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The Disciplinary Differences in the Characteristics And Effects of Non-Tenure-Track Faculty

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Using data with detailed instructor employment information from a state college system, this study examines disciplinary variations in the characteristics and effects of non-tenure-track faculty hired through temporary and long-term employment. We identify substantial differences in the demographic and employment characteristics between the two types of non-tenure-line faculty, where the differences are most pronounced in STEM fields at four-year colleges. Using an instrumental variables strategy to address student sorting, our analyses indicate that taking introductory courses with temporary adjuncts reduces subsequent interest, and the effects are particularly large in STEM fields at four-year colleges. Long-term non-tenure faculty are generally comparable to tenure-track faculty in student subsequent interest, but tenure-track faculty are associated with better subsequent performance in a handful of fields.

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And Effects of Non-Tenure-Track Faculty

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Abstract

Using data with detailed instructor employment information from a state college system, this study examines disciplinary variations in the characteristics and effects of non-tenure-track faculty hired through temporary and long-term employment. We identify substantial differences in the demographic and employment characteristics between the two types of non-tenure-line faculty, where the differences are most pronounced in STEM fields at four-year colleges. Using an instrumental variables strategy to address student sorting, our analyses indicate that taking introductory courses with temporary adjuncts reduces subsequent interest, and the effects are particularly large in STEM fields at four-year colleges. Long-term non-tenure faculty are generally comparable to tenure-track faculty in student subsequent interest, but tenure-track faculty are associated with better subsequent performance in a handful of fields.

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I. Introduction

Notable theories on academic interest and success suggest that students' experiences during their initial exposure to a discipline have substantial influence on their subsequent interest and academic choices (Gasiewski et al., 2012; Stinebrickner & Stinebrickner, 2014). Arguably one of the most important factors in shaping these initial experiences is the course instructor. In view of the increasing reliance on non-tenure-track faculty in postsecondary education institutions, researchers and policy makers have raised concerns that instructors hired through different contract types may differ in their academic knowledge, as well as in their job responsibilities and institutional support available to them (American Federation of Teachers, 2009; Kezar & Sam, 2010). These differences could affect how instructors interact with and advise students which, in turn, may influence students' learning outcomes and subsequent interest in a discipline. Accordingly, there has been a growing policy interest in understanding the characteristics and effectiveness of non-tenure-track faculty relative to tenure-track faculty, as well as whether non-tenure-track faculty hired through different contracts (such as temporary versus long-term employment) may influence student outcomes differently.

With the increasing availability of college administrative datasets that link student transcript records to course instructors, a small but growing number of studies have shed light on this issue using experimental or quasi-experimental designs (Bettinger & Long, 2010; Carrell & West, 2010; Figlio et al., 2015; Hoffmann & Oreopoulos, 2009; Ran & Xu, 2019; Xu, 2019). Overall, there seems to be substantial variation in the employment conditions of non-tenure-track faculty across settings. For example, Figlio et al. (2015) conducted a study at an elite four-year institution and found that non-tenure-line faculty tend to have a longer term relationship with the university and are employed through fixed-term contracts. In contrast, in other settings such as community colleges, many non-tenure-track faculty are employed through temporary part-time appointments (e.g., Xu, 2019). Therefore, it is not surprising that the estimated effects of non-tenure-track faculty on student outcomes also vary across studies, ranging from positive (e.g., Bettinger & Long, 2010; Figlio et al., 2015) to negative effects (e.g., Ran & Xu, 2019; Xu, 2019). The mixed findings from the existing literature suggest that the characteristics and effects of non-tenure-track faculty may vary depending on the contractual form and their working conditions.

In this paper, we extend the current literature by further exploring possible disciplinary variations in non-tenure-track faculty's characteristics, employment features, and effects on student academic outcomes. As we explain in more detail in the background section, the supply of high-quality non-tenure-track instructors depends on a number of factors that are likely to have substantial disciplinary variations, such as job opportunities and compensation in the alternative non-teaching labor market. Moreover, the working conditions for non-tenure-track faculty may differ across departments and correlate with their ability to promote student success. Thus, an understanding of how the characteristics and effectiveness of non-tenure-track faculty differ by discipline could inform effective institutional policies to identify inadequacies in faculty employment policies and improve student achievement.

To our knowledge, only one study has systematically examined how non-tenure-track faculty influence student outcomes in different fields. Using transcript data for the 1999 cohort enrolled at any of the public four-year colleges in Ohio, Bettinger and Long (2010) compared the effects of part-time faculty and full-time faculty on student subsequent interest in a field. They found that students who had a part-time instructor during their initial term in an occupation-focused subject took 9.2 more credits in the same field subsequently than students who had a full-time instructor. In contrast, taking the initial course with part-time instructors in an academic-focused subject had a significant negative effect on majoring in the same field.

Bettinger and Long's (2010) study is important because it highlights the possibility of disciplinary variations in the effects of non-tenure-track faculty. In this paper, we also examine the effects of non-tenure-track faculty by field of study, and further extend Bettinger and Long's (2010) study in three ways. First, our dataset is richer in its description of instructors, not only including instructor demographic information (such as age and highest degree received), but also containing each instructor's quarterly employment records with any employer in the state for an extended period of time. This information allows us to achieve a much more comprehensive understanding regarding the characteristics and employment features of non-tenure-track faculty. For example, comparisons of instructors' compensation from non-teaching positions before they started the college instructor position would enable us to identify fields with more attractive potential employment options outside of teaching. Similarly, by examining instructors' employment history at a college, we are able to determine whether the attrition rate of non-tenure-track instructors is particularly high in certain fields.

Second, our dataset includes detailed instructor rank and contract information, which allows us to differentiate between non-tenure-track instructors with temporary appointments (referred to as "temporary adjunct" hereafter) and non-tenure-track instructors with long-term contracts with an institution (referred to as "long-term non-tenure faculty" hereafter). Making this distinction is important, as our data show noticeable differences between non-tenure-track faculty hired through these two different types of contracts in individual characteristics, employment patterns, and effects on student outcomes. Lastly, our dataset comes from the public college system in a state that includes both two-year and four-year institutions. The breadth of the data allows us to examine whether disciplinary variations in the characteristics and effects of non-tenure-track faculty are consistent or different in the two-year versus four-year sectors.

Our descriptive results show noticeable differences between non-tenure-line faculty and tenure-line faculty, as well as between non-tenure-line faculty hired through temporary and long-term appointments in their educational attainment, earnings from alternative labor markets, and employment conditions in college teaching positions. Additionally, we identify substantial disciplinary variations in these features. We find that non-tenure-line faculty from science, technology, engineering, mathematics, and health-related fields (referred to as "STEM" hereafter) on average have higher earnings than those in non-STEM fields before they begin the college instructor position. While the disciplinary variations in alternative earnings opportunities are consistently reflected in the college teaching compensation to long-term non-tenure faculty and tenure-line faculty across different fields of study, temporary adjuncts seem to face a rather fixed salary schedule that has little variations by field. This results in larger gaps in earnings between the two types of non-tenure-line faculty in STEM fields than in non-STEM fields. We also identify a particularly pronounced gap between the two types of non-tenure-track faculty in their attrition rates in STEM fields at four-year colleges, where temporary adjuncts are close to five times as likely to depart from their college teaching position after one year.

In view of the descriptive differences between different types of faculty, and disciplinary variations in these differences, we then relate different types of instructors to students' academic interest and performance. We focus on the first college-level course (referred to as "introductory course" hereafter) a student takes in a particular field of study and estimate the impacts of different types of instructors during the introduction to a field on the student's subsequent enrollment and performance in the same field. To minimize student self-selection in introductory courses taught by different types of instructors, we employ an instrumental variables strategy similar to that used by Bettinger and Long (2010), where we use term-by-term variations in course offerings by different types of faculty for a student's likelihood of exposure to a given type of faculty in his or her introductory course in a field of study.

Our results suggest that non-tenure-line faculty hired through temporary positions have sizable negative impacts on student subsequent course enrollment compared with either tenure-track/tenured faculty or non-tenure faculty hired through long-term contracts with an institution. Such negative impacts are particularly large in STEM-related fields at four-year colleges. In contrast, non-tenure-track faculty hired through long-term positions are generally comparable to tenure-track faculty in motivating students into subsequent course enrollment in the same field of study and are in fact more effective in promoting subsequent enrollment in fields that are closely tied to career technical training. Yet, tenure-track faculty still have meaningful advantages in preparing students for better performance in the subsequent course in a handful of fields.

II. Background

The goal of this paper is to describe disciplinary variations in the characteristics and effects of non-tenure-track faculty hired through temporary and long-term employment. Although we do not directly test hypotheses for the specific factors driving such disciplinary differences, it is worth considering plausible explanations to place our analyses and results in context. Drawing on both the higher education research in this area and the broader literature on teacher market and quality at the K-12 level, three plausible explanations emerge.

Variations in alternative job opportunities. The classic Roy model of occupational choice suggests that an individual chooses an occupation to maximize expected utility (Roy, 1951). Accordingly, one's willingness to become a teacher is influenced by her alternative labor market opportunities. A large volume of studies conducted at the K-12 level support the empirical link between alternative earnings opportunities and the supply of high-quality teachers (e.g., Bacolod, 2007; Dolton, 2006; Loeb & Page, 2000; Murnane & Olsen, 1990; Nagler et al., 2020). For example, Nagler et al. (2020) exploited business cycle conditions as a source of variation in the non-teaching labor market and investigated the impact of the alternative labor market opportunities on teacher quality. They found evidence that teachers entering the profession during recessions (and thus with less opportunities in the alternative labor market) are more effective as measured by student performance.

In a similar vein, the Roy model can also be applied to considering the supply of non-tenure-track faculty across different fields of study in the postsecondary education sector, and two parameters of the model are particularly relevant. The first one is the average compensation of the adjunct teaching profession versus the non-teaching profession. This condition suggests that it is more difficult to recruit high-quality non-tenure-track faculty in fields where the average compensation of non-teaching professions is high. Considering that college graduates majoring in STEM and health-related fields typically earn higher wages than college graduates in non-STEM fields (Kinsler & Pavan, 2015), individuals with a STEM credential would face a higher opportunity cost of choosing to teach as an adjunct faculty. Compared with those hired through fixed-term employment, adjunct faculty on temporary short-term contracts may be more responsive to the alternative employment options outside of teaching given the greater flexibility and less pecuniary (such as insurance benefits) and nonpecuniary benefits (such as job security) associated with their college teaching contract.

In addition to the average compensation, another important parameter to consider is the returns to ability in the teaching versus non-teaching professions. The pay structure for non-tenure-track faculty tends to be compressed as it is often determined by a fixed scale. Accordingly, in fields with wider pay dispersion or higher returns to ability, the compressed wage schedule associated with adjunct teaching positions would induce lower ability individuals to select into teaching positions and higher ability individuals to select into non-teaching positions (Lovenheim & Turner, 2018).

In summary, consistent with a non-teaching labor market where different skills and expertise are rewarded differently, the Roy model predicts that the supply of high-ability adjunct faculty is likely to vary by field of study. In STEM and health-related fields with higher average compensation and higher returns to ability, it would be particularly challenging to recruit and retain high-ability adjunct instructors.

Variations in working conditions. In addition to compensation from the adjunct teaching positions and alternative non-teaching positions, nonpecuniary working conditions may also influence the effects of non-tenure-track faculty in two distinct ways. First, non-pecuniary job characteristics may play an important role in affecting individual sorting into and out of the adjunct teaching profession. These characteristics may include job security, institutional engagement, characteristics of the student body, average teaching load, control over what to teach, class size, preference for course delivery format (i.e., online versus face-to-face), facilities and support for faculty (such as office space and professional development opportunities), among other things. To the extent that these characteristics differ across academic departments, the recruitment and retention of high-ability non-tenure-track faculty may vary by department.

In addition, some of the working condition characteristics may directly affect faculty's capacity to engage students and consequently, to positively impact student academic outcomes. A large volume of qualitative studies have identified a lack of institutional support and engagement for non-tenure-track faculty, where they often are not invited to departmental meetings, are excluded from curricular decision-making and planning, receive limited professional training opportunities and mentoring, and receive insufficient information on available student academic and non-academic support services (e.g., Hoyt, 2012; Kezar, 2013; Kezar & Sam, 2013; Ran & Sanders, 2020; Schuster & Finkelstein, 2007). The working conditions are found to be particularly challenging for adjunct instructors hired in temporary part-time positions due to lack of office space, inadequate orientation, and insufficient time to prepare for the course (e.g., Eagan et al., 2015; Ran & Sanders, 2020).

Although no studies have systematically examined how the working conditions of non-tenure-track faculty differ by field of study, research that looks into institutional policies and practices of faculty support suggests that there is substantial variation across departments in engaging and supporting non-tenure-track faculty (Kezar, 2013). For example, based on interviews with 107 faculty within 25 departments at three four-year institutions, Kezar (2013) noted a clear distinction between "supportive departments" (i.e., departments that have positive policies and practices in place for supporting non-tenure-track faculty) and "unsupportive departments". Non-tenure-track faculty perceive the presence of these "positive policies" as critical in shaping their performance and ability to create quality learning experiences.

