLDA. Note: 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. The fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. The omitted category includes all students who enroll more than 3 years 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. Standard errors are estimated using multiway clustering by 5 overlapping peer groups. ***p$<$0.01, **p$<$0.05, *p$<$0.10.

Table 12: The Effect of Switching to Semester Calendar on Major-Switching Behavior

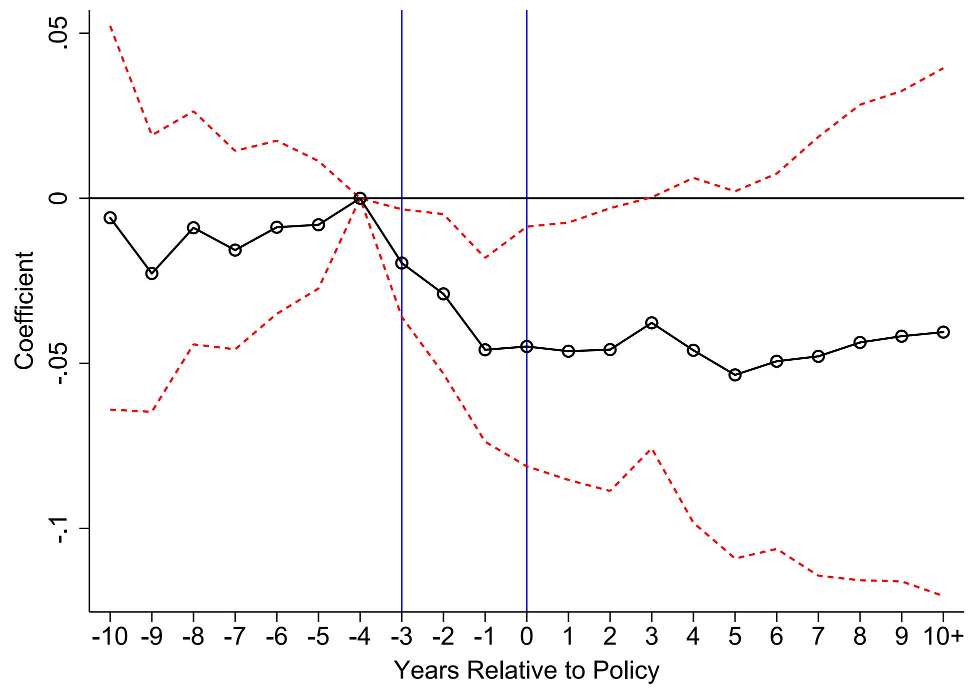
	Switches Major (Conditional on Enrollment) in:			
	Year 1	Year 2	Year 3	Year 4
G1 - partially treated	-0.003	0.034	0.034	-0.001
	(0.017)	(0.025)	(0.015) **	(0.008)
G2 - fully treated	-0.077	0.000	0.043	-0.012
	(0.019) ***	(0.031)	(0.017) **	(0.014)
Mean of Outcome	0.111	0.282	0.222	0.117
Obs	719,268	483,246	374,549	313,545

Data Source: OLDA. Note: 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. The fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. The omitted category includes all students who enroll more than 3 years 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. Standard errors are estimated using multiway clustering by 5 overlapping peer groups. ***p$<$0.01, **p$<$0.05, *p$<$0.10.

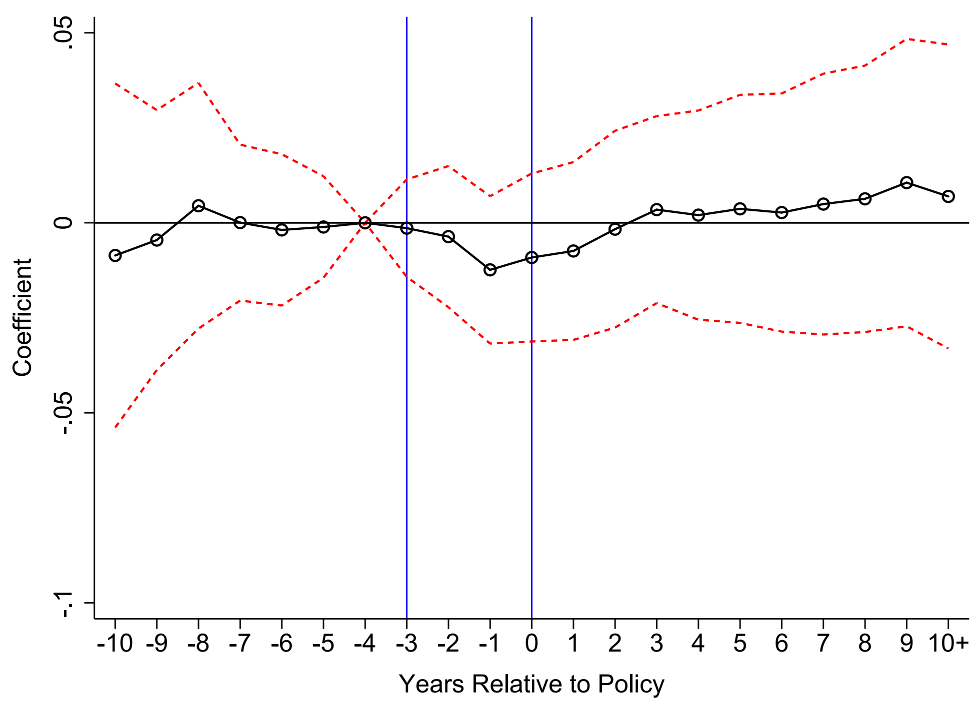
Appendix

Figure A1: Event Study: Institution-Level Analysis (omitting first 10 years of sample)

(a) 4-year Graduation Rates



(b) 6-year Graduation Rates



Data Source: IPEDS. Notes: This figure plots θ_k, and 95% confidence intervals in dashed pink lines, from estimating Eq. (1). Year and institution fixed effects, institution linear time trends, and time varying controls are included.

