# Essays on Instructor Quality in Higher Education

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# ABSTRACT

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How do teachers affect students' academic and labor market outcomes? Research into teacher quality has been thoroughly scrutinized for the K-12 sector, while there is a requirement for examining these questions at post-secondary education level. In the past few decades, several important trends of faculty employment among higher education institutions have emerged. First, faculty employment in higher education in the United States has gradually transformed from a bifurcated system based on tenure status into a trifurcated system, constituting three types of faculty: those which are tenure eligible, fulltime but not tenure eligible, and part-time faculty. Second, due to aging of the American professoriate, particularly those faculty members hired in the 1960s and 1970s, colleges and universities have been recruiting more diverse candidates, such as female faculty, to fill positions.

My dissertation examines the implications behind these two important trends. In the first chapter, I provide a detailed portrait of non-tenure-track faculty in terms of their demographic information, personal attributes, and employment trajectory across institutional sectors and academic subjects. Based on unique datasets linking college administrative information on student transcripts to Unemployment Insurance (UI) data on faculty employment history, I find that there is significant variation in individual characteristics and employment patterns across non-tenure-track faculty who were hired through different types of contracts with the colleges.

In the second chapter (co-authored with Di Xu), we examine the impact of non-tenure track faculty by types of employment on students' academic outcomes in two- and four-year colleges using a two-way fixed effects model and an instrumental variable approach. We also analyze how the estimated effects on student outcomes can be explained by observable instructor characteristics and employment features. We find that non-tenure track faculty have positive impacts on current course grades but negative impacts on subsequent course outcomes. These negative impacts are stronger for non-tenure track faculty hired through temporary appointments than those hired with long-term contracts, which can be explained partly by observable instructor characteristics.

In the third chapter, I document the existence of long-term effects of faculty gender on female students' occupational choices, likelihood of employment, and earnings six years after the initial term of college enrollment, based on a novel dataset that links college administrative data with Unemployment Insurance (UI) records from a state college system for both public two- and four-year colleges. To minimize bias from student systematic sorting by the gender of instructors, I use an instrumental variable (IV) approach which exploits term-by-term variations in total course enrollments with female faculty in each college-department, after controlling for fixed effects of the course set students took during the first term. I find that female students in four-year colleges who take more course credits with female faculty in their initial semester are more likely to be employed overall, be employed in industries with more Science, Technology, Engineering, and Math occupations (STEM), and have higher annual earnings six years after; no effect is detected in two-year colleges.

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## Preface

How much of the student's success depends on the instructor? This is a fundamental issue that has stimulated numerous education policy discussions. From a theoretical perspective, the basic research begins with an education production function in which students' achievements depend on cumulative inputs, including instructors. From an empirical perspective, much prior research has focused on to what extent instructor quality can affect student achievement since the 1966 Coleman Report, in particular concerning K-12 setting (e.g., see Hanushek and Rivkin, 2006).

The research into teacher quality is scrutinized intensely because it has a direct relationship to current policy debates. There is great necessity to examine these questions at the postsecondary education level. In the past few decades, there has been an escalating demand for higher education. Both the student population and faculty members have become more diversified. There have been two important trends of faculty employment among higher education institutions. First, there is a declining source of public financing for higher education, concomitant to the increasing number of freshmen enrollments (Kane & Orszag, 2003). Therefore, colleges have sharply increased their reliance on contingent faculty as a cost-saving strategy in addition to other responses such as raising tuition, increasing class sizes, and cutting programs. The reliance on contingent faculty is realized by hiring more faculty in tenure-ineligible positions, which are oftentimes part-time and temporary appointments. According to a recent National Center for Education Statistics report (NCES, 2016), the number of part-time faculty increased by 104 percent in degree-granting postsecondary institutions from fall 1993 to fall 2013, compared with an increase of 45 percent in the number of full-time faculty. As a result, the ratio between part-time and full-time faculty changed from 2:3 to 1:1 during this period. The increasing reliance on a contingent academic workforce is even more pronounced than the narrowing of this ratio may imply. In recent years, many full-time faculty have been hired in non-tenure-track positions, and the movement away from the tenure system has accelerated over the past two decades since the abolishment of mandatory retirement for tenure-track faculty (Figlio, Schapiro, & Soter, 2015).

Second, due to the aging of the American professoriate, especially the faculty members who were hired in the 1960s and 1970s, colleges and universities have been recruiting more diverse candidates to fill faculty positions. Data show that the proportions of female faculty members have been increasing since the last two decades. According to NCES, the growth of female faculty head count nearly doubled that of male faculty between 1993 and 2013, with approximately 375,300 additional women and 196,900 men. However, they are still under-represented, especially in higher academic ranks. Women continue to be less likely than men to hold full-time positions (44% for women vs. 52% for men). In addition, only approximately 10% of female faculty hold full professorships. Motivated by closing the socio-demographic gap in education achievement, a common policy prescription is to increase the number of role models of female and minority students. The argument behind such policies is that instructors of the same gender or race could serve as role models for female and minority students and improve their academic outcomes. A number of studies examined whether empirical evidence supported the notion (e.g., Bettinger and Long, 2005; Canes and Rosen, 1995; Hoffmann and Oreopoulos, 2009; Rothstein, 1995). But the conflicting results from these studies make the implications of the changing faculty gender composition ambiguous.

My dissertation examines the implications behind these two important trends. Chapter One presents descriptive evidence of the increasing reliance on two types of contingent faculty in a state college system. In contrast to previous studies examining college contingent faculty, I distinguish these faculty by their contracts with the college and categorize them into temporary adjunct faculty, who hold semester-by-semester contracts with the college, and long-term non-tenure-track faculty, who hold fixed-term contracts with the college. I find that the growth of reliance on temporary adjunct faculty is much more pronounced in two-year colleges, while four-year colleges rely more heavily on long-term non-tenure-track faculty. In addition, the usage of contingent faculty varies tremendously by subject areas: non-STEM disciplines are more likely to rely heavily on temporary adjuncts. In addition, a relatively large number of temporary adjunct faculty only hold their college teaching positions for one or two semesters.

In Chapter Two, Di Xu and I evaluate the impact of adjunct instructors on student academic outcome and to what extent such impacts could be explained by observable instructor demographic, aptitude, and employment characteristics. To minimize student self-selection, we use two different empirical strategies. The main one is a two-way fixed effect model adapted from the model used in Figlio et al. (2015) that controls for both individual-level fixed effects and course-level fixed effects. We further build on the instrumental variable strategy similar to Bettinger and Long (2010) as a robustness check in which we use term-by-term variation in departmental faculty composition as an instrument for students' likelihood of taking a course with different types of instructors in their initial term in a certain field of study. Our results suggest that students on average receive higher grades when taking courses with supplemental adjuncts, followed by long-term contingent faculty, and then tenure-track/tenured faculty. In contrast to the positive results associated with current course performance, however, both types of non-tenure-track instructors have negative impacts on students' subsequent course enrollment and performance, and supplemental adjuncts are associated with the largest negative effects. In addition, observable instructor characteristics are able to explain approximately one-quarter of the negative impact of supplemental adjuncts relative to long-term contingent faculty on students' subsequent interest in a field in two-year colleges and more than half of the impact in four-year colleges. The productivity gap between long-term contingent faculty and tenure-track/tenured faculty in four-year colleges is no longer significant once we control for observable instructor characteristics.

Finally, in Chapter Three, I document the existence of long-term effects of faculty gender on female students' occupational choices, likelihood of employment, and earnings 6 years after the initial term of college enrollment, based on a novel dataset that links college administrative data with Unemployment Insurance (UI) records from a state college system for both public two-year and four-year colleges. To minimize bias from student systematic sorting by the gender of instructors, I use an instrumental variable (IV) approach that exploits term-by-term variations in total course enrollments with female faculty in each college department after controlling for fixed effects of the course set students took during the first term. I find that female students in four-year colleges who take more course credits with female faculty in their initial semester are more likely to be employed overall, to be employed in industries with more STEM occupations (for STEM majors only), and to have higher annual earnings six years after. No effect is detected in two-year colleges.