Variations in the relative importance of academic and professional knowledge. Finally, the effects of non-tenure-track faculty relative to their tenure-track counterparts may depend on the relative importance of academic and professional knowledge in a given discipline. This possibility was originally proposed by Bettinger and Long (2010), who provided a framework for understanding the relative effects of part-time faculty to full-time faculty on student outcomes. According to their framework, instructors need to provide both academic knowledge and professional knowledge to students. Yet, due to differences in job responsibilities and industry experiences, instructors hired through tenure-track and non-tenure-track adjunct positions may have different leverage in these two domains. For example, in fields that orient toward academy, tenure-track faculty, especially those actively engaged in research, can ground their instruction in advanced research-led knowledge and are thus in a better position to enhance students' understanding of a concept and inspire their subsequent interest in that discipline.

In contrast, fields that are tied closely to an occupation may put great value on working experiences in a related industry and knowledge of the specific labor market needs. Since many adjuncts are also employed in that labor market, their knowledge of the professional skills needed in the labor market might be just as or more important than their knowledge of the particular college and department's curriculum. Additionally, non-tenure-track faculty with working experiences in the industry may also promote students' interests in subsequent persistence in that field by providing social and employment connections to the college and their students (Leslie & Gappa, 1995).

To sum up, prior research has provided a theoretical basis for the belief that there may be noticeable disciplinary differences in the characteristics, college working conditions, and effects of non-tenure-track faculty. Our analysis provides an empirical foundation for these hypotheses by describing non-tenure-track faculty's demographic characteristics, average compensation from both their teaching and non-teaching positions, characteristics of their college teaching job, and the patterns of attrition from the teaching position by field of study. In estimating the impact of non-tenure-track faculty on student outcomes, we also conduct the analysis separately by discipline. Accordingly, the results not only will identify disciplines that are in greater need to improve the effectiveness of non-tenure-track faculty, but also will enrich our understanding of the broader question regarding the relationship between various parameters and teacher quality.

III. Data, Setting, and Summary Information

A. Data and Sample Description

We draw information from two separate databases. First, we utilize college administrative records that include student demographic information, detailed transcript records, and instructor assignment to each class taken by students who first entered one of the public postsecondary institutions in an anonymous state college system (referred to as ASCS) between the academic year of 2005-06 and 2009-10, tracked until summer 2012.[1] The instructor file includes any individual who ever worked at ASCS between 1994 and 2012, and contains information on each instructor's demographic characteristics, highest degree received in each

[1] It is also important to note that our data track students across colleges within ASCS. Therefore, even if a student transfers to or takes courses in a college other than the one they started with (such as transfer to a four-year institution after their introductory coursework), we are still able to note their subsequent course taking patterns and grades.

term, annual earnings from ASCS, and employment status at ASCS in a given term, such as part-time versus full-time appointment.

Second, we further link these administrative records with the unemployment insurance (UI) database that includes each faculty's quarterly earnings records from each employer in the state between 2001 and 2013. The UI database we have access to includes the six-digit North American Industry Classification System (NAICS) code for each employer, which indicates the industry of the employment. The first two digits of the NAICS code indicate the economic sector of an institution and represent 20 categories in total. For example, if a code starts with "61", it indicates the sector of "educational services". Additional digits provide more detailed information regarding the industry. For example, a 6-digit code of 611310 indicates "colleges, universities, or professional schools" whereas a code of 611110 indicates "elementary and secondary schools". Accordingly, if an individual works both as an instructor at ASCS and at a non-teaching position during a given quarter, she would have two separate data entries for that quarter, one from each employer respectively. Similarly, if an instructor works at the K-12 sector while also working at ASCS in a given term, we are able to distinguish between the two employment records as well. The detailed employment information from different employers in our data allows us to capture instructors' employment status and compensation from both teaching and non-teaching positions.

ASCS includes a mix of large and small institutions. Overall, ASCS institutions serve a higher proportion of African Americans and students eligible for need-based financial aid, and have a lower graduation rate compared with public institutions nationwide. The income level in this state seems to be lower on average: According to the U.S. Bureau of Labor Statistics, the unemployment rate in this state was fairly comparable to the national average in 2005, but the median household income was close to 25% lower compared with the national median in the same year. This is also reflected in the compensation for faculty at ASCS, where the average annual salary is lower than the national average by 10% to 20% depending on the specific category of academic rank.[2]

Because the aim of this study is to understand the impact of alternative instructors during students' initial exposure to a field of study on their subsequent academic outcomes in the same field, we limit our analysis to the first college-level course a student takes in each field of study, which we refer to as "introductory courses" in our paper.[3] The final analytic sample includes 339,602 introductory course enrollments among 68,692 students in two-year colleges and 694,395 enrollments among 87,212 students in four-year colleges. Summary statistics of the student sample are displayed in Table 1.[4]

B. Usage and Characteristics of Non-Tenure-track Faculty

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[2] Please see Ran & Xu (2019) for a detailed description of the institutional characteristics of ASCS compared with the average characteristics of public two-year and four-year institutions.

[3] Specifically, an introductory course is defined as the first course a student takes in a field between fall 2005 to summer 2011. If a student takes multiple college-level courses in a field during her initial term of exposure, we randomly choose a course for our analysis. In a separate robustness check, we further restrict to introductory courses taken during a student's first year in college only. The size of the sample becomes smaller but the estimates are fairly similar. A related concern is that students in later cohorts would have a shorter follow-up window than students in earlier cohorts. We conduct two sets of robustness checks to address this concern: One uses exactly the same follow-up window (two years since initial college enrollment) for every student in our sample; the other further restricts the analyses to the 2005-06 and 2006-07 cohorts only and allows for a six-year follow-up window. Results from both checks are consistent with our main findings.

[4] Approximately 7.4% of the introductory course enrollments in four-year colleges are in courses taught by graduate students. Yet, teaching assignments for graduate students are often viewed as part of their graduate training. Since the reasons for hiring non-tenure-track instructors and using graduate students as instructors are distinct from each other, we focus only on college instructors in this paper and exclude course enrollments with graduate student instructors from our analysis.

During the period of this study, non-tenure-track faculty are hired through one of two distinct contracts: short-term contracts that are one year or less and are typically appointed on a term-by-term basis, and fixed-term contracts that are usually renewed every two to three years. In this paper, we refer to them as "temporary adjuncts" and "long-term non-tenure faculty", respectively. All the community colleges in this state rely exclusively on non-tenure-line faculty except for one institution. Due to the concern that this particular college may be different from the other colleges in resources and mission, we exclude it from our main analyses.[5] Table 2 presents proportions of course enrollments in our introductory course sample with different types of instructors in each main field of study that are divided into STEM (including health) and non-STEM fields broadly. Overall, two-year colleges are twice as likely to rely on temporary adjuncts than four-year colleges. There are also substantial variations across fields: In two-year colleges, non-STEM fields rely more heavily on temporary adjuncts than STEM fields.[6] Yet, even in fields where temporary adjuncts are least involved in teaching (e.g., math), still close to one third of the course enrollments are with temporary adjuncts.

Similar to two-year colleges, the reliance on temporary adjuncts at four-year colleges is heavier in non-STEM fields than STEM fields; yet, compared with two-year colleges, four-year institutions are much less likely to rely on temporary adjuncts across all fields of study, especially in STEM. Instead, four-year institutions heavily rely on long-term non-tenure-track faculty: In STEM-related fields, in particular, almost half of the total course enrollments are with long-term non-tenure-track faculty.

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[5] We also conduct a robustness check that includes course enrollment records with non-tenure-track faculty at this institution. The results are presented in Appendix Table 1 and resemble our main findings.

[6] We use "field" and "discipline" interchangeably in this paper to refer to a broad subdivision of knowledge, such as math, natural science, social science, etc. The specific categories of disciplines are presented in Table 2.

Table 3 presents the average characteristics of different types of instructors who taught at least one introductory course between fall 2005 and summer 2011 in ASCS, where Table 3A focuses on two-year institutions and Table 3B on four-year institutions. Consistent with the course enrollment statistics presented in Table 2, the proportion of temporary adjuncts is higher in non-STEM than in STEM fields in both two-year and four-year colleges. Interestingly, while long-term non-tenure faculty have course enrollments that are larger or comparable to tenure-track faculty in the majority of STEM and non-STEM disciplines in four-year institutions, their headcounts are outnumbered by tenure-track faculty: In STEM disciplines, about one quarter of the instructors are hired through long-term non-tenure-track positions and they collectively taught almost half of the total STEM introductory course enrollments between 2005 and 2011; similarly, less than 30% of non-STEM instructors are long-term non-tenure faculty who accounted for almost 40% of the introductory course enrollments in these fields. As we will show in Table 4, this seems to be partly driven by larger class enrollment size for long-term non-tenure faculty than for tenure-line faculty.

We examine three sets of characteristics by type of instructors and discipline in Table 3: instructor demographic information (panel A), instructors' labor market performance prior to their ASCS employment (panel B), and employment features at ASCS (panel C). Available instructor demographic characteristics presented in panel A reveal noticeable differences between faculty hired through tenure-track versus non-tenure-track positions at four-year institutions.[7] Overall, both types of non-tenure-track faculty in four-year colleges are more likely to be female, younger in age, and less likely to have received a doctoral degree compared with

[7] The comparison between tenure-track and non-tenure-track faculty is not available at the two-year setting because these institutions almost unanimously relied on non-tenure-track faculty.

faculty hired in tenure-track positions. In addition, comparisons between the two types of non-tenure-track faculty also reveal noticeable differences, although the patterns of these differences vary by discipline and sector of the institution. In four-year colleges, compared with non-tenure-track faculty with long-term contracts, temporary adjuncts are substantially less likely to have received a Master's or doctoral degree, while the pattern is opposite at two-year colleges. Moreover, the share of non-tenure-track faculty who only have a baccalaureate or associate degree as the highest degree is particularly high in STEM-related fields. For example, more than one third of temporary adjuncts in STEM fields at four-year institutions have a baccalaureate or lower as their highest degree, compared with less than a quarter in non-STEM fields.

The Roy model predicts that the disciplinary variations in the supply of high-ability individuals is partially driven by alternative labor market opportunities across disciplines. To further shed light on this possibility, panel B presents information on non-tenure-line instructors' employment records before they started working at ASCS. Since the UI records we have access to start from 2001, we limit our sample to non-tenure-track instructors hired by ASCS in or after 2004, so that we observe at least three years of their employment history prior to ASCS employment. The vast majority of non-tenure-line faculty in this restricted subsample have worked in a non-education sector before starting their college instructor position at ASCS. Furthermore, approximately 20% to 40% of the instructors have worked in the K-12 sector before their ASCS employment.

To examine instructors' labor market performance before they started working at ASCS, we calculate the average annual earnings from the last three years prior to ASCS employment, again among individuals who started working at ASCS in 2004 or later. The results show clear disciplinary differences, where individuals in STEM fields have consistently higher earnings than those in non-STEM fields. In four-year colleges, for example, the average annual earnings of temporary adjuncts and long-term non-tenure faculty in STEM fields are $26,402 and $30,014, respectively, compared with $24,232 and $21,253 in non-STEM fields. Similar earnings gaps between STEM and non-STEM fields are also observed at two-year colleges.

Finally, summary statistics in panel C focus on employment features of the college teaching positions. To show the relative size of the gaps in these features between different types of faculty more clearly, we report the percentage difference relative to long-term non-tenure faculty as the reference group for each variable in panel C. For example, in calculating the gap in earnings from college between the two types of non-tenure-line faculty in STEM disciplines at two-year colleges, we first subtract the average earnings of long-term non-tenure faculty from the average earnings of temporary adjuncts in STEM fields at two-year colleges, and then divide the differential by the average earnings of long-term non-tenure faculty. This allows us to take into account overall disciplinary variations in earnings and put the earnings differentials between different types of faculty into context.

Descriptive results indicate that overall, temporary adjuncts have lower compensation and job stability at ASCS compared with long-term non-tenure faculty. Specifically, temporary adjunct faculty are more likely to teach in multiple institutions and less likely to be employed full-time by any institution than their long-term non-tenure counterparts. The average annual compensation of temporary adjuncts from their college teaching positions is around half as much as that of long-term non-tenure faculty, which seems to be due to both lower teaching load and lower pay per credit. Given the limited teaching load and low compensation through the college teaching position, it is unsurprising that temporary adjuncts are more likely to hold concomitant non-college jobs while teaching as a college instructor, and earnings from non-college jobs tend to be one of the main sources of income for temporary adjuncts.

Moreover, comparisons across disciplines further reveal that the earnings gaps between the two types of non-tenure-line faculty in general tend to be larger in STEM fields than in non-STEM fields. For example, the average annual earnings of temporary adjuncts are $25,959 lower than long-term non-tenure faculty in STEM disciplines at four-year colleges, representing a 53% gap; the corresponding average earnings gap in non-STEM disciplines is $19,088, or a 45% gap. In a similar vein, the gaps in pay per credit between the two types of non-tenure-line faculty are $828 (or a 19% gap) in STEM fields and $545 (or a 14% gap) in non-STEM disciplines.