Table A1: Effect of Switching to Semesters on Institution-Level Graduation Rates - Unweighted

	All	Women	Men	URM	Non-URM	Public	Private
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Effect on 4-year Grad. Rates							
G1 - partially treated	-0.015	-0.018	-0.016	-0.018	-0.012	-0.008	-0.027
	(0.009)*	(0.010)*	(0.008)*	(0.009)*	(0.010)	(0.010)	(0.018)
G2 - fully treated	-0.029	-0.031	-0.029	-0.031	-0.028	-0.017	-0.048
	(0.010)***	(0.011)***	(0.010)***	(0.012)**	(0.013)**	(0.011)	(0.022)**
Panel B: Effect on 6-year Grad. Rates							
G1 - partially treated	-0.010	-0.012	-0.007	-0.021	-0.004	-0.006	-0.015
	(0.008)	(0.010)	(0.009)	(0.011)*	(0.013)	(0.010)	(0.013)
G2 - fully treated	-0.002	-0.007	0.005	-0.019	-0.002	0.005	-0.016
	(0.011)	(0.012)	(0.013)	(0.015)	(0.019)	(0.014)	(0.017)
Observations	12,065	12,041	12,052	12,064	11,989	6,194	5,871
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Note: The sample includes 635 institutions for 19 years. In Panel A within each column, point estimates in rows 1 and 2 come from the same regression. In Panel B within each column, point estimates in rows 3 and 4 come from the same regression. The left out category is G0 ($k \leq -4$), which are the pre-treatment years. Standard errors are reported in parentheses and 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 (Unbalanced Panel)

	All	All	All	Women	Men	URM	Non-URM	Public	Private
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4-year Grad Rates	-0.016	-0.015	-0.016	-0.016	-0.016	-0.010	-0.019	-0.015	-0.011
	(0.014)	(0.013)	(0.008)**	(0.008)*	(0.008)*	(0.010)	(0.009)**	(0.009)	(0.008)
6-year Grad Rates	0.015	0.015	0.006	0.005	0.007	0.001	0.005	0.008	-0.002
	(0.011)	(0.010)	(0.006)	(0.006)	(0.006)	(0.010)	(0.007)	(0.007)	(0.006)
Observations	17,821	17,821	17,821	17,760	17,624	17,817	17,384	8,553	9,268
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trends	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Note: The sample includes 993 institutions over 19 years. Not all institutions are observed in each year. All regressions are weighted by average cohort size. Standard errors are reported in parentheses and are clustered at the institution level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A3: Effect of Switching to Semesters on Graduation Rates (Obs. held constant across outcomes)

	All (1)	All (2)	All (3)	Women (4)	Men (5)	URM (6)	Non-URM (7)	Public (8)	Private (9)
4-year Grad Rates	-0.008	-0.009	-0.017	-0.017	-0.018	-0.010	-0.022	-0.015	-0.021
	(0.017)	(0.016)	(0.008)**	(0.009)*	(0.007)**	(0.011)	(0.008)***	(0.009)*	(0.012)*
6-year Grad Rates	0.017	0.015	-0.002	-0.004	0.002	-0.008	-0.009	-0.001	-0.006
	(0.014)	(0.013)	(0.007)	(0.007)	(0.007)	(0.012)	(0.007)	(0.007)	(0.006)
Observations	11,723	11,723	11,723	11,723	11,723	11,723	11,723	6,099	5,624
School, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trends	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data Source: IPEDS. Note: The sample includes 617 institutions in 19 years. All regressions are weighted by average cohort size. Standard errors are reported in parentheses and are clustered at the institution level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A4: Analysis of Error Structure

	Graduate in 4 Yrs (1)	Graduate in 5 Yrs (2)	Drop Out in 4 Yrs (3)	Drop Out in 5 Yrs (4)	Transfer Out in 4 Yrs (5)
G1 - partially treated	-0.009	-0.010	-0.004	-0.006	0.003
SE clustered by cohort	(0.011)	(0.008)	(0.007)	(0.006)	(0.005)
SE multi-way clustered	(0.014)	(0.011)	(0.008)	(0.008)	(0.009)
SE clustered by campus	(0.017)	(0.014)	(0.009)	(0.009)	(0.011)
G2 - fully treated	-0.044	-0.036	0.019	0.015	0.004
SE clustered by cohort	(0.015) ***	(0.014) ***	(0.008) **	(0.010)	(0.007)
SE multi-way clustered	(0.022) **	(0.018) **	(0.010) *	(0.011)	(0.011)
SE clustered by campus	(0.032)	(0.026)	(0.013)	(0.013)	(0.016)
# of Cohort Clusters	555	518	555	518	555
# of Multiway Clusters (min)	111	111	111	111	111
# of Campus Clusters	37	37	37	37	37
Obs	595,502	557,122	595,502	557,122	595,502

Data Source: OLDA. Note: 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. The fully treated group, G2, includes all students who first enroll at a university that is on a semester calendar. The omitted category includes all students who enroll more than 3 years 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.