# Chapter One

## The Invisible Academic Job Market:
## Heterogeneity in Characteristics and Employment Trajectory of Contingent Faculty

### I. Introduction

It is a well-documented fact that the proportion of tenure-line faculty in the academic labor force has been in significant decline for decades. Data from the National Center of Education Statistics (NCES) show that slightly less than half (45.1%) of all academic labor force were in tenure-line in 1975, while the number dropped to 34.4% in 1995 and further fell to 25.9% in 2005. Now, every two out of three faculty members in U.S. postsecondary institutes are not currently tenure eligible, with a majority of them holding part-time positions (U.S. Department of Education, 2017). As the ASHE Higher Education Report (Kezar and Sam, 2010) stated, “We can no longer continue to operate according to the perceived status quo, pretending that tenured faculty are the mainline faculty of the academy.” The once-invisible group of faculty members have become the new mainstream. They teach the majority of undergraduate students and are the key to creating a teaching and learning environment.

Indeed, faculty employment in higher education in the United States has gradually transformed from a bifurcated system based on tenure status into a trifurcated system, constituting three types of faculty: those who are tenure eligible, fulltime but not tenure eligible, and part-time faculty (Zhang, Ehrenberg, and Liu, 2015). In addition, the changes of academic labor force vary across institution sectors. Community colleges have the greatest percentage of part-time faculty (Eagan, 2007; Gappa and Leslie, 1993); in some schools, the percentage has been as high as 80 percent (National Education Association Research Center, 2007). Public four-year universities have also been increasing their share of part-time faculty: From 1997 to 2007, the percentage increased from 14 to 16 percent for public research and doctorate-grant universities; the share increased from 34 to 44 percent for public comprehensive institutions (American Federation of Teachers, 2009). The employment of fulltime non-tenure-track faculty started to increase significantly in the early 1990s. Now, this type of employment has become the new majority of fulltime appointments and non-tenure hires have become the norm (Schuster and Finkelstein, 2006). In addition, they are most notable among the four-year research universities (Shavers, 2000): the proportions of fulltime non-tenure-track faculty are 30.3 percent in public doctoral institutions and 32.7 percent in private doctoral universities, while public two-year colleges had around 10.1 percent of their entire fulltime faculty nontenured (Cataldi, Fahimi, and Bradburn, 2005).

Existing literature explored various reasons for colleges to increase part- and full-time non-tenure-track faculty, which were a combination of market force, budget constraints, and decentralizing decision-making optimized locally at the departmental and college levels (Monks, Dooris, and Erickson, 2009). Imbalance of demand and supply of PhDs, decrease of state appropriations, and the gap of compensation for tenure-line faculty and non-tenure-track faculty are among the major reasons for the growth of contingent appointments in the postsecondary sector. However, the missing piece to the picture is on the supply side. Except for some anecdotal evidence, it is still not quite clear what the labor market experiences for contingent faculty before their employment with a college are.

To fill the gap in the literature, I bring together unique datasets of both student transcripts at classroom level linked with instructor profile and unemployment insurance (UI) data containing key employment information from an anonymous state. In this paper, I provide a detailed portrait of contingent faculty in terms of demographic information, personal attributes, and employment trajectory across institutional sectors and academic subjects. Based on the detailed information of contract types from the state college system, I am able to distinguish contingent faculty who are hired through a temporary or term-by-term contract and those who are hired with a fixed-term contract that is generally renewed every two or three years. The latter type of faculty are much more likely to have fulltime positions than the temporary adjuncts. In addition, I also find that non-STEM fields rely more heavily on temporary adjuncts than STEM fields, particularly in two-year colleges.

Another interesting finding is the employment pattern of the contingent faculty. A relatively large number of temporary adjunct faculty only hold their college teaching positions for one or two semesters. This is potentially costly for the colleges because they have to provide extra resources in terms of orientation and professional development when they hire new faculty members. In addition, contrary to a frequently used argument for hiring more adjunct faculty that they bring first-hand industry experience to the classroom, I find that K-12, instead of industries directly related to the subject that they teach, is the sector that the largest proportion of contingent faculty worked for prior to their appointment with the college.

## II. Institutional Context and Data Description

The data used in this chapter come from two sources. First, I obtained course offering information in an anonymous state college system (ASCS) from fall 1993 to summer 2012. The course offering information is further linked with student enrollment data that are available from fall 2005 to summer 2012. The matched data are at course-section or classroom level with a total of around 600,000 classroom records. Each course-section record is associated with a variable indicating the instructor ID of who taught the corresponding course section. Other information includes course number, section number, course name, course subject, course level (college level, remedial level, or other non-credit courses), delivery method (traditional face-to-face, online, or hybrid), and semester during which the course was offered. The instructor ID can be further linked to a separate instructor file with information on the gender, race, birth year, degree attainment, academic rank (assistant professor, associate professor, full professor, lecturer, or graduate students), and tenure status (temporary adjunct, fixed-term faculty, tenure track, or tenured faculty). Using these information, I retrieved a file including all instructors who have taught at least one course in the system from fall 1993 to summer 2012 with their contractual form with the college and their personal attributes.

Second, I obtained earnings data from the Unemployment Insurance (UI) database. The UI records include quarterly earnings for every individual who worked in a non-federal civilian job within this state from the first quarter of 2001 to the fourth quarter of 2013. Other information includes de-identified employer ID and industry ID based on North American Industry Classification System (NAICS) codes. The UI data provides important features to explore the employment patterns of instructors before and after their appointments with ASCS colleges since I am able observe each job one holds during a quarter. Therefore, I am able to identify the number of positions each individual held during each quarter and which industry or industries the individual has worked for during that quarter.

Both the two-year community college system and four-year public college system in ASCS are comprised of a mix of large and small colleges, as well as institutions located in rural, suburban, and urban settings. Table 1.1 presents institutional characteristics of ASCS in fall 2005, based on statistics reported to the Integrated Postsecondary Education Data Systems (IPEDS) database. Compared with the characteristics of nationally representative samples of institutions, ASCS institutions tend to be smaller, more instruction focused (versus research focused), have lower graduation rates in general, and serve a higher proportion of African Americans and students eligible for need-based financial aid. The average annual salary for instructional faculty is also lower than the national average by 10% to 20%, depending on the specific category of academic rank.

During the period of this study, ASCS divides faculty into two major categories in two-year colleges and four categories in four-year colleges. With only one exception, none of the two-year colleges has tenure track positions,[1] and faculty are categorized into temporary adjunct and long-term non-tenure-track faculty depending on the length of the contract with the college. In four-year institutions, there are four categories of academic ranks: temporary adjunct, long-term non-tenure-track, tenure-track assistant professors, and tenured faculty.

Figure 1.1 shows the changes in the distributions of different types of instructors over 10 years between 2001 and 2011 in ASCS. The figure indicates that the number of tenure-track and tenured faculty increased gradually over time, with an average annual growth rate of approximately 5 percentage points among tenure-track and tenured faculty in four-year colleges. In contrast, the number of non-tenure-track instructors, especially temporary adjuncts, increased at a much greater pace: In 2001, temporary adjuncts represented 47% of all faculty in two-year colleges and 18% in four-year colleges; 10 years later, they increased to 60% and 32% in these two settings, respectively. Such increasing reliance on non-tenured faculty in ASCS, especially on temporary adjunct instructors, echoes the national trends during the past two decades.

In addition to academic rank, instructor profiles also include information on demographic characteristics such as gender and race, employment status (i.e., part-time vs. full-time) during

[1] Based on the concern that this college might have a different instructor ranking system than other two-year colleges, I exclude this college from the analytical sample.

each term of employment, highest degrees attained at the beginning of each term, and quarterly earnings between the first quarter in 2001 and the last quarter in 2013. Importantly, since the earnings data are drawn from the Unemployment Insurance (UI) database that includes quarterly earnings records from each employer in this state, I am able to create indicators for whether an instructor had ever worked in a non-teaching industry position, whether he/she held other non-teaching positions during a term, and whether he/she ever taught in multiple colleges as a college instructor.[2]

## III. Faculty Characteristics in ASCS

A. Variation by Types of Faculty

Table 1.2 presents the average characteristics of different types of instructors who taught at least one course between fall 2005 and summer 2012 in ASCS, which includes 3,728 temporary adjuncts and 1,211 long-term non-tenure faculty in two-year colleges; four-year colleges include 3,064 temporary adjuncts, 2,320 long-term non-tenure, 1,562 tenure track, and 861 tenured faculty.