Finally, at both two-year and four-year institutions, temporary adjuncts are subject to substantially high attrition rates, and the contrasts are especially pronounced in STEM fields at four-year institutions. Specifically, temporary adjuncts in STEM fields at four-year colleges are less likely to be consecutively employed for at least two semesters by the college during their first year of employment than long-term non-tenure faculty by 15.2 percentage points (or an 18% gap), whereas the difference in likelihood of consecutive employment during the first year is 11.8 percentage points (or a 15% gap) in non-STEM fields. Almost 20% of temporary adjuncts in STEM fields depart from their ASCS teaching positions after one year, whereas the corresponding attrition rate is only 4.2% among long-term non-tenure faculty in similar disciplines. Although temporary adjuncts in non-STEM disciplines are also more likely to leave their college teaching positions than their long-term non-tenure colleagues (17% among temporary adjuncts versus 7% among long-term non-tenure-track), the gap is substantially more pronounced in STEM disciplines, implying that factors related to income and relative working conditions might make it especially challenging to retain temporary adjuncts in STEM disciplines at four-year institutions.

To sum up, the descriptive statistics reveal substantial variations between non-tenure-track faculty and tenure-track faculty, as well as between non-tenure-line faculty hired through temporary and long-term employment. Additionally, we also observe noticeable disciplinary variations in the demographic characteristics and employment features of non-tenure-track faculty, where the relative employment conditions and compensation from college teaching positions seem to be particularly worse off for temporary adjuncts in STEM disciplines at four-year institutions. To the extent that these observed individual characteristics and employment features may influence how instructors interact with their students, there might be meaningful variations in the effectiveness of non-tenure-track faculty hired through different contracts, and these variations may also vary by discipline.

C. Key Outcome Measures

The primary outcome measure we focus on in examining the impacts of alternative instructors on student academic outcomes is subsequent enrollment and completion of the next class in the same field of study after initial exposure, where either failure to enroll or failing the next class would be coded as zero. In addition to this primary outcome measure, we further examine three other measures to help shed light on the specific channels through which having different instructors may influence students' academic outcomes: (i) whether a student enrolled in any additional class in the same field of study after taking the introductory course; (ii) the difficulty of the next course, as measured by the average peer pass rates of the subsequent course a student takes; and (iii) grade in the subsequent class, where mid-semester course withdrawal is coded as zero.

Table 4 uses college transcript information and summarizes student academic outcomes by type of instructors. Panel A shows course-section characteristics including delivery methods, credits attempted, and class enrollment size. Descriptive results indicate that sections taught by temporary adjuncts are slightly more likely to be delivered through the online format. In terms of class enrollment size, it seems that long-term non-tenure-track faculty tend to teach classes with larger enrollment, whereas temporary adjuncts tend to teach classes with smaller numbers of students in both STEM and non-STEM fields.

Panel B summarizes students' enrollment and completion of the next class in the same field of study. On a descriptive basis, it seems that the most pronounced gap is between temporary adjuncts and long-term non-tenure faculty in STEM fields at four-year institutions: Students who have temporary adjuncts during their initial exposure to a field on average have a lower probability of attempting additional classes in the same field (37.6%) by 11-13 percentage points compared with students who have their introductory courses with either long-term non-tenure faculty (48.2%) or tenure-track/tenured faculty (50.8%). Similar sizes of gaps between temporary adjuncts and the other two types of faculty are also observed once we further take next class completion into account.

In addition to enrollment and completion of the next class, panels C and D further show the difficulty of the next course and student outcomes conditional on enrolling in subsequent classes in the same discipline. We use two indicators to measure the level of difficulty of the next course: average course pass rate of peers in the next course and the average course grade of peers in the next course.[8] Based on the two measures, it seems that the subsequent courses are fairly comparable in peer completion rates and course grades. The descriptive statistics also do not reveal any substantial differences in student course performance in the subsequent class. Taken together, these descriptive statistics seem to suggest that temporary adjuncts in introductory courses are associated with lower subsequent interest in the same discipline, and such associations are particularly strong in STEM-related disciplines at four-year colleges.

IV. Identification Strategy

A. Addressing Between-Course Sorting: College-Course Fixed Effects

To examine the influence of having different types of instructors in introductory courses on students' subsequent course enrollment and performance in the same field of study, we conduct a student-by-field analysis that relates types of instructor during a student's initial exposure to a particular field of study to the outcome measure examined. Using whether enrolling in a second course in the same field as an example, the empirical model proceeds as follows:

$$Y_{icskjt+1} = \alpha + \beta \, \text{Instructor}_{icskjt} + \rho_{ckj} + \pi_t + X_{ikjt} + S_{cskjt} + \mu_{icskjt} \qquad (1)$$

The outcome measure (Y_{icskjt}) indicates whether student *i* enrolls in another course following her initial exposure to field *k* through section *s* of introductory course *c* at college *j* in semester *t*. The key explanatory variable is the type of instructor with whom a student took the introductory course in a field of study ($\text{Instructor}_{icskjt}$). Since two-year colleges do not have

[8] Specifically, we take the average of course pass rates and the average of course grades for each college course taken by any student between fall 2005 and summer 2012 in our data, but exclude the student's own course completion and course grade.

tenure-track positions, we use long-term non-tenure faculty as the base group for both the two-year and four-year analyses for easier comparisons of coefficients across settings. In the analysis of four-year colleges, the vector "Instructor" consists of two dichotomous variables: temporary adjuncts and tenure-track faculty (including tenured faculty), compared with long-term non-tenure faculty. In the analysis of two-year colleges, there is only one variable in the "Instructor" vector (temporary adjuncts), also with long-term non-tenure faculty serving as the reference group. ρ_{ckj} represents college-course fixed effects that compare the outcomes of students who took exactly the same course within a college during their initial exposure to a field of study; π_t represents semester fixed effects that control for overall variations over time.

The model also controls for student-level covariates (such as all student demographic and academic characteristics shown in Table 1, cohort of enrollment, and whether they intended to receive a degree in STEM-related fields upon college enrollment),[9] student-by-term information (such as total credits taken in semester *t*), and student-by-field information (such as whether the course is within the student's declared major) as indicated by X_{ikjt}. Finally, S_{cskjt} represents course-section-level information (e.g., number of total enrollments in the course section, whether the course section is online or face-to-face, and average high school GPA of peers in that section).[10]

B. Addressing Within-Course Sorting: Instrumental Variable Approach

[9] Approximately 11% of the students did not declare a major upon college enrollment. For these students, we create an indicator for missing major declarations.

[10] We use the term "section" or "class" to refer to a particular offering of a course with a specific instructor at a specific time, such as "MATH 101 Calculus – section 01 in the fall term of 2009"). Hence, a "section" or "class" is uniquely defined by course title, section, and term.

Equation 1 controls for any between-course variations within a college. The remaining source of selection is hence due to students' differential sorting by type of instructors within a specific college course. For example, more academically motivated students might prefer tenure-track/tenured faculty for their accessibility and potential research opportunities. We directly explore the extent of this problem by relating different types of instructors to a wide range of student characteristics controlling for college-course fixed effects, term fixed effects, cohort fixed effects, student-by-term information, student-by-field information, and course-section-level characteristics.

Results presented in Appendix Table 2 suggest that the patterns of sorting vary by discipline and by sector of the institution. At two-year institutions, students taking classes with non-tenure-track faculty tend to be older, are more likely to be Black students, residents of the state, and enroll part-time during the initial term of college enrollment. Despite these demographic differences, we do not find any evidence that students with weaker academic preparation are more likely to opt into classes taught by temporary adjuncts. If anything, the evidence supports the opposite. Specifically, students taking classes with temporary adjuncts are less likely to have taken any remedial coursework. We also identify a positive correlation between higher high school GPA and greater likelihood of taking classes with temporary adjuncts in non-STEM fields. At four-year institutions, older students and students who enroll part-time in their first term in college are more likely to attempt a course with non-tenure-line faculty. Students with better academic preparedness (as indicated by attainment of high school diploma and not enrolling in any remedial coursework) are more likely to attempt classes with tenure-line faculty in non-STEM fields, but we do not observe similar patterns in STEM fields.

To address student sorting by type of instructors, we further combine the college-course fixed effects in equation (1) with an instrumental variables approach, where we use term-by-term fluctuations in proportions of total number of course sections offered by different types of instructors in each department as an instrument for students' probability of taking their introductory course with a certain type of instructor. Specifically, we construct the instrumental variables as the deviation in the proportion of course sections offered by a specific type of instructor in a given department during a certain term from the average proportion of sections offered by that type of instructor in a typical fall, spring, or summer term, thus addressing possible seasonality of using non-tenure-track faculty.[11] We then run the following first-stage equation to predict the probability of taking a particular introductory course with a given type of instructor within a field . Taking the probability of taking a math course with a temporary adjunct instructor in the four-year setting as an example:

$$TempAdjunct_{icskjt} = \alpha+\beta pctTempAdjunct_{kjt} +\gamma pctTenureProf_{kjt} +\rho_{ckj} + \pi_t +X_{ikjt} +S_{cskjt} +\varepsilon_{icskjt} \quad (2)$$

"$pctTempAdjunct_{kjt}$" and "$pctTenureProf_{kjt}$" represent the variations in the proportion of sections taught by temporary adjuncts and tenure-track/tenured faculty in a particular department *k* at college *j* during term *t*. The coefficients β and γ hence measure the association between having more classes offered by temporary adjuncts and tenure-track/tenured faculty in the department and the likelihood that student *i* takes her first course *c* within the field *k* with a temporary adjunct instructor in section *s*. Similar to equation (1), we also control for college-course fixed effects as represented by ρ_{ckj}. Accordingly, the variation for the IVs comes only from fluctuations in course offering by non-tenure-track faculty over time rather than students

[11] Please see Bettinger and Long (2010) for a more detailed discussion of this instrumental variable strategy.

taking different first courses within a field. In other words, students taking the same introductory course (such as "Introductory Chemistry") during the same term (such as Fall 2008) would hence have identical IVs.

Table 5 shows the first-stage results by detailed breakdowns of disciplines at two-year and four-year colleges respectively. The results indicate that the proportions of course sections taught by a given type of instructor in a department are significant predictors of a student's probability of taking a course with that type of instructor in all disciplines at both two-year and four-year colleges. Based on Stock and Yogo (2005), the first-stage *F*-statistics need to be 16.38 or higher for two-year colleges (one endogenous variable and one instrumental variable) and 19.93 for four-year colleges (two endogenous variables and two instrumental variables) to rule out the possibility of weak instruments. The majority of the first-stage regressions presented in Table 5 have met these criteria, except for a handful of cases. To address the potential concern due to weak instruments, we further conduct a weak instrument robust test for fields that are potentially prone to the weak instrumental variables problem using the method explained in Finlay et al. (2013) that ensures correct coverage regardless of instrument strength. The results are presented in Appendix Table 3 and are consistent with the main findings.[12]

C. Validity of the Instrumental Variables Strategy

[12] Specifically, four first-stage regressions using the four-year sample yield an *F* statistic that is lower than the threshold based on Stock and Yogo (2005): the predicted probability of taking a course with a temporary adjunct in the field of science ($F = 11.7$) and health ($F = 13.4$), and the predicted probability of taking a course with tenure-track or tenured faculty in math ($F = 11.1$) and CTE ($F = 14.7$). Based on the weak instrument robust inference following the method in Finlay et al. (2013), results presented in Appendix Table 3 indicate that the 95% confidence intervals for the impact of adjuncts on enrolling and completing the next class at four-year colleges are [-0.53, -0.18] for the field of science and [-0.64, -0.21] for health; the 95% confidence intervals for the impact of tenure-track/tenured faculty are [0.05, 0.31] for math and [-0.63, -0.12] for CTE. None of these confidence intervals include zero, thus aligning with our main findings reported in Table 6.

One potential threat to the validity of the instrumental variables approach in the current context is the possibility of violating the exclusion assumption. Specifically, it is possible that variations in course offering from non-tenure-track faculty may reflect departmental changes that directly affect student learning outcomes, rather than merely affecting them indirectly through course enrollment with different instructors. For example, if a department is faced with increasing funding cuts and financial constraints, the department might rely more heavily on temporary adjuncts to save on costs, while at the same time reducing academic and institutional support to students.

We conduct two exploratory analyses to shed light on the extent of this concern. First, we examine whether our instrumental variables (seasonally adjusted share of course sections offered by different types of faculty in a department) are associated with other departmental changes which we are able to observe in our data, such as the average demographic characteristics of students who take any course in a department during a given term. To serve this goal, we aggregate our dataset at the department-by-term level, and Appendix Table 4 shows the results from a series of regressions that use our instrumental variables to predict the variations of a set of pre-determined student characteristics by discipline and by sector of the institution. Except for a few cases, we do not see any consistent pattern of correlation between student characteristics in a department and reliance on non-tenure-track faculty.