Panel A of Table 1.2 presents demographic and degree attainment information for faculty by institution sector and employment contracts with the college. In both two-year and four-year colleges, temporary adjuncts are fairly similar to long-term non-tenure faculty in their demographic characteristics overall, except that temporary adjuncts are much more likely to be "career enders" --- individuals who started in a college instructor position when they are 55 or older. Yet, both types of instructors hired in non-tenure positions are noticeably different from

[2] The match was performed by the college systems; I received de-identified and pre-matched information without being provided with instructors' social security numbers. On average, each instructor in our analytical sample had 25 non-zero quarterly earnings records between the first quarter in 2001 and the last quarter in 2013.

tenure track/tenured faculty in four-year colleges. Compared with tenure track or tenured faculty, temporary adjuncts and long-term non-tenure faculty are almost twice as likely to be female, are less likely to be Asian, and are only 1/6 as likely to have received a doctorate.

Panel B of Table 1.2 presents the employment information for faculty with different types of employment contracts with a college. One of the major critiques about hiring non-tenure track faculty is that they may teach in multiple institutions and hold scant loyalty for an institution (e.g. Brewster, 2000). However, my results suggest that the majority of temporary and long-term non-tenure faculty teach in a single institution and less than 10% of them ever taught in more than one institution, even considering switching across institutions in different terms. In terms of full-time employment status, the majority of temporary adjuncts work on part-time basis: Specifically, only one quarter and one third of temporary adjuncts are employed fulltime in two-year colleges and four-year colleges respectively, which are substantially lower than the proportion of full-time employees among long-term non-tenure faculty in both settings. Compared with tenure track/tenured faculty, both types of non-tenure track faculty have fewer years of teaching experience and are more likely to have worked in non-education sector prior to embarking on their college instructor positions; such differences are particularly strong among temporary adjuncts.

Finally, Panel C of Table 1.2 presents detailed earnings distribution information for each type of faculty by sources of earnings. Overall, the results show two patterns. First, both types of non-tenure track faculty receive lower earnings from colleges compared with tenure track/tenured faculty, which is reflected in both annual earnings from college and per-course-credit income. Yet, between temporary adjuncts and long-term non-tenure instructors, earnings from college positions are particularly low for the former: the median annual income from the college teaching position is $7,726 for temporary adjuncts in two-year colleges, and $10,944 in four-year colleges, which are approximately one quarter of the median annual income of long-term non-tenure faculty in each setting. Such earnings gap seems to be attributable to both greater probability of part-time employment and lower salary per course credit.

While both types of non-tenure track faculty tend to receive income from non-teaching positions concomitantly, the prevalence differs between temporary adjuncts and long-term non-tenure-faculty and by settings: Out-of-college employment and earnings is much more prevalent among non-tenure faculty hired in two-year colleges than in four-year colleges; within each setting, a larger proportion of temporary adjuncts hold non-teaching jobs than long-term non-tenure instructors. Among temporary adjuncts hired in two-year colleges in particular, more than 75% hold concomitant out-of-college positions, and earnings from their college teaching positions are not their main source of annual income.

B. Variation by Academic Areas

Table 1.3 presents proportions of course enrollments in our analytic sample with different categories of instructors in each main field of study that are divided generally into STEM (with public health) and non-STEM disciplines. Overall, two-year colleges are twice more likely to rely on temporary adjuncts than four-year colleges. There are also substantial variations across academic areas: in two-year colleges, non-STEM fields rely more heavily on temporary adjuncts than STEM fields, whereas adjuncts are most actively involved in teaching education-related courses, with almost two-thirds of the total course enrollments taken with temporary adjuncts. Yet, even in fields in which adjuncts are least involved in teaching (e.g., math), still more than one-third of the course enrollments are with adjuncts. Similarly to two-year colleges, adjuncts are also most popular in education and least popular in math at four-year colleges; yet, compared to two-year colleges, four-year institutions are much less likely to rely on temporary adjuncts across all fields of study, especially in STEM-related disciplines. 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 teaching faculty, making this category of faculty the primary teaching force in this setting.

Table 1.4 presents the average characteristics of different types of instructors who taught at least one course between fall 2005 and summer 2012 in ASCS across different subject areas. Consistent with the course enrollment statistics presented in Table 1.3, the proportion of adjuncts is substantially higher in non-STEM fields than STEM fields in both two-year and four-year colleges. However, while long-term non-tenure faculty had the largest course enrollments in both STEM and non-STEM disciplines in four-year institutions, their headcount is outnumbered by tenure-track faculty: in STEM disciplines, 28% of the instructors are hired in fixed-term non-tenure-track positions, and they collectively taught almost half of the total STEM course enrollments between 2005 and 2012. Similarly, less than 30% of non-STEM instructors are long-term non-tenured faculty who accounted for 38% of the course enrollments in these fields. Summary statistics in Table 3 further indicate that long-term non-tenured faculty on average teach a similar number of credit hours as tenure-track faculty. These patterns suggest that long-term non-tenured faculty are likely to be assigned to teaching courses with larger student enrollments compared to tenure-track faculty in four-year colleges.

Available instructor characteristics in Table 1.4 also reveal noticeable differences in individual characteristics between faculty hired through tenure-track versus non-tenure-track positions across subject areas. In general, both types of non-tenure-track faculty in four-year colleges are more likely to be female, younger, and less likely to have received a master's or doctorate degree compared with faculty hired in tenure-track positions. Yet, the gap between non-tenure-track faculty and those hired through tenure-track positions is particularly large in STEM-related fields. Specifically, less than two-thirds of temporary adjuncts and 84% of non-tenured long-term faculty in STEM have received a master's or doctorate degree; the corresponding numbers are 77% among temporary adjuncts and 90% among non-tenured long-term faculty in non-STEM fields. Unsurprisingly, the average annual earnings of non-tenure-track faculty from their college teaching positions are substantially lower than the earnings of tenure-track/tenured faculty. In particular, the average annual salaries from college teaching positions for temporary adjuncts are less than one-third of the salaries of tenure-track faculty; the difference is even wider considering that adjunct faculty typically receive minimal benefits (NCES, 2001). The compensation to long-term non-tenure faculty is also substantially lower than tenure-track faculty, even though the average credit hours are almost identical between the two categories.

More interestingly, comparisons between the two types of non-tenure-track faculty further reveal substantial distinctions as well. In both two-year and four-year colleges, temporary adjuncts, compared with long-term contingent faculty with long-term contracts with a college, are substantially less likely to have received a master's or doctorate degree, and the difference is much larger in STEM fields than non-STEM fields. Adjuncts also assume lower teaching loads and are more likely to work part-time. Given the limited amount of 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:

earnings from non-college jobs tend to be one of the primary sources of income for temporary adjuncts, especially in STEM fields.

C. Employment Pattern

Figure 1.2 presents the employment pattern of contingent faculty employed by ASCS between fall 2001 and summer 2013. One pattern the results reveal is that a nontrivial proportion of contingent faculty only keep their college appointments for one or two semesters, especially so for temporary adjunct faculty. For example, only approximately 70% of temporary adjunct faculty still keep their college appointments after one academic year (or four quarters), while about 85% of long-term non-tenure-track faculty did so. On the other hand, contingent faculty turnover is largest within the first academic year after hiring: the proportions of contingent faculty still remained in their college positions are quite stable after the first year for both college sectors and types of faculty.

These results are important because high turnover rates of contingent faculty mean higher costs and less efficiency for colleges. Colleges have to provide orientation and professional development for newly hired faculty and these faculty also need time and effort to gain pedagogical, curriculum, and institution knowledge. If only two-thirds of these faculty stay in their positions after three academic years, the resources colleges provided would not be utilized to a great extent. Turnover will also affect the engagement between faculty and students and could potentially have adverse impacts on students' academic outcomes.