In the second set of exploratory analyses, we further examine whether course offerings at a given department at a college demonstrates a clear trend in relying on a specific type of faculty. Figure 1 visually presents the over-time changes in share of course sections taught by different types of faculty for the top 15 college departments with the largest course enrollments for our two-year (Panel 1) and four-year samples (Panel 2), respectively. For each panel, we show the over-time changes for STEM fields (figure A) and non-STEM fields (figure B) separately. Most of the departments do not exhibit a clear trend or pattern in course sections by type of faculty across terms. In addition to visual presentations, we can also directly test whether there is significant association between course offerings by type of faculty in a department and time, after controlling for the overall time trend in reliance on non-tenure-track faculty within the state.[13] For the two-year college sample, we regress the de-seasoned proportion of course sections taught by temporary adjuncts on time for each of the 115 unique college-by-department combinations, thus running 115 regressions. In a similar vein, we run two sets of regressions for each of the 315 college-by-department combinations for the four-year college sample, one on proportions of course sections taught by temporary adjuncts and the other on proportions of course sections taught by tenure-line faculty, thus running 630 regressions. Among all the regressions we run, only 4% show significant time trends (5 regressions out of 115 for the two-year college sample and 25 regressions out of 630 for the four-year college sample), suggesting that the fluctuations in reliance on non-tenure-track faculty are plausibly idiosyncratic in the majority of the departments in our sample.

Another threat to the validity of our identification is that our data do not include information on the day and time of a class. If non-tenure-track faculty are systematically assigned to teaching evening classes, for example, the result may partially reflect the association between time of the class and student outcomes. One of the four-year colleges (also the largest

[13] To take out the overall time trend in course sections taught by different types of faculty in this state, we first regress the de-seasoned proportions of course sections by each type of non-tenure-track faculty over time across all college-by-department combinations on time. We then use the model to predict the outcome measure for each college department in each term and use the residuals as the dependent variable in our subsequent exploration of unique time trends within each college department.

four-year college in this state) has published its course schedules online since the academic year 2010-11, which includes course section IDs that can be linked to our administrative data. We scrape all the class schedules in the academic year of 2010-11 from this institution, which constitute approximately 8% of all the student course enrollment records of our sample and 12% of the four-year college sample in that academic year. Among the course sections which we are able to link to class schedules, only 1.6% are night sections (i.e., course sections that start after 6 pm). While temporary adjuncts are slightly more likely to teach night sections, the difference is fairly small (4% of course sections taught by temporary adjuncts are night sections, compared with 1% by long-term non-tenure faculty and 2% by tenure-line faculty) and the estimated impact of non-tenure-track faculty on student outcomes is not sensitive to the inclusion of class time.

V. Results

A. Overall Impacts

Table 6 presents the IV estimates of different types of instructors in one's introductory course in a specific field of study on our primary outcome of interest—student's probability of attempting and completing a subsequent course in the same field. The results reveal three interesting patterns. First, temporary adjuncts are associated with negative impacts on students' subsequent course enrollment and completion compared with the other two types of faculty across all fields of study, and such negative effects are significant in four out of six fields at two-year colleges and in all fields at four-year colleges except for math. These patterns indicate that the problems with temporary adjuncts in inspiring students into additional classes and preparing students for the subsequent coursework are widely shared within this state college system.

Second, the negative impacts of temporary adjuncts are particularly large in STEM fields at four-year colleges. On average, students taking their introductory STEM courses with temporary adjuncts in four-year colleges are associated with lower probability of "taking and completing a subsequent course" in the same field by 34 percentage points, which is more than twice as large as the negative impacts associated with having one's introductory course with a temporary adjunct in non-STEM fields at four-year colleges. To test explicitly whether the effects of alternative faculty on subsequent academic outcomes are indeed different in STEM versus non-STEM fields, we run pooled analyses with interaction terms between types of faculty and a dummy variable indicating STEM fields. The results are presented in Appendix Table 5, and the coefficients on the interaction terms between temporary adjuncts and STEM fields are significantly negative for the four-year college sample, indicating that the negative effects of temporary adjuncts relative to long-term non-tenure faculty on student subsequent course enrollment and completion are indeed stronger in STEM than non-STEM fields in four-year colleges.

Finally, in contrast to the consistently negative coefficients associated with temporary adjuncts, the differences between long-term non-tenure faculty and tenure-track faculty in student subsequent academic outcomes tend to be smaller and nonsignificant, indicating that long-term non-tenure faculty in general achieve parity with their tenure-track counterparts in inspiring and preparing students for subsequent courses. Among all the six fields examined, only math and Career Technical Education (CTE) show significant differences in student outcomes between the two categories of faculty. Interestingly, the impacts of long-term non-tenure faculty relative to tenure-line faculty are opposite in these two fields: Tenure-track faculty outperform long-term non-tenure faculty in math, whereas long-term non-tenure faculty are more effective in promoting subsequent interest in CTE fields.

One potential concern regarding our analyses is multiple hypothesis testing: As we run analyses for multiple fields simultaneously, the likelihood of false positives or Type I error increases, and some of the tests may yield statistically significant *p*-values purely by chance due to a large number of hypotheses being tested. One common approach that has been used in the existing literature to address the multiple hypothesis testing problem is to adjust the *p*-values controlling for the False Discovery Rate (FDR). Specifically, if we accept a probability of Type I error of 5%, the FDR correction would adjust our rejection criteria such that the expected proportion of our null hypotheses that are incorrectly rejected is less than 5%.[14] We follow the sharpened procedures described in Anderson (2008) and Benjamini et al. (2006) to calculate the FDR adjusted *p*-values. The adjusted *p*-values presented in Appendix Table 6 indicate that the significant effects of taking an introductory course with temporary adjunct faculty on subsequent course enrollment and performance across subject fields are unlikely to be an artifact of multiple hypothesis testing.

Lastly, we run a robustness check on subsequent course enrollment and performance focusing on courses outside a student's intended major declared upon college enrollment. The out-of-major analysis focuses on fields where a student's academic interests and decisions, such as course withdrawal and enrollment in additional classes, are most plausibly affected by

[14] Another commonly used approach for multiple comparisons is to adjust the *p*-values based on familywise error rate (FWER), such as the Bonferroni correction procedure, which controls the probability of making a Type I error in any of the hypothesis tests. Yet, a potential problem with FWER is that the stringent control of the probability of making Type I errors is often at the cost of a substantial reduction in power, or an increased likelihood of making Type II errors. Different from FWER-controlling procedures which control the chance of making any Type I error, FDR-controlling procedures instead control the proportion of significant results that are false positives and thus offer better power by formalizing the trade-off between correct and false rejections (Anderson, 2008).

instructors. The results are presented in Appendix Table 7. All of the estimated effects are fairly consistent and in most cases larger in magnitude when we restrict the sample to classes taken outside a student's intended major. In addition, considering that earning a D in a student's class may not necessarily be a positive outcome, we also run a robustness check by using C or above instead of D or above to define course completion. The results are presented in Appendix Table 8. While the size of the coefficients generally attenuates, the patterns of results resemble those presented in Table 6.

B. Additional Outcome Measures

The results from our primary analysis indicate that taking one's first course with a temporary adjunct reduces the student's probability of enrolling in and completing a subsequent class in the same field. Yet, the specific channel through which such effect operates is unknown. Specifically, the initial course experience in a field may influence students' subsequent outcomes in at least three ways: whether a student attempts a subsequent course in the same field of study, choice of the specific subsequent course to enroll in, and performance in the subsequent course in the same field, such as course persistence and course grade.

To shed light on the specific channels, we conduct separate analyses with three distinct outcome measures: (i) whether a student enrolls in any additional course in the same field of study after taking the introductory course; (ii) the difficulty of the next course, as measured by the average pass rate of the subsequent course the student takes;[15] and (iii) the student's course grade in the subsequent class conditional on enrollment, where mid-semester course withdrawal is coded as zero. We use equation (1) for the first two outcomes; for student performance in the

[15] We also conduct a robustness check using average peer grades as an alternative way to define next course difficulty and the results resemble those presented in Table 8. The results are available upon request.

subsequent class, we further expand equation (1) to control for next-course-section fixed effects, which are constructed as a combination of college, course, and section number. Accordingly, this model specification compares student performance in the exact same next course section, controlling for the possibility that initial experience in a field may influence a student's next course choice, as well as preference for different types of instructors in the next class in that field.

Table 7 shows the results on student subsequent enrollment in the same field of study. The patterns of results are fairly similar to those shown in Table 6, except for consistently larger effect sizes across almost all fields of study. One possible explanation for the reduced effect size once considering next class performance (instead of focusing on course enrollment alone) might be due to selection into next classes with different levels of difficulty as a result of initial experiences in a field of study. For example taking one's introductory course with temporary adjuncts may reduce a student's self-perceived capability in a particular field and induce them to take an easier subsequent course in the same field of study.

To explore this possibility, Table 8 examines the influence of different types of instructors in one's introductory course on the average course pass rate among peers in the next course. Overall, the majority of the estimates are insignificant with two exceptions: In two-year colleges, students who take introductory math courses with temporary adjuncts are more likely to opt into less challenging math classes subsequently. In four-year colleges, students who take introductory courses with tenure-line faculty in social science are more likely to opt into more challenging classes subsequently.

In Table 9, we further show the impacts of introductory course instructors on students' subsequent course grades in a field controlling for next-course-section fixed effects, which control for the possibility that initial experiences in a field may influence a student's next class choice. Overall, the majority of the estimates are not significant except for a handful of distinctions between long-term non-tenure faculty and tenure-line faculty at four-year institutions. Specifically, in STEM-related fields, taking one's introductory course with a tenure-line faculty instead of long-term non-tenure instructor is on average associated with a higher next class grade by close to 0.2 grade points on a 1-4 grading scale. This correlation is driven primarily by the specific field of Natural Science. The positive impact of tenure-line faculty on subsequent course performance is also observed in two non-STEM fields, including Social Science and CTE.

C. Heterogeneity by Field of Study or Heterogeneity by Institution?

The results shown above demonstrate clear heterogeneity in instructor impacts by field of study and indicate that the negative impacts associated with temporary adjuncts are particularly large in STEM fields at four-year colleges. One potential concern, however, is that the heterogeneous impacts could be partially driven by variations in quality of instruction across colleges. For example, suppose colleges that have a STEM focus also have the most resources and can therefore hire the best tenure-track faculty and well-supported long-term teaching faculty. In this case, there may be only a limited number of temporary adjuncts in these institutions, and the differences in instructor quality between temporary adjuncts and other faculty may be particularly large.

Although we cannot directly answer this question with the data we have, we could at least shed some light on this possibility by examining institutional variations in STEM focus and reliance on non-tenure-track faculty. Descriptive statistics shown in Appendix Table 9 do not show a clear correlation between the proportion of student course enrollments in STEM fields and faculty composition. In fact, the variation in the proportion of student course enrollments in STEM fields is fairly small across the four-year institutions. That said, we further run the by-field heterogeneity analyses within each four-year institution. The patterns of disciplinary variations in individual colleges are fairly consistent with those presented in Tables 6 to 9.

VI. Conclusion and Implications

Based on data from five cohorts of students in a state public college system, this study contributes to the existing literature on college instructor effectiveness by focusing on disciplinary variations in the characteristics and effects of non-tenure-track faculty hired through temporary and long-term employment. Drawing on the rich information about college instructors from multiple sources of data, we examine three sets of instructor characteristics, including their demographic characteristics, labor market performance prior to their ASCS employment, and employment features of the college teaching position. We identify substantial differences in these characteristics between the two types of non-tenure-line faculty.

More importantly, the size of these differences also varies by discipline and by sector of the institution, and the gaps are especially pronounced in STEM fields at four-year colleges. Most notably, temporary adjuncts in STEM fields at four-year colleges are close to five times as likely to depart from their college teaching position after one year than STEM long-term non-tenure faculty, which may due to both better alternative job opportunities in STEM fields overall, and undesirable employment conditions at ASCS relative to their long-term non-tenure colleagues. These statistics suggest that four-year institutions seem to face particularly great challenges in recruiting and keeping high-quality teaching forces through temporary adjunct contracts.

Using an instrumental variables approach to control for student self-sorting by type of instructors, our subsequent analyses indicate that students who take their introductory courses with temporary adjuncts are less likely to attempt another course in the same field than students who take their introductory coursework with long-term non-tenure faculty. Such negative impacts are consistent across fields of study and sector of the institution, indicating that the problems with temporary adjuncts in inspiring students' interests in a field are widely shared within this state college system. Furthermore, the negative impacts of temporary adjuncts on subsequent course enrollment in a field are particularly sizable in STEM fields in four-year colleges.

In contrast, long-term non-tenure-track faculty are fairly comparable to tenure-track faculty in terms of students' continuation into subsequent courses in most of the fields, although there are also some between-field differences. Specifically, compared with tenure-line faculty, long-term non-tenure faculty seem to be less effective in inspiring students to take another math course, but are more effective in promoting subsequent interest in CTE fields. These results align with the findings of Bettinger and Long (2010), who identified positive impacts of non-tenure-track faculty on student subsequent interest in fields that are tied more closely to an occupation.

One of the most important reasons for hiring non-tenure-track faculty is to save cost (Adamowicz, 2007; Wagoner et al., 2004). Indeed, our data indicate that the average pay per credit is substantially lower for both types of non-tenure-track faculty compared with tenure-line faculty at four-year colleges. With the declines in public financing and the movement away from the tenure system in higher education, increasing reliance on the non-tenure-track teaching force is likely to continue nationwide. Our results provide several policy implications for colleges' hiring practices. First, in view of the apparent contrasts between non-tenure-track faculty hired through temporary and long-term contracts, colleges may consider limiting the number of temporary positions and instead creating more long-term positions with greater job security and institutional support to stabilize and professionalize the teaching force.