Another interesting result is that around 20% to 30% of these contingent faculty do not have employment records in the UI dataset before they were employed by ASCS. The results are shown in Figure 1.3 Panel A. This suggests that they were either without a job, self-employed, or employed in a job that was not reported in the UI database. One concern of these results is the limitation of UI data. As widely aware in the existing literature using UI data, a few categories of employment are not present in the unemployment insurance data system, including federal employment, self-employment, and individuals without a social security number. However, the overall coverage is high: According to the Bureau of Labor Statistics (BLS), less than 1.6% of employees in the state of ASCS are estimated to be federal employees; among the civilian jobs, UI data had a 96% coverage (U.S. Department of Labor, BLS, 1997). Another source of missing data is due to interstate mobility: since we were only able to retrieve UI data in the state of ASCS, instructors working in other states before employed by ASCS would not be recorded in the local UI data. According to United States Census Data, in this state, around 2% of the residents who are more than 25-year old and have earned at least a bachelor's degree have moved to another state within the same region in 2005. Another 1.2% of the residents who met the criteria described above moved to a state in a different region. Such low inter-state mobility thus ameliorates the concern that only in-state earnings were observed for the labor market outcomes examined in this study.

Nevertheless, I conduct a robustness check excluding the colleges located in the counties on the borderline with two other states. Instructors who work in these colleges are supposed to have higher interstate migration rates comparing to those who work for colleges not on the state borderline. Instructors who work for four universities and two community colleges are dropped out from the sample. These results are shown in Figure 1.3 Panel B and look fairly similar to Panel A. It shows that even for the instructors working for colleges located in inner state and are subject to lower interstate migration rates, a sustainable proportion of them still were either without a job or self-employed before they were hired by ASCS.

As for employment after hired by ASCS, a fair amount of contingent faculty is still employed in non-ASCS positions after they started working at the college. The phenomenon is more notable for temporary adjunct faculty and in two-year colleges. For example, approximately half of two-year college temporary adjunct faculty were still employed in non ASCS positions, decreasing from 75% a quarter before, and the proportion stayed fairly stable afterwards. On the other hand, only slightly more than 20% of long-term non-tenure-track faculty in four-year colleges still kept their outside employment after starting college appointment.

This highlights the heterogeneity within contingent faculty across college sectors and employment contracts. Faculty who complete left their non-college position are more likely to be the ones who treat college faculty as their primary job and seek career transition from their previous jobs; faculty who still keep their non-college position, on the other hand, are more likely to be the ones who enjoy college teaching as a second career or use adjunct faculty as a way to explore higher education while still keeping their main employment.

## D. Employment History

### *a. Previous employment*

I then examine the employment history before college appointments for these contingent faculty in terms of which industries they have worked in, their earning trajectories, and how their earnings compare against individuals who worked in the same sector or industry. To do this, I further restrict the sample to a balanced panel. The analytic sample hereafter includes instructors who have appeared in the UI database every quarter for the eight quarters before their college appointment as well as for the eight quarters after their college appointment. The reason to perform this restriction is still due to the limitation of the UI database. Therefore, I only include the individual whose labor market information could be fully observed up to two years before the ASCS appointment.

As shown in Table 1.5, elementary and secondary schools are the biggest source for adjunct instructors. Another sector that provides a significant share of adjunct instructors is health care and social assistance. In four-year colleges, the professional, scientific, and technology industry, which has relatively higher average earnings, also provide a fair amount of non-tenure-track faculty.

In view of the prevalence of non-college work experience among both types of non-tenure-track instructors, I further examine where these instructors were employed before they started teaching in a college by more detailed breakdown of industry and by subject area. Table 1.6 presents the main industries of employment among either temporary adjuncts or long-term non-tenure faculty who ever worked before they started college teaching positions by field of study, which includes 3,321 instructors from two-year colleges (67% of non-tenure-track faculty in the sample of two-year colleges) and 2,338 from four-year colleges (43% of non-tenure-track faculty in the sample of four-year colleges).[3] Those contingent faculty who are excluded from this table either had never worked in non-college positions before they started their college appointments in the UI record, or had started ASCS appointments before 2001 and thus could not be observed in the UI dataset. Consistent with the results shown in Table 1.5, for almost every field of study, a nontrivial proportion of non-tenure-track faculty had work experience in the K-12 sector. In the fields of education and childcare in particular, more than half of non-tenure-track faculty in two-year colleges and almost two-thirds in four-year colleges were previously

[3] In each field, any industries with 10 or fewer adjunct instructors are not shown.

employed in the K-12 sector. In certain subject areas, there are varying proportions of contingent faculty who had worked in industries that were directly related to the subject that they teach. This is particularly the case in occupation-oriented fields of study, such as health and business. For example, more than half of all contingent faculty who teach in health had working experience in general hospitals, offices of different types of doctors, and nursing facilities; around 3% to 6% of contingent faculty who taught in Business had prior experience in commercial banking.

*b. Earning trajectory*

Figure 1.4 presents the trajectory of total quarterly earnings before and after contingent faculty's entry of college appointment.[4] To avoid the noise from seasonal fluctuation, I smooth the earning data by applying the moving average as following:

$$x_{it} = \frac{1}{5}(x_{i\,t-2} + x_{i\,t-1} + x_{i\,t} + x_{i\,t+1} + x_{i\,t+2})$$

Where $x_{i\,t}$ refers to the total quarterly earnings for individual *i* in quarter *t*.

Results in Figure 1.4 suggest that for both temporary adjunct faculty and long-term non-tenure track faculty, their total quarterly earnings stay stable before and after their job transition in general. Long-term non-tenure track faculty do experience a slight decrease of total quarterly earnings during the first two quarters, and the downward trend is slightly more severe for the faculty in four-year colleges.

I then examine the trajectory of earnings from non-ASCS positions for the contingent faculty. The results from Figure 1.5 suggest that long-term non-tenure faculty experienced a nontrivial downward trend of earnings prior to their college appointments, but the trend is flatter for temporary adjunct faculty, particularly in four-year colleges. After hired by ASCS, the

[4] All earning data are CIP adjusted to 2012 dollar.

downward trend of earnings from non-college positions continues for about two quarters for long-term non-tenure track faculty. This perhaps results in the slight decrease in total quarterly earnings for the first few quarters after starting their college positions for these faculty as shown in Figure 1.4. The results revealed in both Figure 1.4 and Figure 1.5 suggest that long-term non-tenure-track faculty are more likely to be the ones who made a career change switching from one industry to higher education and treat higher education as their primary employment.

*c. Percentile in industry earning distribution*

One important argument supporting the recruitment of adjunct faculty is that they bring valuable first-hand industry experience to the classroom, which could be very beneficial for students both for aspiring their interests in the subject area and for providing important information and network for the job market. The underlying assumption behind this argument is that the contingent faculty colleges hire should be the type of person who had substantial experience and connection in their primary industry of employment, and therefore probably placed towards the higher end of earning distribution when compared with the entire industry.

The results from Figure 1.6 suggest that that is not always the case. To produce these figures, I calculate the percentile of one's quarterly earning when compared to everyone who work in the same industry during that quarter in this state.[5] Since K-12 is one sector provides a significant amount of contingent faculty, it is useful to separate the information into two categories: K-12 and non-education sectors. I find that contingent faculty who taught in K-12 schools prior to ASCS generally placed between 55$^{th}$ to 70$^{th}$ percentile in quarterly earnings comparing to all K-12 employees in the state. Long-term non-tenure-track faculty in four-year colleges placed significantly higher than temporary adjunct faculty and all contingent faculty in

[5] If one holds multiple jobs during a quarter, I calculate the percentile for the job with the highest earnings for the individual.

two-year colleges in the earning distribution. Since experience or seniority are the most important predictors for earnings for K-12 sector, these results suggest that contingent faculty who used to worked at K-12 schools indeed had extensive teaching experience and potential more pedagogical knowledge before they started teaching in the higher education level.