From a cost perspective, the average pay per credit is 12%-22% lower for temporary adjuncts than long-term non-tenure faculty, and this calculation does not take into account the additional gaps in benefits provided to faculty. Since the majority of temporary adjuncts are hired through part-time appointments and typically receive reduced benefits from the university, the costs are likely to be higher if institutions rely more heavily on long-term non-tenure faculty than temporary adjuncts. On the other hand, long-term non-tenure-track faculty hired to focus on teaching may bring other benefits to an institution, such as being actively involved in administrative services and serving as pedagogical leaders through discipline-based education research (e.g. Bush et al., 2015, 2017).

Second, considering that individuals with credentials in STEM-related fields typically have more alternative industry job opportunities and better compensation packages outside of teaching, hiring policies and compensation for non-tenure-track faculty in STEM fields need to be renegotiated to take into account disciplinary differences in alternative job opportunities. This may require colleges to invest more in STEM fields and develop policies to address disciplinary differences in compensation during the hiring process.

Finally, the subtle differences between long-term non-tenure faculty and tenure-line faculty in their impacts on student outcomes should not be ignored. The possibility that non-tenure-track faculty may have a different leverage in professional skills and experiences in relevant industries and may benefit students in fields that are tied more closely to an occupation deserves further exploration. Considering that long-term non-tenure faculty are relatively less expensive than their tenure-track colleagues, institutions may consider being strategic in using long-term non-tenure faculty across different fields of study.

Yet, while long-term non-tenure faculty are generally comparable to their tenure-line colleagues in motivating students to continue in the same field of study, we still identify nontrivial advantages of tenure-track faculty over long-term non-tenure faculty in student subsequent course performance in several fields of study. One possibility is that non-tenure-track faculty overall have relatively diminished involvement in more advanced coursework and in curriculum design, which may limit their capacity in broadening introductory course content such that it prepares students for follow-on learning. This type of story suggests that colleges should consider involving non-tenure faculty more intensively into departmental discussions and also connect introductory instructors with those teaching more advanced coursework in more proactive ways. Another way for colleges and departments to engage faculty and improve their teaching is through professional development. If tenure-track faculty are supported, encouraged, and rewarded to improve their teaching, but non-tenure-track faculty are not, ultimately, students will pay the price for the inadequate support to non-tenure-track faculty. Therefore, colleges should not only provide more easily accessible resources and professional development opportunities to non-tenure-track faculty, but also come up with incentives for encouraging and rewarding efforts to improve their teaching.

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Table 1

Sample Descriptive Statistics: Student Characteristics

	(1) Two-year colleges	(2) Four-year colleges
Female	56.2%	53.2%
Age when started	24.3	19.5
	(8.6)	(4.0)
Race		
White	72.3%	70.9%
Black	21.8%	20.4%
Hispanic	3.8%	2.6%
Asian	1.1%	1. 9%
High school diploma	75.2%	92.7%
High school GPA	2.7	3.2
	(0.6)	(0.6)
Entered in fall term	67.5%	89.7%
Placed as college ready in		
Math	26.2%	65.6%
English	49.7%	76.0%
Reading	58.1%	78.2%
Taken remedial courses	64.7%	40.2%
N	68,692	87,212

Note. Presented are proportions or means with standard deviations in parentheses. Data include students who first entered one of the public postsecondary institutions in ASCS between fall 2005 and summer 2010, and took at least one college-level course between fall 2005 and summer 2011.

Table 2

Proportion of Student Course Enrollments by Type of Faculty and Department

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Two-year colleges			Four-year colleges			
	Temporary adjunct	Long-term non-tenure-track	*N*	Temporary adjunct	Long-term non-tenure-track	Tenure-track or tenured	*N*
STEM	**39.2%**	**60.8%**	**96,216**	**15.6%**	**48.1%**	**36.3%**	**186,897**
Math	32.9%	67.1%	24,909	11.8%	65.7%	22.5%	49,492
Natural Science	38.4%	61.6%	55,710	14.9%	41.4%	43.7%	116,821
Health	51.8%	48.2%	15,597	28.4%	44.1%	27.5%	20,584
Non-STEM	**50.3%**	**49.7%**	**243,386**	**24.0%**	**37.7%**	**38.3%**	**507,498**
English and Humanities	52.5%	47.5%	89,925	24.4%	43.1%	32.5%	210,765
Social Science	49.0%	51.0%	110,987	21.4%	31.0%	47.6%	229,932
Career Technical Education (CTE)	49.1%	50.9%	42,474	31.7%	43.9%	24.4%	66,801

Note. Data include the student course enrollments in introductory courses, that is, the first college-level course that a student takes in a field of study between fall 2005 and summer 2011, excluding courses with pass/fail grades.

Table 3

Instructor Descriptive Statistics

Table 3A. Two-Year Colleges

	(1)	(2)	(3)	(4)
	STEM		Non-STEM	
	Temporary adjunct	Long-term non-tenure	Temporary adjunct	Long-term non-tenure
Panel A. Demographic Information				
Female	55.7%	55.3%	56.5%	52.6%
Race[a]				
White	70.2%	79.8%	72.4%	82.4%
Black	7.2%	4.7%	7.6%	5.4%
Hispanic	0.6%	0.4%	1.2%	0.8%
Asian	1.3%	0.9%	0.4%	0.2%
Highest degree				
Bachelor or lower	38.4%	46.6%	27.8%	34.0%
Master	50.9%	44.7%	61.7%	56.2%
Doctoral	10.7%	8.7%	10.5%	9.8%
Age in 2012	46.4	47.4	46.5	47.8
Panel B. Labor Market Information Before College Instructor Position[b]				
% of faculty who started at ASCS after 2004	41.4%	25.7%	37.7%	20.8%
Worked in non-education sector	89.0%	94.0%	83.8%	82.4%
Worked in K-12 sector	31.2%	25.4%	39.7%	37.2%
Earnings from previous position[c]	$30,637	$32,082	$27,550	$24,642
Panel C. College Employment Information				
Taught in more than one institution	2.4%	1.3%	1.2%	1.5%
[Difference across faculty ranks[d]]	*85%*		*-20%*	
Full-time employed at college	21.7%	77.7%	20.9%	71.2%
[Difference across faculty ranks]	*-72%*		*-71%*	
Earnings from college	$19,161	$44,599	$19,596	$40,391
[Difference across faculty ranks]	*-57%*		*-51%*	
Earnings from other jobs while employed at ASCS	$24,058	$7,300	$18,960	$7,287
[Difference across faculty ranks]	230%		154%	
Credit hours	7.7	14	7.5	13.6
[Difference across faculty ranks]	*-45%*		*-45%*	
Pay per credit	$2,488	$3,186	$2,613	$2,970
[Difference across faculty ranks]	*-22%*		*-12%*	
Consecutively employed by college during first year	66.2%	83.9%	68.0%	79.5%

[Difference across faculty ranks]	*-21%*		*-14%*	
Depart from teaching position after one year	17.5%	6.7%	17.2%	5.2%
[Difference across faculty ranks]	*163%*		*232%*	
N	**927**	**710**	**2,052**	**880**

Table 3B. Four-Year Colleges

	(1)	(2)	(3)	(4)	(5)	(6)
	STEM			Non-STEM		
	Temporary adjunct	Long-term non-tenure	Tenure-track or tenured	Temporary adjunct	Long-term non-tenure	Tenure-track or tenured
Panel A. Demographic Information						
Female	52.2%	54.4%	29.8%	53.5%	54.6%	37.6%
Race[a]						
White	66.5%	78.9%	73.6%	66.8%	73.6%	75.4%
Black	3.9%	4.4%	6.0%	6.9%	9.2%	7.8%
Hispanic	0.5%	0.5%	1.0%	1.2%	1.5%	1.3%
Asian	2.9%	3.3%	9.3%	1.0%	1.7%	4.1%
Highest degree						
Bachelor or lower	34.9%	16%	1%	23.1%	10.1%	0.8%
Master	43.5%	56.3%	14.2%	57.9%	62.6%	15.9%
Doctoral	21.6%	27.7%	84.8%	19.0%	27.3%	83.3%
Age in 2012	43.3	44.9	50	43.5	45	50.5
Panel B. Labor Market Information Before College Instructor Position[b]						
% of faculty who started at ASCS after 2004	36.6%	19.0%	NA	35.7%	16.2%	NA
Worked in non-education sector	89.5%	91.1%	NA	83.8%	82.4%	NA
Worked in K-12 sector	34.1%	19.4%	NA	34.7%	38.0%	NA
Earnings from previous position[c]	$26,402	$30,014	NA	$24,232	$21,253	NA
Panel C. College Employment Information						
Taught in more than one institution	2.1%	1.0%	1.9%	1.3%	1.0%	1.3%
[Difference across faculty ranks[d]]	*110%*		*90%*	*30%*		*30%*
Full-time employed at college	33.9%	84.9%	NA	34.0%	77.8%	NA
[Difference across faculty ranks]	*-60%*			*-56%*		
Earnings from college	$22,701	$48,660	$80,748	$23,557	$42,496	$75,140
[Difference across faculty ranks]	*-53%*		*66%*	*-45%*		*77%*
Earnings from other jobs while employed at	$19,114	$3,394	$1,126	$13,298	$4,220	$557

ASCS						
[Difference across faculty ranks]	463%		-67%	215%		-87%
Credit hours	6.6	11.4	11.4	6.8	10.6	11.3
[Difference across faculty ranks]	*-42%*		*0%*	*-36%*		*7%*
Pay per credit	$3,440	$4,268	$7,083	$3,464	$4,009	$6,650
[Difference across faculty ranks]	*-19%*		*66%*	*-14%*		*66%*
Consecutively employed by college during first year	70.1%	85.3%	NA	68.6%	80.4%	NA
[Difference across faculty ranks]	*-18%*			*-15%*		
Depart from teaching position after one year	19.3%	4.2%	NA	17.4%	6.9%	NA
[Difference across faculty ranks]	*354%*			*154%*		
N	**593**	**547**	**850**	**1,659**	**1,308**	**1,596**

Note. Data in Tables 3A and 3B include instructors who taught at least one introductory course between fall 2005 and summer 2011.
[a] The rest includes American Indian, Pacific Islander, multiple race, and unknown.
[b] Statistics presented in row 2 to row 4 of Panel B are restricted to faculty who started working at ASCS in 2004 or after, for whom we were able to observe UI records for three years prior to ASCS employment.
[c] Average annual earnings up to three years prior to ASCS employment in the UI records.
[d] Difference across faculty ranks was calculated using long-term non-tenure faculty as the base group.

Table 4

Course Section Characteristics and Summary of Outcome Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Two-year colleges				Four-year colleges					
	STEM		Non-STEM		STEM			Non-STEM		
	Adjunct	Long-term	Adjunct	Long-term	Adjunct	Long-term non-tenure	Tenure-track or tenured	Adjunct	Long-term non-tenure	Tenure-track or tenured
Panel A. Course section characteristics										
Face-to-face delivery section	81.3%	85.8%	75.5%	86.3%	88.6%	94.4%	94.3%	92.2%	93.3%	92.4%
Credits attempted	3.23	3.20	2.95	2.89	3.13	2.02	3.17	2.88	2.87	2.92
	(0.73)	(0.89)	(0.36)	(0.65)	(0.86)	(0.81)	(0.95)	(0.50)	(0.52)	(0.45)
Enrollment size	25.7	32.8	30.3	40.1	103.1	156.3	136.2	131.0	204.6	136.2
	(49.3)	(85.0)	(79.1)	(125.5)	(196.8)	(232.2)	(209.5)	(258.5)	(378.6)	(216.3)
N	21,093	75,123	72,923	170,463	24,387	96,985	65,525	109,871	198,165	199,462
Panel B. Student-field outcomes										
Took additional course in the same field	34.7%	38.3%	34.3%	37.3%	37.6%	48.2%	50.8%	39.1%	41.1%	38.2%
Took additional course and passed[a]	25.3%	27.7%	24.1%	27.7%	29.4%	38.3%	42.2%	31.7%	34.4%	31.9%
N	21,093	75,123	72,923	170,463	24,387	96,985	65,525	109,871	198,165	199,462
Panel C. Difficulty of next course										
Average pass rate of peers in next course[b]	73.0%	71.3%	71.9%	74.5%	79.1%	78.7%	80.6%	81.0%	82.3%	82.1%
Average course grade of peers in next course[c]	2.18	2.10	2.21	2.29	2.25	2.24	2.35	2.49	2.53	2.47
	(0.63)	(0.67)	(0.48)	(0.56)	(0.69)	(0.72)	(0.65)	(0.53)	(0.58)	(0.58)
Panel D. Student-next-class outcomes										
Persisted to the end of the course	82.7%	83.1%	82.7%	84.7%	87.0%	87.8%	89.6%	90.4%	91.2%	91.1%
Course grade given persistence	2.16	2.11	2.15	2.28	2.23	2.23	2.42	2.47	2.56	2.54
	(1.56)	(1.53)	(1.62)	(1.57)	(1.49)	(1.47)	(1.43)	(1.48)	(1.44)	(1.43)

N	7,319	28,772	25,013	63,582	9,170	46,747	33,287	42,960	81,446	76,195

Note. Standard deviation in parentheses. The introductory course sample (Panel A) is restricted to the first college-level course taken by each student in each field of study between fall 2005 to summer 2011, excluding courses on a pass/fail grading system. The student-field outcomes (Panel B) and subsequent course outcomes (Panel C and D) are tracked to summer 2012.