However, contingent faculty who came from non-education sector show a different trend. They generally earned slightly higher than the median employee in the industry they work for. Moreover, long-term non-tenure-track faculty experienced a decline in terms of percentile in industry earning distribution in the two to three quarters before their college appointments. This is align with the previous finding that they experienced a slight earning decline before college. At least, it suggests that their earning trajectory did not catch up with the result of the industry.

## IV. Conclusion

With the decline in public financing and the movement away from the tenure system in higher education, increasing reliance on non-tenure-track teaching force is likely to continue nationwide. Thus, colleges are likely to face challenges in recruiting high-quality teaching faculty through non-tenure track contracts. Results revealed from this paper suggest that the type of non-tenure-track faculty colleges hire are different from the stereotype that a large amount of the anecdotal evidence suggests. Instead of experienced employees from private industry who enjoy teaching as a side-job, contingent faculty are more likely to be someone who worked at K-12 or other public sectors and are searching for a second career.

Since contingent faculty have become the key to creating teaching and learning for the majority of college students, colleges should identify ways to better support non-tenure-track faculty, particularly those hired through transitory positions. One way for colleges and departments to engage faculty and improve their teaching is through professional development. However, adjuncts hired through temporary positions are typically not compensated for participating in professional development, and even if they are interested, campus workshops or programs are often offered during regular working hours on weekdays when many adjuncts are not available. If tenure-track faculty are supported, encouraged, and rewarded to improve their teaching, but adjuncts are not, ultimately students will pay the price for the inadequate support to adjunct faculty.

## Chapter Two

## Does Contractual Form Matter? The Impact of Different Types of Non-Tenure Track Faculty on College Students' Academic Outcomes[6]

### I. Introduction

One of the most pronounced trends in post-secondary institutions during the past three decades has been an increasing reliance on non-tenure track faculty (Anderson 2002; Ehrenberg and Zhang 2004). This growth was due to two separate trends. On one hand, colleges have dramatically increased their reliance on temporary appointments of adjunct instructors, most often hired on a part-time basis as a cost-saving strategy to cope with the decline in public financing and escalating enrollment in higher education (Kane & Orszag, 2003). According to a recent NCES report (2015), the number of part-time faculty increased by 104% in degree-granting postsecondary institutions from fall 1993 to fall 2013, compared with an increase of 45% in the number of full-time faculty. As a result, the ratio between part-time and full-time faculty changed from 2:3 to 1:1 during this period. On the other hand, movement away from the tenure system has quickened over the past two decades since the abolishment of mandatory retirement for tenure track faculty, which resulted in a steady increase in full-time faculty hired with long-term contracts with the institution but without the security of employment through tenure (Figlio, Schapiro, & Soter, 2015).

Due to these recent changes in faculty composition, a college student nowadays may take a course with an instructor with any of the four employment contracts with an institution: non-tenure track adjuncts hired through temporary appointments, non-tenure track instructors hired

[6] This chapter is a joint work with Di Xu

with long-term contracts, tenure track assistant professors, and tenured faculty. [7] The four different contractual forms, with different job responsibilities, varying levels of job security and accompanying compensation packages, attract instructors with highly divergent individual profiles that might also be correlated with instructional effectiveness (Anderson, 2002; Conley, Lesley, and Zimbler 2002).

Do students learn similarly from different types of college instructors? Understanding this question is highly policy-relevant: different types of institutions vary noticeably in their reliance on different types of instructors. For example, as shown in Figure 1, the proportion of part-time faculty has consistently been higher in two-year institutions than in pubic four-year institutions over the past two decades. Considering that community colleges disproportionately serve low-income, first-generation, and historically underrepresented groups, heavier reliance on non-tenure track faculty in this particular setting may have a profound influence on the national equity agenda if students learn differently from non-tenure track than tenure track faculty.

A small but growing literature has used college administrative data to examine the impact of different types of instructors on student academic outcomes (Bettinger & Long, 2011; Bettinger & Long, 2010; Carrell & West, 2010; Figlio et al., 2015; Hoffmann and Oreopoulos, 2009; Xu, 2013). Yet, none of these studies differentiated between non-tenure track instructors hired with long-term contracts from those hired through temporary appointments. Instead, they used the vague term "adjunct" with varying definitions and the comparison faculty group varied across studies as well. [8] Failure to differentiate between non-tenure track faculty by their

[7] Some of the college courses may be taught by graduate student. Yet, the teaching assignment for graduate student is often viewed as part of their graduate training. Since the motivation of hiring college instructors and using graduate students are distinct from each other, we only focus on college instructors in this paper.
[8] For example, Bettinger & Long (2011) defined adjuncts as part-time instructors and compared them with full-time faculty. They found that taking one's initial course with an adjunct instructor negatively impacted students' subsequent interest in the field. In contrast, Figlio et al. (2015) defined adjuncts as all faculty who were not hired in

contractual form is problematic because instructors hired in these two academic ranks may differ in their quality. More importantly, an instructor's productivity may also depend on her employment situation. For example, compared with those hired in temporary positions, non-tenure track instructors with longer-term contracts with an institution are more likely to have an office space at the college and to hold longer and more consistently scheduled office hours, to be more familiar with the institution and potential student services, and to better understand the contents and requirements of other courses offered by the department. In contrast, non-tenure faculty hired in transitory positions may face more challenges in maintaining quality and production, mirroring concerns that have been cited in literature about temporary labor hired in other industries (e.g. McNerney, 1995; Lewis, 1998).

In addition to the necessity to differentiate between non-tenure track faculty by their contractual form, it is also desirable from a policy perspective to explain the sources of variation in instructor teaching effectiveness --- that is, if students learn differently from different types of instructors, to what extent can such variation be explained by observable employment features (such as part-time versus full-time), educational training, and previous work experience (such as teaching experience and non-teaching work experience)? While the existing literature on teacher quality in higher education has gone down this route, they typically only had access to instructor demographic information. Therefore, the possible linkage between college instructor's effectiveness and their previous employment sector and work experience remains largely unknown, except for some theoretical arguments that stress the promise of hiring practitioners as

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tenure-track positions, where the majority had a longer-term relationship with the university and many might be hired on a full-time basis. They compared adjuncts with tenure-track/tenured faculty and found positive impacts of adjuncts on student subsequent interest and course performance.

adjunct instructors to enhance institutional prestige by bringing to the classroom their industry knowledge and skills (Jacobs, 1998; Leslie & Gappa, 1995).

Finally, almost all of the existing studies that associate college instructors hired through different contractual forms and student academic outcomes were carried out in the four-year university setting, which may not speak to the impacts of non-tenure track faculty in community colleges. Yet, understanding the impacts of non-tenure track faculty in community colleges is of particular importance, not only because community colleges rely much more heavily on adjunct instructors than four-year institutions as shown in Figure 1, but also because of the critical role these open-access institutions assume in addressing the national equity agenda by disproportionately serving low-income, first-generation, and historically underrepresented groups.

In this paper, we analyze a novel dataset with detailed instructor employment information in a state public higher education system that includes both two-year and four-year institutions. The information about the specific contract form with which each instructor is hired enables us to make detailed categorizations of college instructors and, in particular, recognize the heterogeneity among non-tenure track faculty by their nature of employment. Specifically, we divide faculty into four major categories: non-tenure track instructors with temporary appointments (referred to as "temporary adjunct" hereafter), non-tenure track instructors with long-term contracts with the institution (referred to as "long-term non-tenure faculty" hereafter), tenure track faculty, and tenured faculty.[9]

We begin by documenting the differences between these types of instructors on observable academic and employment characteristics. The descriptive results suggest that

[9] Our categorization is based on the administrative data we received from the state and how they distinguish faculty's type of employment including tenure status in their system.

colleges depend heavily on non-tenure track faculty in both two-year and four-year sectors, but much more so in the former. In the four-year sector, non-tenure track faculty take up almost two thirds of all faculty; in the two-year sector, only one college examined in this study offered any tenure track positions, taking up only 1% of all faculty hired in two-year colleges. Compared with tenure track/tenured faculty, non-tenure track faculty, especially those hired on a temporary basis, tend to be less educated, are more likely to be employed on a part-time basis, have worked previously and concomitantly in non-teaching positions, and have much higher turnover rates.