[a] This variable is coded as one if the student enrolled in an additional class and completed the class (earning a D or above) in the field of study after taking the introductory course, where either failure to enroll or failing the next class would be coded as zero.

[b] This variable is defined as the proportion of students earning a D or above among all the students who took the course in our data, excluding the student's own course outcome.

[c] This variable is defined as the average grade of the course taken by any student between fall 2005 and summer 2012, excluding the student's own course grade.

Table 5

Results of First-Stage IV Regressions

Panel A. Two-Year Colleges

	(1)	(2)	(3)	(4)	(5)	(6)
	STEM			Non-STEM		
	Math	Natural Science	Health	English and Humanities	Social Science	CTE
Change in seasonally adjusted share of sections						
Taught by adjunct faculty	0.943***	0.793***	0.831***	0.902***	1.163***	0.823***
	(0.158)	(0.149)	(0.179)	(0.137)	(0.116)	(0.094)
F-statistics	35.6	28.3	21.5	43.4	101.1	77.0
N	24,909	55,710	15,597	89,925	110,987	42,474

Panel B. Four-Year Colleges

	(1)	(2)	(3)	(4)	(5)	(6)
	STEM			Non-STEM		
	Math	Natural Science	Health	English and Humanities	Social Science	CTE
Outcome: Adjunct faculty Change in seasonally adjusted share of sections						
Taught by adjunct faculty	0.931***	0.643***	0.334***	1.063***	1.406***	1.242***
	(0.170)	(0.203)	(0.116)	(0.203)	(0.120)	(0.123)
Taught by tenure-track or tenured faculty	0.080	-0.007	-0.058	0.167*	0.117**	0.224**

	(0.060)	(0.061)	(0.195)	(0.092)	(0.048)	(0.108)
F-statistics	39.2	11.7	13.4	27.8	72.5	98.7
Outcome: Tenure-track or tenured faculty						
Change in seasonally adjusted share of sections						
Taught by adjunct faculty	0.071	0.064	-0.007	-0.096	-0.027	-0.067
	(0.158)	(0.093)	(0.069)	(0.071)	(0.098)	(0.071)
Taught by tenure-track or tenured faculty	0.720***	0.688***	0.493***	0.687***	0.796***	0.475***
	(0.217)	(0.086)	(0.122)	(0.081)	(0.056)	(0.121)
F-statistics	11.1	66.5	21.0	86.8	102.7	14.7
N	49,492	116,821	20,584	210,765	229,932	66,801

Note. For both Panel A and Panel B, the base group for all regressions is long-term non-tenure faculty. All regressions control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Standard errors are clustered at college-by-field level.
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 6

Impact of Different Types of Instructors in Introductory Courses on Taking and Passing a Second Course in the Same Field of Study

	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**-0.120*** **	**-0.337*** **	**-0.021**
	(0.045)	**(0.072)**	**(0.045)**
Math	-0.046	-0.253	0.178***
	(0.071)	(0.166)	(0.067)
Natural Science	-0.151**	-0.356***	-0.064
	(0.065)	(0.090)	(0.051)
Health	-0.138	-0.424***	-0.230
	(0.109)	(0.112)	(0.190)
Non-STEM Overall	**-0.131*** **	**-0.151*** **	**0.009**
	(0.032)	**(0.023)**	**(0.021)**
English and Humanities	-0.115*	-0.156***	0.028
	(0.063)	(0.041)	(0.036)
Social Science	-0.119***	-0.175***	0.038
	(0.039)	(0.037)	(0.024)
CTE	-0.183***	-0.098**	-0.378***
	(0.067)	(0.044)	(0.130)

Note. The outcome variable is defined as taking and passing a second course in the same field of study with a grade D or above. Each cell presents the regression coefficient on a subset of the analytic sample by field of study. The STEM overall sample includes all student course enrollments in all three STEM fields listed underneath it, and the non-STEM overall sample includes all student course enrollments in all three fields listed underneath it. All models use our preferred instrumental variables specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 7

Impact of Different Types of Instructors in Introductory Courses on Taking a Second Course in the Same Field of Study

	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**-0.185*** **	**-0.444*** **	**-0.001**
	(0.058)	**(0.076)**	**(0.056)**
Math	-0.281***	-0.416*	0.222**
	(0.089)	(0.235)	(0.100)
Natural Science	-0.180**	-0.451***	-0.039
	(0.086)	(0.085)	(0.065)
Health	-0.101	-0.564***	-0.306
	(0.110)	(0.165)	(0.239)
Non-STEM Overall	**-0.172*** **	**-0.205*** **	**0.024**
	(0.042)	**(0.030)**	**(0.027)**
English and Humanities	-0.166*	-0.202***	0.054
	(0.086)	(0.053)	(0.046)
Social Science	-0.139**	-0.243***	0.055*
	(0.055)	(0.050)	(0.032)
CTE	-0.261***	-0.134***	-0.454***
	(0.074)	(0.051)	(0.155)

Note. The outcome variable is defined as taking and passing a second course in the same field of study with a grade D or above. Each cell presents the regression coefficient on a subset of the analytic sample by field of study. The STEM overall sample includes all student course enrollments in all three STEM fields listed below it, and the non-STEM overall sample includes all student course enrollments in all three fields listed underneath it. All models use our preferred instrumental variable specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 8

Impact of Different Types of Instructors in Introductory Courses on Subsequent Course Difficulty (Measured by Average Peer Pass Rates in the Next Course Enrolled)

	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**0.052**	**0.174**	**-0.059**
	(0.073)	**(0.118)**	**(0.058)**
Math	0.164*	-0.066	-0.009
	(0.098)	(0.190)	(0.075)
Science	-0.007	0.222	-0.083
	(0.096)	(0.139)	(0.076)
Health	0.063	0.265	0.109
	(0.189)	(0.388)	(0.222)
Non-STEM Overall	**0.064**	**-0.008**	**-0.058****
	(0.041)	**(0.030)**	**(0.024)**
English and Humanities	0.102	0.005	-0.066
	(0.071)	(0.038)	(0.049)
Social Science	0.021	-0.038	-0.076***
	(0.056)	(0.050)	(0.029)
CTE	0.077	0.036	0.072
	(0.098)	(0.052)	(0.112)

Note. The outcome variable is defined as the percentage of peers receiving passing grades (D or above) for the next course a student enrolls in within the same field of study. Each cell presents the regression coefficient on a subset of the analytic sample by field of study. The STEM overall sample includes all student course enrollments in all three STEM fields listed below it, and the non-STEM overall sample includes all student course enrollments in all three fields listed underneath it. All models use our preferred instrumental variable specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and current college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student’s declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

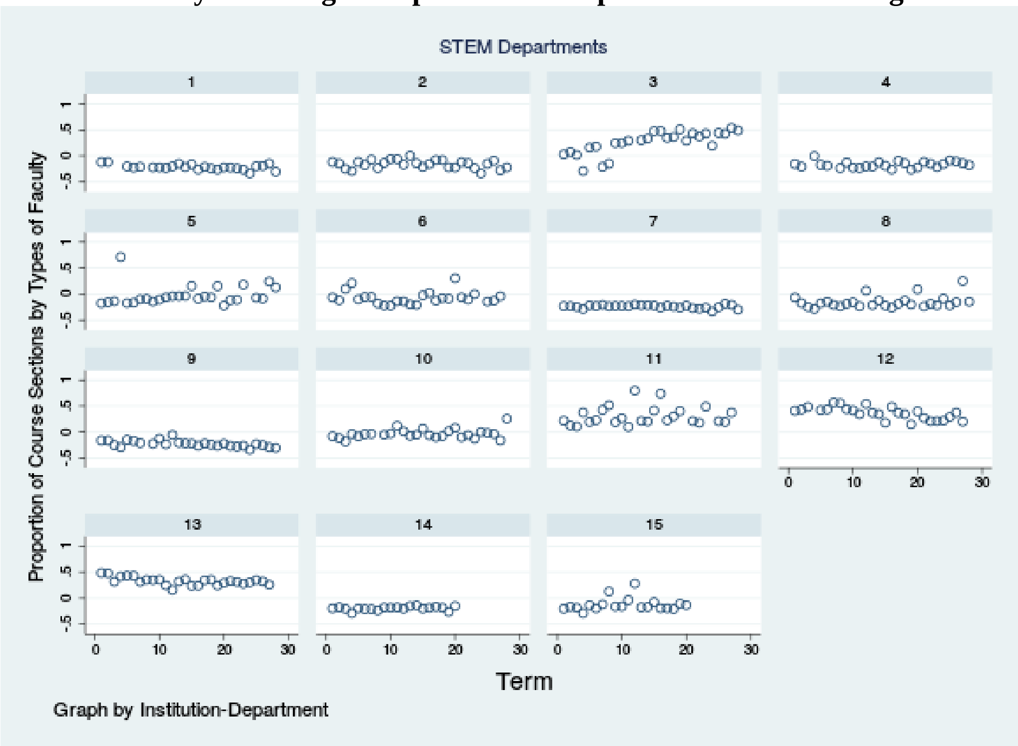
Table 9

Impact of Different Types of Instructors in Introductory Courses on Next Course Grades

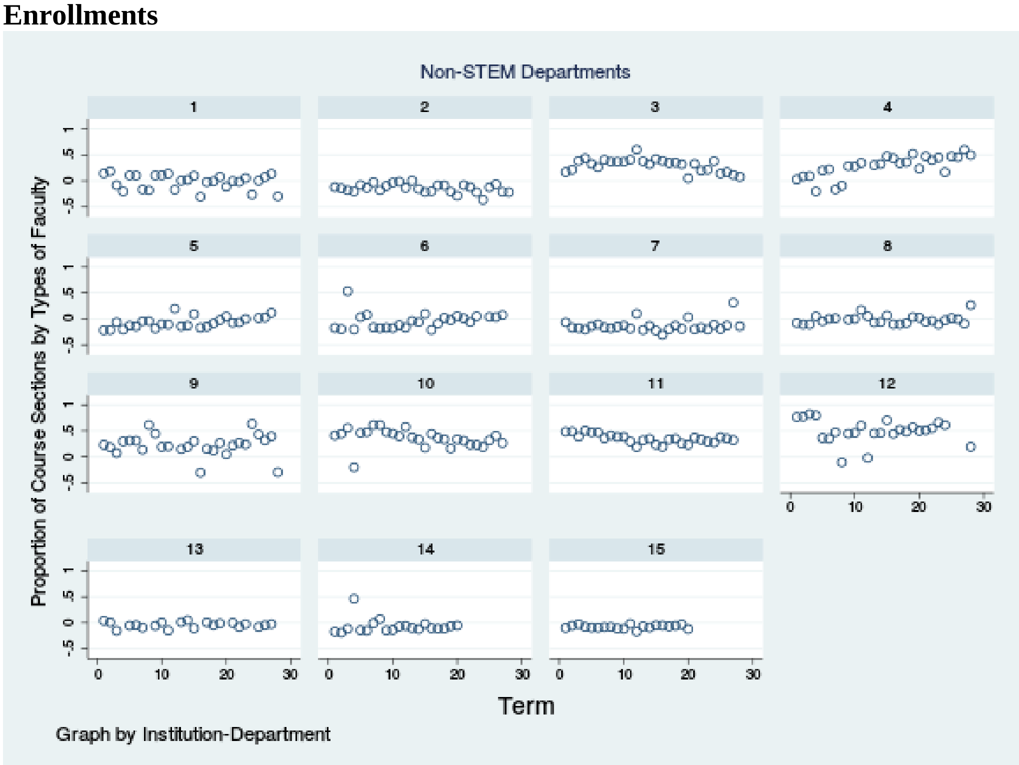
	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**-0.219**	**-0.076**	**0.195***
	(0.386)	**(0.173)**	**(0.110)**
Math	0.039	0.236	-0.152
	(0.538)	(0.249)	(0.260)
Natural Science	-0.579	-0.097	0.217*
	(0.644)	(0.190)	(0.129)
Health	0.061	-0.048	-0.503
	(0.844)	(0.716)	(0.647)
Non-STEM Overall	**0.030**	**-0.038**	**0.114****
	(0.136)	**(0.071)**	**(0.058)**
English and Humanities	0.018	-0.130	0.009
	(0.242)	(0.131)	(0.111)
Social Science	-0.155	-0.062	0.124*
	(0.187)	(0.101)	(0.066)
CTE	0.611	0.172	0.572**
	(0.423)	(0.136)	(0.232)

Note. The outcome is defined as the grade of the next course a student takes in the same field of study after taking the introductory course, where mid-semester withdrawal is coded as zero. Students who do not enroll in an additional course in the field of study are excluded from this analysis. Each cell presents the regression coefficient on a subset of the analytic sample by field of study. The STEM overall sample includes all student course enrollments in all three STEM fields listed below it, and the non-STEM overall sample includes all student course enrollments in all three fields listed underneath it. All models use our preferred instrumental variable specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, current college-course fixed effects, and next college-course-section fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

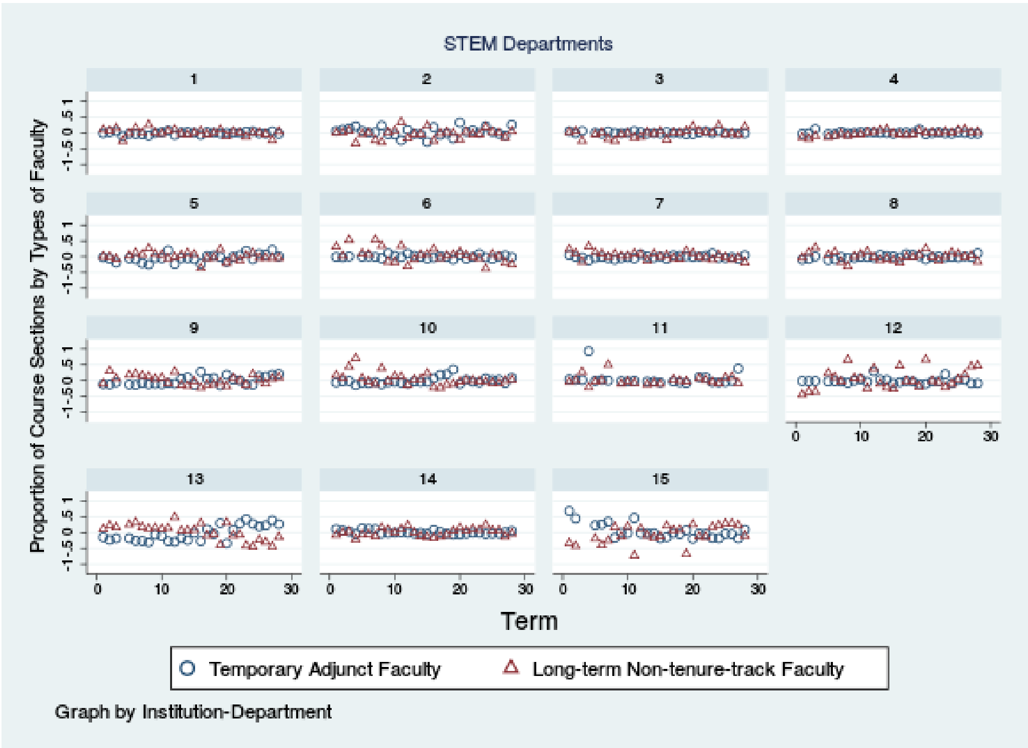
Figure 1. Proportion of Course Sections Taught by Different Types of Faculty over Time
Panel 1A. Two-year Colleges: Top 15 STEM Departments with the Largest Number of Enrollments



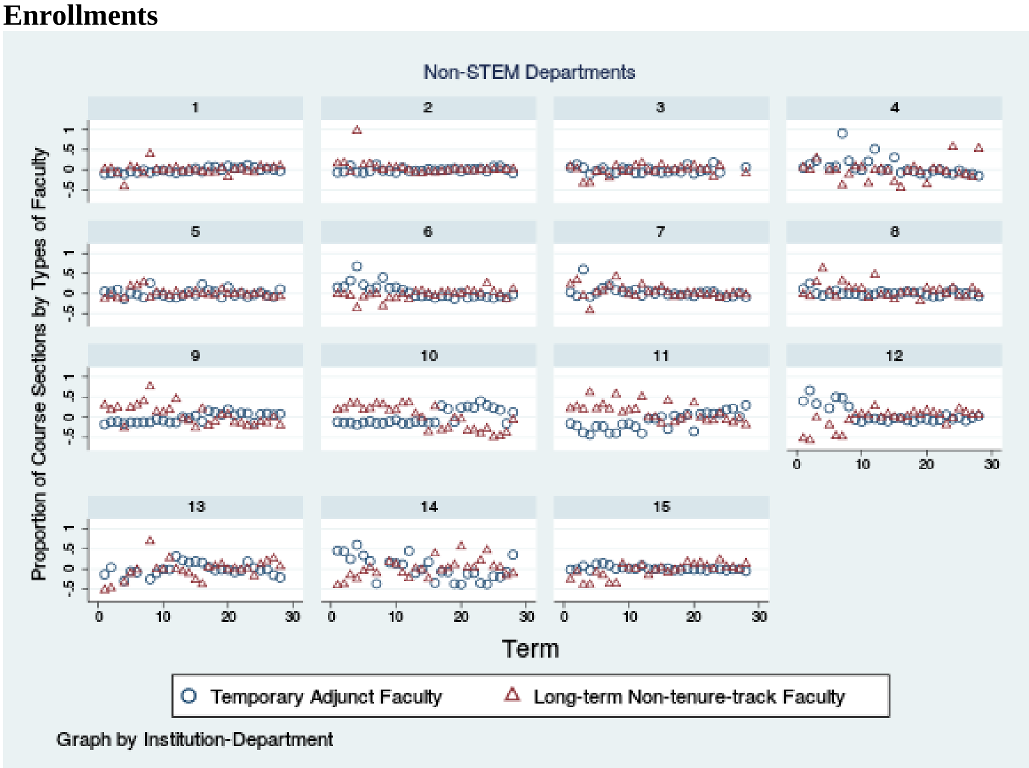
Panel 1B. Two-year Colleges: Top 15 non-STEM Departments with the Largest Number of Enrollments



Panel 2A. Four-year Colleges: Top 15 STEM Departments with the Largest Number of Enrollments



Panel 2B. Four-year Colleges: Top 15 non-STEM Departments with the Largest Number of Enrollments



Notes: The figures shows term-by-term changes in course sections taught by different types of faculty between fall 2005 and summer 2012 for the top 15 college-departments with the largest course enrollments for our two-year and four-year samples, respectively, taking out the overall trend in course sections taught by different types of faculty across all colleges during this period of time. Specifically, we first aggregate our data at the college-department-term level. Since the majority of the colleges in this state divide summer into two terms, a college-department would have up to 28 time points between fall 2005 and summer 2012 (i.e., up to four terms per year over seven years). Based on the aggregated data, we first regress the instrumental variables (i.e., seasonally adjusted shares of course sections taught by different types of faculty) on time fixed effects that account for general time trend in course section composition in the two-year or four-year state college system and college fixed effects that account for variations between institutions in course section composition. We then plot the residuals for selected college-departments with the largest course enrollments for two-year and four-year samples. The graphs indicate that the majority of the departments do not exhibit a clear department-specific trend or pattern in course section composition over time.

Appendix Table 1

Impact of Different Types of Instructors in Introductory Courses on Taking and Passing a Second Course: Alternative Analytic Sample

	(1)	(2)
	Adjunct	Adjunct
STEM Overall	**-0.120*** **	**-0.094*** **
	(0.045)	**(0.035)**
Math	-0.046	-0.058
	(0.071)	(0.051)
Natural Science	-0.151**	-0.107**
	(0.065)	(0.049)
Health	-0.138	-0.125
	(0.109)	(0.107)
Non-STEM Overall	**-0.131*** **	**-0.108*** **
	(0.032)	**(0.026)**
English and Humanities	-0.115*	-0.052
	(0.063)	(0.055)
Social Science	-0.119***	-0.138***
	(0.039)	(0.032)
CTE	-0.183***	-0.131**
	(0.067)	(0.055)
Include course enrollments at the two-year college with tenure-track system	No	Yes

Note. Each cell presents the regression coefficient on a subset of the analytic sample by field of study. Results in Column 1 are the same as those in Column 1 of Table 6. Results in Column 2 are based on an alternative sample including the two-year college with a tenure-track system. The analysis was restricted to student course enrollments with either temporary adjuncts or long-term adjuncts. All models use our preferred instrumental variable specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Appendix Table 2

Probability of Taking an Introductory Course with Different Types of Instructors

	(1)	(2)	(3)	(4)	(5)	(6)
	Two-year colleges		Four-year colleges			
	STEM	Non-STEM	STEM		Non-STEM	
	Adjunct faculty	Adjunct faculty	Adjunct faculty	Tenure-track or tenured faculty	Adjunct faculty	Tenure-track or tenured faculty
Demographics:						
Age when taking the course	0.0016***	0.0008***	0.0028***	-0.0019***	0.0025***	-0.0026***
	(0.0004)	(0.0002)	(0.0008)	(0.0005)	(0.0007)	(0.0006)
Female	-0.0054	-0.0013	0.0017	-0.0057**	0.0071***	-0.0074***
	(0.0050)	(0.0026)	(0.0023)	(0.0028)	(0.0018)	(0.0017)
Race: Black[a]	0.0189**	0.0222***	-0.0108	-0.0011	-0.0089	0.0175***
	(0.0095)	(0.0062)	(0.0134)	(0.0089)	(0.0079)	(0.0050)
Race: Hispanic	-0.0055	0.0158**	0.0032	-0.0048	-0.0050	0.0071*
	(0.0139)	(0.0063)	(0.0057)	(0.0069)	(0.0043)	(0.0041)
Race: Asian	-0.0282	0.0103	-0.0001	0.0102	0.0032	0.0024
	(0.0193)	(0.0100)	(0.0078)	(0.0074)	(0.0051)	(0.0052)
Race: Other race	-0.0088	0.0165*	-0.0099	-0.0233**	-0.0324***	-0.0055
	(0.0139)	(0.0095)	(0.0086)	(0.0098)	(0.0080)	(0.0056)
Resident of the state	0.0049**	0.0033**	-0.0053***	-0.0008	-0.0026	0.0047**
	(0.0024)	(0.0014)	(0.0017)	(0.0030)	(0.0023)	(0.0019)
Academic Attributes:						
High school GPA	-0.0003	0.0111*	-0.0030	0.0104*	0.0038	0.0006
	(0.0055)	(0.0058)	(0.0060)	(0.0061)	(0.0051)	(0.0036)
Earned high school diploma	-0.0024	-0.0031	-0.0124*	0.0082	-0.0124***	0.0108***
	(0.0055)	(0.0048)	(0.0075)	(0.0060)	(0.0045)	(0.0038)
Enrolled full-time 1st term	-0.0386***	-0.0355***	-0.0121***	0.0112**	-0.0172***	0.0064*
	(0.0072)	(0.0034)	(0.0041)	(0.0044)	(0.0037)	(0.0036)

Entered in fall term	-0.0067	0.0012	-0.0024	-0.0045	-0.0044	0.0008
	(0.0041)	(0.0028)	(0.0037)	(0.0034)	(0.0041)	(0.0037)
Took remedial courses	-0.0155***	-0.0086***	-0.0038	-0.0002	0.0101***	-0.0077***
	(0.0057)	(0.0029)	(0.0042)	(0.0063)	(0.0029)	(0.0022)
Observations	96,216	243,385	186,897	186,897	507,499	507,499
R-Squared	0.0220	0.0218	0.0152	0.0216	0.0215	0.0185
Number of courses	1,032	3,793	1,283	1,283	5,517	5,517

Note. All regressions control for college-course fixed effects, term fixed effects, and cohort fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).

The base group for regressions in both two-year and four-year colleges is non-tenure-track faculty. Standard errors are clustered at college level due to multiple observations within a college.

[a] Base group for race is white, non-Hispanic; other race includes American Indian, Pacific Islander, multiple race, and unknown.

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Appendix Table 3

Impact of Different Types of Instructors in Introductory Courses on Taking and Passing a Second Course in the Same Field of Study: Weak IV Robust Confidence Interval

	(1)	(2)	(3)	(4)
Four-year colleges	Adjunct faculty		Tenure-track or tenured faculty	
	Lower bound	Upper bound	Lower bound	Upper bound
Math	NA	NA	0.047	0.310
Natural Science	-0.533	-0.179	NA	NA
Health	-0.644	-0.205	NA	NA
CTE	NA	NA	-0.633	-0.123

Note. The table reports weak instrument robust confidence sets at 95% level based on the method developed by Finlay et al. (2013). The outcome variable is defined as taking and passing a second course in the same field of study with a grade D or above. The original results are presented in Table 6. All models use our preferred instrumental variable specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and current college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).