We then examine the impacts of taking an initial course in a field of study with different types of instructors on students' current course performance, subsequent enrollment in the same field, and performance in follow-on courses given enrollment. To minimize bias from student self-selection into courses taught by different types of instructors, we use a two-way fixed effects model, adapted from Figlio et al. (2015), which controls for both student individual-level fixed effects and course-level fixed effects. The key assumption underlying the fixed effects strategy is that students have consistent preferences, if any, for different types of instructors across subject areas. We also implement a version of the instrumental variable strategy used by Bettinger & Long (2010) as a robustness check, using term-by-term variation in departmental faculty composition as an instrument for the student's likelihood of taking a course with different types of instructors in their initial term in a certain field of study.

Both analyses yield similar results in both two-year and four-year colleges: Students on average receive higher grades in courses taken with instructors with the least job security (that is, highest among temporary adjuncts, followed by long-term non-tenure faculty, then tenure track faculty, and finally tenured faculty). In contrast to the positive results associated with current course performance, however, both types of non-tenure track instructors are negatively associated with students' subsequent course enrollment and performance relative to the tenure track/tenured faculty, and temporary adjuncts are associated with the largest negative effects.

We also use several measures of instructors' productivity related characteristics to explore the extent to which the differences in students' subsequent academic outcomes can be explained by observable differences in instructor characteristics, including employment features (such as part-time versus full-time status), highest education credential attained, and previous work experience (such as years working in a non-teaching position). We use a value added approach to estimate the instructor effect and further use empirical Bayes shrinkage techniques that take into account both the variance and number of observations for each instructor to adjust the value added. Our results indicate that observable instructor characteristics are able to explain approximately one fifth to a half of the differences among the four types of faculty on students' subsequent interest in a field.

## II. Data Description

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 current and later academic outcomes in the same field, we limit our analysis to the first college-level course a student takes in each field of study. We choose to focus on the first course that a student takes in a field of study for both applied and methodological reasons. From an applied standpoint, instructional quality in introductory courses can not only affect students' interest and success in subsequent learning in the same field, but may also influence important academic decisions such as major choice or even early college withdrawal. As a result, colleges, especially two-year colleges, tend to be particularly concerned with instructional effectiveness in entry-level courses and potential ways of improving them. In addition, non-tenure track instructors in ASCS are more actively involved in teaching lower-division courses than more advanced courses. In four-year colleges, about half of the total course enrollments between 2005 and 2012 were with non-tenure track instructors, compared with more than 60% with non-tenure track instructors when we restrict the sample to only include the first course each student takes in a particular field.

From a methodological standpoint, entry-level courses typically have larger enrollments compared with more advanced courses, yielding a large sample size for analysis. In addition, most students take these courses at an early stage of their college career when they are less likely to have pre-existing knowledge regarding instructors in a particular field at their college. Accordingly, focusing on these introductory courses (rather than more advanced courses) should reduce self-selection bias. Given that students usually take introductory (entry-level) courses during their initial exposure to a particular field of study, these courses are referred to as "introductory courses" hereafter. If a student attempts a particular "introductory course" multiple times, only their first attempt is kept.[10]

The final analytical sample includes 324,883 introductory course enrollments among 68,692 students in two-year colleges and 730,408 introductory course enrollments among 87,212 students in four-year colleges. Summary statistics of the student sample are displayed in Table 2.1. Students enrolled in four-year colleges consistently outperform students enrolled in two-year colleges across all pre-college academic measures. For example, four-year students had higher

[10] Among students who take multiple introductory courses during their initial exposure to a field of study (15% of the introductory course enrollment sample: 67,154 in two-year colleges and 95,327 in four-year colleges), we randomly choose an introductory course in order to control for introductory course fixed effects in the analytical model. We also conduct a robustness check using all introductory course sample and collapsing the sample at student-subject level and define the key explanatory variables as the proportion of credits taken with different types of faculty during their initial exposure to a field. The results are fairly consistent.

high school GPAs on average (3.2 vs. 2.7) and are more likely to have attained a high school diploma (93% vs. 75%).

Table 2.2 uses information from students' college transcripts and summarizes the type of instructors and academic outcomes at the student-course level, focusing on the introductory courses. The first panel summarizes characteristics of course sections taken by each student including delivery method, credits attempted, and class enrollment size. Sections taught by temporary adjuncts are more likely to be delivered through the online format at two-year colleges and tend to have smaller class sizes than those taught by the other three types of instructors in both settings.

The next two panels in Table 2.2 summarize key outcome measures. Panel B presents four current course outcomes: a) persisting to the end of the course (as opposed to early course withdrawal);[11] b) passing the course (as opposed to either failing or withdrawing from the course); c) earning a C or better from the course (as opposed to earning a D, failing, or withdrawing from the course); and d) course grade on a 0 to 4 grading scale where failing the course or withdrawing from the course is coded as zero.

Among all the introductory courses, the overall course persistence rate in two-year colleges is 84%, which is virtually the same between those taught by temporary adjuncts (84%) and those taught by long-term non-tenure faculty (83%); in four-year colleges, the average persistence rate is 92% and 91% among sections taught by temporary adjuncts and long-term non-tenure faculty respectively, both of which are slightly higher than sections taught by tenure track/tenured faculty (90%). The same pattern is also observed among the other three measures,

[11] It is worth noting that withdrawal from the course is only indicated if students drop out after the add/drop period. As a result, we are only capturing withdrawals that have negative impacts on students in that students pay tuition for these courses and a course grade of "withdrawal" will show up on the transcripts.

where students taught by temporary adjuncts are associated with the highest probability of passing a course, earning C or above, and receiving higher grade conditional on persistence, whereas tenure track/tenured faculty are associated with the lowest current course performance measures.

In terms of subsequent course enrollment and success within a particular field of study, the overall probability that a student takes any additional courses within the same field of study is 37% in two-year colleges and 43% in four-year colleges. In contrast to the positive association between temporary adjuncts and immediate course outcomes, students who had temporary adjuncts during their initial exposure to a field of study on average had a lower probability of attempting additional courses in the same field of study by 3-4 percentage points compared with students who had their introductory courses with either long-term non-tenure faculty or tenure track/tenured faculty.

Among students who went on to enroll in another course in the same field, again, temporary adjuncts in introductory courses are associated with the lowest probability that the student passes the next course in both settings. In two-year colleges, the next-course completion rate in the same field is 71% among students who took their introductory courses with a temporary adjunct, compared with 74% among students with long-term non-tenure faculty. In four-year colleges, temporary adjuncts are also associated with the lowest next-class completion rate (80%), compared with 82% for long-term non-tenure faculty and 83% for tenure track/tenured faculty. The negative association between non-tenure track faculty, particularly temporary adjuncts, and student subsequent course outcomes is also observed among the other next-class performance measures. However, as mentioned previously, these descriptive patterns could reflect student-level and course-level selection.

## III. Empirical Framework

*A. Empirical Model for Current Course Outcomes*

Our primary identification strategy for current course outcomes relates student *i*'s outcomes (*Y*) in section *s* of course *c* in field *k* in semester *t* at campus *j* to the type of instructor that the student had during his/her initial exposure to this subject area:

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

The key explanatory variable is the type of instructor with whom a student took the introductory course in a field of study ($\text{Instructor}_{icskjt}$). 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 three dichotomous variables: temporary adjuncts, tenure track faculty, and tenured faculty, with long-term non-tenure faculty serving as the reference group. 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. $\pi_t$ is time fixed effects and $\rho_{ckj}$ represents college-course fixed effects, thus enabling comparisons among different sections of the same course taught within a particular college while controlling for overall variations over time.[12] In addition to the time fixed effects and college-course fixed effects, the model also controls for student-term-level information (e.g., total credits taken in this term), and course-section-level information, as indicated by $X_{cskjt}$ (e.g., number of total enrollments in the course section; whether the course section is online or face-to-face; average high school GPA of peers

[12] We can also add an interaction between time and college-course fixed effects to address the concern that there might be course-specific variations over time in grading criteria; however, this would only draw on courses that offer multiple sections with a mixture of different types of faculty in a particular semester, which represents only 58% of the course enrollments in two-year colleges and 66% in four-year colleges. In a separate robustness check, we added college-course-term fixed effects into the model; the estimates are fairly similar to those based on model specification (1) and the results from this robustness check are presented in Appendix Table 2.1A.