Appendix Table 4

Correlation Between Instrumental Variables and Variation in Pre-Determined Student Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
	STEM			Non-STEM		
	Math	Natural Science	Health	English & Humanities	Social Science	CTE
Panel A. Two-Year Colleges						
	Seasonally Adjusted Share of Course Sections with Temporary Adjunct					
Average age when taking the course	0.203	0.284	0.106	-0.348	-1.035*	-0.166
	(0.659)	(0.572)	(0.706)	(0.231)	(0.555)	(1.745)
Percent female	-0.014	-0.024	0.031	-0.019	0.046	-0.036
	(0.035)	(0.025)	(0.034)	(0.013)	(0.033)	(0.077)
Percent Black	0.030	-0.004	-0.000	0.010	-0.042**	0.048
	(0.023)	(0.018)	(0.027)	(0.010)	(0.020)	(0.068)
Percent Hispanic	0.018**	0.000	0.006	0.003	-0.001	-0.012
	(0.008)	(0.006)	(0.009)	(0.003)	(0.011)	(0.033)
Percent Asian	-0.012	-0.005	-0.003	0.002	-0.002	-0.005
	(0.011)	(0.004)	(0.004)	(0.003)	(0.002)	(0.005)
Percent resident of the state	-0.005	0.020*	0.021	-0.000	0.091***	0.048
	(0.011)	(0.010)	(0.013)	(0.008)	(0.012)	(0.041)
Average high school GPA	0.011	-0.035	-0.039	-0.003	-0.012	-0.159*
	(0.040)	(0.034)	(0.045)	(0.022)	(0.037)	(0.091)
Percent earned HS diploma	-0.021	0.007	-0.014	0.001	-0.034	-0.023
	(0.032)	(0.025)	(0.032)	(0.012)	(0.025)	(0.085)
Percent enrolled full-time 1st term	0.010	-0.023	-0.030	0.004	0.026	0.024
	(0.028)	(0.028)	(0.042)	(0.011)	(0.028)	(0.091)
Percent entered in fall term	0.044	-0.020	-0.035	-0.009	0.060*	0.081
	(0.034)	(0.028)	(0.040)	(0.014)	(0.031)	(0.097)
Percent took remedial courses	-0.013	0.017	0.027	0.000	0.061**	0.141*
	(0.040)	(0.027)	(0.043)	(0.014)	(0.029)	(0.084)

Panel B. Four-Year Colleges						
	Seasonally Adjusted Share of Course Sections with Temporary Adjunct					
Average age when taking the course	-0.118	0.125	1.679***	-0.079	1.372***	0.084
	(1.201)	(0.295)	(0.490)	(0.171)	(0.352)	(0.343)
Percent female	-0.053	-0.021	0.063*	-0.005	0.018	0.003
	(0.070)	(0.027)	(0.033)	(0.018)	(0.033)	(0.023)
Percent Black	0.159**	-0.004	-0.004	0.017	0.003	-0.015
	(0.063)	(0.020)	(0.030)	(0.015)	(0.027)	(0.021)

Percent Hispanic	-0.009	0.000	0.001	-0.003	-0.010	0.001
	(0.015)	(0.005)	(0.007)	(0.004)	(0.009)	(0.006)
Percent Asian	-0.001	-0.007	0.004	-0.002	0.012	0.001
	(0.011)	(0.007)	(0.010)	(0.005)	(0.008)	(0.007)
Percent resident of the state	0.011	-0.051**	0.054**	0.005	-0.030	0.002
	(0.051)	(0.021)	(0.022)	(0.013)	(0.024)	(0.019)
Average high school GPA	-0.033	0.004	0.004	0.005	-0.068*	-0.010
	(0.082)	(0.030)	(0.046)	(0.020)	(0.037)	(0.033)
Percent earned HS diploma	0.051	-0.040**	0.013	-0.020	-0.026	-0.003
	(0.060)	(0.020)	(0.027)	(0.013)	(0.025)	(0.019)
Percent enrolled full-time 1st term	0.045	-0.004	-0.05	-0.015	-0.041*	-0.023
	(0.057)	(0.020)	(0.035)	(0.012)	(0.022)	(0.022)
Percent entered in fall term	0.001	-0.039*	-0.019	-0.001	-0.028	-0.020
	(0.071)	(0.020)	(0.036)	(0.015)	(0.024)	(0.023)
Percent took remedial courses	-0.085	-0.013	-0.016	-0.018	0.056*	0.011
	(0.068)	(0.025)	(0.043)	(0.018)	(0.032)	(0.029)
Seasonally Adjusted Share of Course Sections with Tenure-track or Tenured						
Average age when taking the course	-0.138	-0.032	0.051	0.222*	-0.275	-0.055
	(0.520)	(0.171)	(0.320)	(0.117)	(0.178)	(0.336)
Percent female	-0.002	-0.006	-0.011	0.019	-0.014	0.014
	(0.030)	(0.015)	(0.021)	(0.012)	(0.017)	(0.023)
Percent Black	-0.006	0.013	-0.010	-0.003	-0.013	-0.024
	(0.028)	(0.015)	(0.021)	(0.012)	(0.017)	(0.023)
Percent Hispanic	-0.000	0.000	-0.000	-0.003	-0.003	0.000
	(0.028)	(0.012)	(0.020)	(0.010)	(0.013)	(0.021)
Percent Asian	-0.007	-0.004	-0.008	0.003	-0.003	-0.005
	(0.007)	(0.003)	(0.005)	(0.003)	(0.005)	(0.006)
Percent resident of the state	0.034	-0.008	0.003	0.005	0.004	-0.015
	(0.004)	(0.003)	(0.007)	(0.003)	(0.004)	(0.005)
Average high school GPA	-0.000	0.003	0.013	-0.020	-0.006	0.039
	(0.022)	(0.012)	(0.014)	(0.009)	(0.012)	(0.019)
Percent earned HS diploma	0.024	0.013	-0.010	-0.000	0.009	0.001
	(0.036)	(0.018)	(0.030)	(0.013)	(0.019)	(0.033)
Percent enrolled full-time 1st term	0.026	0.011	-0.013	-0.004	-0.025**	0.021
	(0.026)	(0.012)	(0.018)	(0.009)	(0.012)	(0.019)
Percent entered in fall term	-0.034	0.018	-0.012	-0.008	0.003	-0.018
	(0.025)	(0.011)	(0.023)	(0.008)	(0.011)	(0.021)
Percent took remedial courses	-0.041	-0.000	-0.015	0.014	-0.006	-0.050*
	(0.031)	(0.011)	(0.023)	(0.010)	(0.012)	(0.022)

Note. Each cell presents the regression coefficient on the instrumental variable, where the dependent variable is the change of student composition for the department over time. The regressions also control for term fixed effects.

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

Appendix Table 5.

Impact of Different Types of Instructors in Introductory Courses on Taking and Passing the Second Course: Interactional Effects Between Faculty Type and Field.

	(1)	(2)
	Two-year Colleges	Four-year Colleges
Adjunct	-0.132***	-0.149***
	(0.032)	(0.023)
Tenure-track or tenured		0.009
		(0.021)
Adjunct*STEM	0.028	-0.200**
	(0.057)	(0.078)
		-0.028
Tenure-track/tenured * STEM		(0.050)
Observations	339,602	694,395

Note. This table presents IV estimates for taking and passing a second course in a field of study by field using sample pooling observations from all fields of study. Models for two-year colleges included two instrumented variables: adjunct faculty, and the interaction term between adjunct faculty and an indicator for STEM fields; models for four-year colleges included four instrumented variables: adjunct faculty, tenure-track or tenured faculty, and two interaction terms with the indicators for faculty ranks and STEM fields. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All regressions control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 6

Impact of Different Types of Instructors in Introductory Courses on Taking and Passing a Second Course in the Same Field of Study: Correction for Multiple Hypothesis Testing

	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**-0.120*** **	**-0.337*** **	**-0.021**
***p*-value**	**(0.007)**	**(0.000)**	**(0.632)**
sharpened q-value	**[0.011]**	**[0.001]**	**[0.563]**
Math	-0.046	-0.253	0.178***
	(0.515)	(0.128)	(0.008)
	[0.148]	[0.031]	[0.034]
Natural Science	-0.151**	-0.356***	-0.064
	(0.020)	(0.000)	(0.216)
	[0.017]	[0.001]	[0.370]
Health	-0.138	-0.424***	-0.230
	(0.206)	(0.000)	(0.225)
	[0.097]	[0.001]	[0.370]
Non-STEM Overall	**-0.131*** **	**-0.151*** **	**0.009**
	(0.000)	**(0.000)**	**(0.672)**
	[0.004]	**[0.001]**	**[0.563]**
English and Humanities	-0.115*	-0.156***	0.028
	(0.070)	(0.000)	(0.440)
	[0.037]	[0.001]	[0.563]
Social Science	-0.119***	-0.175***	0.038
	(0.002)	(0.000)	(0.116)
	[0.008]	[0.001]	[0.303]
CTE	-0.183***	-0.098**	-0.378***
	(0.006)	(0.026)	(0.004)
	[0.011]	[0.008]	[0.034]

Note. This table presents coefficient results for taking and passing a second course in a field of study by field (as shown in Table 6), with the original *p*-values and sharpened False Discovery Rate (FDR) q-values using the method described in Anderson (2008). The outcome variable is defined as taking and passing a second course in the same field of study with a grade D or above.

Original *p*-values in parentheses; sharpened q-values in brackets.

Appendix Table 7

Robustness Check: Impact of Different Types of Instructors in Introductory Courses on Taking and Passing a Second Course in a Field Outside of Declared Major

	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**-0.123*****	**-0.373*****	**-0.024**
	(0.045)	**(0.080)**	**(0.050)**
Math	-0.045	-0.254	0.185***
	(0.071)	(0.167)	(0.068)
Natural Science	-0.153**	-0.405***	-0.072
	(0.065)	(0.101)	(0.058)
Health	-0.161	-0.496***	-0.443**
	(0.120)	(0.114)	(0.198)
Non-STEM Overall	**-0.128*****	**-0.155*****	**0.010**
	(0.032)	**(0.023)**	**(0.022)**
English and Humanities	-0.122*	-0.149***	0.031
	(0.064)	(0.040)	(0.036)
Social Science	-0.125***	-0.189***	0.034
	(0.040)	(0.037)	(0.025)
CTE	-0.154**	-0.092**	-0.397***
	(0.072)	(0.046)	(0.146)

Note. The sample for all regressions includes the first college-level course taken by each student outside of their first declared major. The outcome variable is defined as taking and passing a second course in the same field of study with a grade D or above. All regressions use the same instrumental variable specification as shown in Table 6. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All regressions control for student characteristics listed in Table 1, cohort of enrollment, whether they entered college in the fall term, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects.

Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and peer demographic composition).

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Appendix Table 8

Robustness Check: Impact of Different Types of Instructors in Introductory Courses on Taking and Passing a Second Course with a Grade C or Above in the Same Field of Study

	(1)	(2)	(3)
	Two-year colleges	Four-year colleges	
	Adjunct	Adjunct	Tenure-track or tenured
STEM Overall	**-0.102****	**-0.276*****	**-0.031**
	(0.043)	**(0.058)**	**(0.042)**
Math	-0.019	-0.195	0.144***
	(0.074)	(0.135)	(0.052)
Natural Science	-0.143**	-0.278***	-0.068
	(0.064)	(0.069)	(0.049)
Health	-0.107	-0.405***	-0.206
	(0.100)	(0.112)	(0.180)
Non-STEM Overall	**-0.124*****	**-0.135*****	**-0.001**
	(0.030)	**(0.022)**	**(0.020)**
English and Humanities	-0.119**	-0.145***	0.016
	(0.059)	(0.037)	(0.034)
Social Science	-0.112***	-0.148***	0.030
	(0.038)	(0.035)	(0.023)
CTE	-0.160***	-0.097**	-0.383***
	(0.062)	(0.042)	(0.136)

Note. The outcome variable is defined as taking and passing a second course in the same field of study with a grade C or above. Each cell presents the regression coefficient on a subset of the analytic sample by field of study. The STEM overall sample includes all student course enrollments in all three STEM fields listed underneath it, and the non-STEM overall sample includes all student course enrollments in all three fields listed underneath it. All models use our preferred instrumental variable specification. The instrumental variable is defined as the deviation in the proportion of course sections taught by a specific type of instructor in a department during a certain term from term-specific (i.e., fall, spring, and summer) average proportions of course sections offered by that particular type of instructor. All specifications control for student characteristics listed in Table 1, cohort of enrollment, whether they intended to receive a degree in STEM-related fields upon college enrollment, term fixed effects, and college-course fixed effects. Other controls include student-by-term information (e.g. total credits taken in a semester), student-by-field information(e.g. whether the course is within the student's declared major), and course-section-level information (e.g. delivery format, enrollment size, and average high school GPA of peers in the section).
Robust standard errors in parentheses: ***$p < 0.01$,
**$p < 0.05$, *$p < 0.1$.

Appendix Table 9

Institutional Variation in STEM Focus and in Faculty Composition

Panel A. Two-Year Colleges

	(1) Student course enrollments % STEM fields	(2) Faculty composition % Adjunct faculty
College A	40.0%	67.3%
College B	37.4%	62.2%
College C	37.1%	66.3%
College D	35.4%	56.1%
College E	35.3%	63.1%
College F	34.4%	68.7%
College G	32.6%	70.5%
College H	30.4%	67.2%
College I	29.8%	47.8%
College J	29.5%	51.3%
College K	26.6%	77.3%
College L	26.5%	19.6%
College M	25.9%	76.5%
College N	25.1%	73.4%
College O	23.7%	20.5%
College P	23.6%	20.2%
College Q	23.5%	67.9%
College R	23.3%	65.4%
College S	23.3%	70.3%
College T	21.6%	17.5%

Panel B. Four-Year Colleges

	(1)	(2)	(3)
	Student course enrollments	Faculty composition	
	% STEM fields	% Adjunct faculty	% Long-term non-tenure-track
College A	31.8%	20.2%	30.2%
College B	30.7%	57.5%	36.8%
College C	30.0%	34.4%	18.0%
College D	29.8%	43.0%	17.6%
College E	26.2%	15.6%	40.4%
College F	26.0%	34.1%	24.7%
College G	25.4%	25.6%	27.2%
College H	24.9%	29.1%	26.8%
College I	23.9%	38.9%	25.8%
College J	23.3%	12.2%	48.8%