enrolled in the section to capture peer effects; and whether the course is within the student's declared major).[13]

The remaining source of selection after controlling for college-course and term fixed effects is due to students' differential sorting by types of instructors within courses. 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-level and course-section-level characteristics controlling for college-course and term fixed effects. The results presented in Table 2.3 suggests that while there is no consistent relationship between types of instructors and indicators of student previous academic performance, students taking a course with non-tenure faculty, especially temporary adjuncts, tend to be older, are more likely to enroll part-time during initial term of college enrollment, and are more likely to enroll in course sections with smaller class size. To address possible selection bias due to student sorting by type of instructors, we further include student fixed effects into the model, thus controlling for any unobservable student-level characteristics that are constant across courses. [14]

Equation (1) thus draws on two sources of variation. The first includes student-level variations, where a student takes introductory courses with different types of instructors in different fields of study. For example, a student may take an introductory physics course with a temporary adjunct but an introductory math course with a tenured faculty. The majority of the students (68% in two-year colleges and 91% in four-year colleges) take a mixture of introductory

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

[14] Another way to address students possible sorting among instructors within a term is to drop college-course-terms for which different sections are taught by instructors with different contractual terms. The results from this robustness check are presented in Appendix Table 2.2A and echo those based on the full sample.

courses taught by different types of instructors.[15] The second source of variation comes from within-course differences in the type of instructors teaching a specific section, which could be either due to multiple sections offered during a particular term in a college: 58% of the enrollments in two-year colleges and 66% in four-year colleges are from courses with such within-term variation), or due to changes in the type of instructors teaching the same course over time (48% of the course enrollments in two-year colleges and 44% in four-year colleges are from courses with by-term variations in the type of instructors). These distributions support the use of both student fixed effects and college-course fixed effects, so that the estimates reflect whether introductory courses taught by different types of instructors lead to different concurrent course outcomes, holding constant course specific characteristics as well as student attributes that are constant across courses.

B. Empirical Model for Subsequent Outcomes

The initial course experience in a field of study may influence students' subsequent outcomes in at least three ways: whether enrolled in another course in the same field of study, the type of course enrolled, and learning outcomes in the next course. Therefore, in addition to using equation (1) to examine the impacts of different types of instructors on students' probability of enrolling in another course and their course performance, we use a separate model that further controls for next-class fixed effects:

[15] In two-year colleges, 8% of the students took their introductory courses only with temporary adjuncts and another 24% took courses only with long-term non-tenure faculty; in four-year colleges, the percentages of students taking their introductory courses only with a certain type of instructor are 2% with temporary adjuncts, 4% with long-term non-tenure faculty, 1% with tenure-track faculty, and 2% with tenured faculty only. It is worth noting that having a proportion of students who have no variation in instructors does not cause a selection bias to the student fixed effects estimator, as long as the selection across different types of instructors is constant within an individual; the only concern is that there might be insufficient within-individual variations to deliver a precise estimator due to large standard error. However, this issue is less of a concern in the current study, as the majority of the students have variation in the type of instructors.

$$Y_{icskjt+1} = \alpha + \beta \text{ Instructor}_{icskjt} + S_{cskjt+1} + \rho_{ckj} + X_{cskjt} + \sigma_i + \mu_{icskjt+1} \qquad (2)$$

where student $i$'s outcomes in the next class section $s$ in course $c$ in field $k$ at campus $j$ in time $t$+1 to the type of instructor that the student had in his introductory course ($\text{Instructor}_{icskjt}$). Since the next course-section fixed effect $S_{cskjt+1}$ is a combination of college, course, time and specific section, this model specification compares student performance in exactly the same next course section, therefore 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 course in that field. For example, if a student found the introductory course challenging, she might choose to enroll in a comparatively easier course in her subsequent enrollment. We directly estimate the influence of different types of instructors in a student's introductory course on the difficulty of the next course by examining the average grade of the subsequent class the student takes. Similarly, if a student had an unsatisfactory experience with a temporary adjunct instructor in the introductory course, he might intentionally avoid taking another course in that department with a temporary adjunct. Comparing estimates with and without controlling for next class fixed effects can shed light on the possible mechanisms through which instructors in introductory courses may influence student later academic outcomes.

It is worth noting that for subsequent outcomes, we still keep the college-by-introductory-course fixed effects ($\rho_{ckj}$) in the model. This is intended to take care of potential between-course biases arising from students shopping across different introductory courses within a field. In the field of economics, for example, some students take Introductory Microeconomics as their first course while others take Introductory Macroeconomics. Suppose that we examine students' subsequent course performance in a particular section in Intermediate Microeconomics in Spring 2009 in a particular college, and suppose that Introductory Microeconomics prepares students better than Introductory Macroeconomics. The estimated effect of β in equation (2) would be biased in favor of tenured faculty if better students are more likely to choose Introductory Microeconomics as their first economics course and if tenured faculty are also more likely to be assigned to teaching Introductory Microeconomics than the other types of instructors. By adding fixed effects for introductory courses, equation (2) controls for any between-course selection bias during a student's initial exposure to a field.

## V. Empirical Results

*A. Current Course Performance*

Table 2.4 presents the estimated effects of different types of instructors on a student's first course in a field of study based on equation (1): columns 1-3 present results on two-year colleges and columns 4-6 present results on four-year colleges. We explore three outcome measures in looking at students' introductory course performance: (1) whether the student persists to the end of the course (versus withdrawing from the course); (2) whether the student passes the course (versus either failing or withdrawing from the course); and (3) course grade on a 0-4 scale where failing the course or withdrawing from the course is coded as zero.

The results tell similar stories about the two-year and four-year sectors: students taking their introductory courses with temporary adjuncts are more likely to have better course outcomes relative to long-term non-tenure faculty, including a higher probability of persisting to the end of the course, passing the course, and receiving higher grades. In terms of course grade, for example, taking a course with a temporary adjunct rather than a long-term non-tenure faculty increases course grades by 0.14 grade points in two-year colleges and 0.16 in four-year colleges.

In contrast, students taking their introductory courses with either tenure track or tenured faculty are on average more likely to have lower course persistence and performance relative to long-term non-tenure faculty, where the effect sizes are larger for tenured faculty than for tenure track faculty. As a result, focusing on course grade presented in column 6, a student taking an introductory course with a tenured faculty (the category of faculty associated with the lowest average course performance) in a four-year college would see their grade point reduced by 0.33 compared with a student taking the same course with a temporary adjunct (the category of faculty associated with the highest average course performance). On a 0-4 scale, an increase of 0.33 grade points represents one letter grade up, such as from B to B+.

We further explore the impact of different types of instructors on the full distribution of the letter grades in introductory courses. The results presented in Appendix Table 2.3A indicate that in both two-year and four-year colleges, the magnitude of the positive impacts of temporary adjuncts on introductory course grades are largest for students receiving a grade of A or equivalent, and the magnitude of the estimated coefficients decrease steadily as we lower the threshold to “B or better”, “C or better”, and “D or better”. In a similar vein, the estimated gaps between the long-term non-tenure faculty and tenure track/tenured faculty are also largest in terms of a student’s probability of receiving “A or equivalent” and smallest in the probability of receiving “D or better”. This pattern suggests that the positive effects of non-tenure track faculty on the average introductory course grades presented in Table 2.4 are driven by the increased probability of receiving higher grades in general. Finally, we also estimate the impacts of different types of instructors on introductory course grades conditional on course persistence (Column 5 in Appendix Table 2.3A). The effect sizes are slightly smaller than the unconditional effects presented in Table 2.4 but remain positive and significant.

*B. Subsequent Academic Outcomes*

We next estimate the effects of different types of instructors on subsequent course enrollment, course choice, and performance. Table 2.5 presents results on the probability of taking another course in the same field of study, as well as the probability of taking another course and passing it.

The results present a completely opposite story to the estimates shown above on current course outcomes: With long-term non-tenure faculty as the reference group, students taking their introductory courses with temporary adjuncts are associated with lower probabilities of attempting another course in the same field in both two-year and four-year colleges, while students taking their introductory courses with tenure track and tenured faculty are associated with higher probabilities, with a larger effect size identified for tenured faculty than tenure track faculty. Considering that the average probability of enrolling in another course after the initial attempt in a field of study is 37% in two-year colleges and 43% in four-year colleges, the 1.6-1.7 percentage-point decrease in column 1 and column 5 represents approximately a 4% lower probability for enrolling in another course in the same field in both two-year and four-year colleges, which are both fairly sizable in magnitude.

Once we combine next course enrollment with course completion information, both types of non-tenure track faculty have negative impacts on "taking the next course and passing it" compared to tenure track/tenured faculty. Yet, the effect sizes of the estimated impact on course completion (Column 2) is considerably smaller than the impact on course enrollment alone for the two-year sample (Column 1). One possible explanation for the reduced impact once considering next course performance might be due to selection into the next courses with different levels of difficulty due to initial experiences in a field of study. That is, taking one's introductory course with different types of instructors may influence a student's self-perceived capability in a particular field and influence their choice of subsequent courses. For example, if a student had discouraging experiences in her introductory course in a field, she might opt into a less challenging course for her subsequent enrollment in the same field. To explore this possibility, we calculate the average course pass rate and average course grade for each college-course (excluding the student's own course completion and course grade) in our dataset and examine the impacts of taking one's introductory courses with different types of instructors on two proxies for the difficulty of a student's subsequent course enrollment in a field: the average pass rate and the average course grade of the next course. The results (presented in column 3 & 4 for the two-year sample, and column 7 & 8 for the four-year sample in Table 2.5) indicate that students who took their introductory courses with non-tenure track faculty, especially temporary adjuncts, tend to take subsequent courses with higher average pass rate and grades, or less difficult courses, compared with students taking introductory courses with tenure track/tenured faculty, indicating that they are less confident about their capacities with a particular field if they had their introductory course with a non-tenure track instructor.

The sizable negative impacts of non-tenure track faculty on student persistence into the next course may be driven by two distinct sources: an uninspiring experience in an introductory course may either reduce the student's probability of taking another course in a particular field or drop out from college completely. While both are undesirable, the latter is particularly worrisome, as college persistence is imperative when it comes to economic opportunity, especially among disadvantaged populations. To examine the possible influence of different instructors in students' early stage of college career on their college persistence, we conduct a student-level exploratory analysis that relates the proportion of course credits taken with different types of instructors during a student's initial semester in college to his/her probability of persisting into the second semester in college. The results from this exploratory analysis are presented in Table 2.6.

We use three different models to control for selection bias: i) An OLS model (Column 1 and 4) that controls for student characteristics and initial major choice, the number of courses students take in each field of study during their first year of enrollment, and college fixed effects; ii) a college-course-set fixed effect model (Column 2 and 5) that compares the results of students who take the same set of courses within the same college during their first semester of enrollment, and iii) college-course-set fixed effects with an instrumental variable approach, where we use term-by-term fluctuations of faculty composition in each department as an instrument for the average proportion of credits taken with different types of instructors to minimize selection bias (Column 3 and 6).[16] For example, if a student takes a three-credit English course and a six-credit math course in the fall of 2008 as his/her first semester in college, the instrument for this particular student would be calculated by averaging between the proportion of different types of instructors in the English department and the proportion of different types of instructors in the math department in the fall of 2008, weighted by course credits. For easier interpretation, we multiply the proportions of credits taken with each type of faculty by 10 (such as converting 2% to 0.2). The coefficients hence measure the estimated effects on the outcome measure given a ten-percentage-point increase in the proportion of credits taken with a specific type of faculty.

[16] College-course-set is defined as a set of dummy variables for each possible combination of all courses that a student takes in the first term. For example, one college-course-set could be English 101, Math 101, and Economics 101 in College A; another college-course-set could be English 102, Calculus 101, and Economics 102 in College B.

The results show an overall negative correlation between the proportion of first-term credits taken with non-tenure track faculty and students' probability of persisting into the second term in college. Such negative association is particularly strong among temporary adjuncts than long-term non-tenure faculty. Based on the preferred instrumental variable approach (Column 3 for the two-year sample and Column 6 for the four-year sample), a ten-percentage-point increase in the proportion of credits taken with temporary adjuncts during one's first term significantly reduces the student's probability of college persistence by more than 1.4 percentage points in two-year colleges. Yet, the estimates for the four-year sample are close to zero and are not statistically significant.

Table 2.7 further presents results on subsequent course performance conditional on enrolling in another course in the same field of study based on equation (2) that controls for student fixed effects, college-next-class-section fixed effects and college-course fixed effects for introductory courses. In two-year colleges, the estimated impacts of temporary adjuncts in introductory courses on a student's next class performance in the same field of study are generally small and nonsignificant relative to long-term non-tenure faculty. In four-year colleges, the results echo the patterns presented in Table 2.5 but the estimated effects also tend to be small in magnitude: Among students who did enroll in another class in four-year colleges, temporary adjuncts during their introduction to a field of study significantly decreases a student's probability of passing the next class in the same field by approximately one percentage point and reduces the course grade by 0.02 grade points compared with long-term non-tenure faculty. No significant differences are identified between long-term non-tenure faculty and tenure track/tenured faculty in terms of next-class performance.[17] The fact that the estimates are consistently smaller in effect size compared to the corresponding estimates on the same outcome measures presented in Table 2.5 that do not control for next-class fixed effects suggests that a substantial proportion of the impacts of introductory course instructors are on students' next class choice, such as difficulty of the next course in the same field and the type of instructor teaching the course.

These results on subsequent course enrollment and performance, taken together with those on contemporaneous course outcomes, suggest that while non-tenure track faculty excel in promoting contemporaneous course grades, they are comparatively less effective than tenure track/tenured faculty in inspiring students' interest in a field and preparing students for follow-on learning. Such impacts are particularly strong for temporary adjuncts compared with long-term non-tenure faculty.

*C. IV Estimates and Robustness Checks*

The remaining concern from the two-way fixed effects model is student-level sorting that varies across courses. That is, students may still sort by different types of instructors within a particular introductory course based on considerations that are also correlated with their academic performance in a particular course. For example, a student may take more important courses with tenure track/tenured faculty and less important courses with non-tenure track faculty. Although this concern is soothed by the fact that we only focus on students' first course taken in a field of study when students are least likely to have existing knowledge about different

[17] We also explore the impacts of different types of instructors on the full distribution of the letter grades in the subsequent course in the same field of study based on equation (2). The results are presented in Appendix Table 2.5A: in two-year colleges, the impacts of temporary adjuncts on subsequent course performance are mainly due to reduced likelihood of receiving A while in four-year college, such negative impacts are due to increased probability of receiving a D instead of C or above.

types of faculty in a department, we further use an instrumental variable strategy to cross-validate the results.

Specifically, we adapt Bettinger & Long (2010)'s empirical approach and use term-by-term variation in different types of instructors in a department as an instrument for the student's likelihood of taking a particular course with different types of instructors in their initial term in a certain field. Specifically, a department is often subject to term-by-term variations in retirements and sabbaticals of tenure track/tenured faculty, as well as temporary shocks in demand for course offerings. Since non-tenure track faculty, especially those hired through temporary contracts can be relatively easily increased or decreased, departments often use them to meet staffing needs, which might be plausibly idiosyncratic once controlling for course and time fixed effects.

To address possible seasonality of using non-tenure track faculty, especially temporary adjunct instructors in each department, we construct the instrumental variables 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 between 2005 and 2012.[18] As we show below, fluctuations in faculty composition are highly correlated with students' probability of taking a course with a certain type of instructor.

Appendix Table 2.5A shows the first stage results and indicates that the proportion of different types of instructors in a department is a significant and positive predictor of the probability of taking a course with a particular type of instructor in both two-year and four-year colleges. The F-statistics on the excluded instrument are all substantially greater than 10, thus ruling out the possibility of a weak instrument. Table 2.8 shows the instrumental variable

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

estimates for alternative instructors in terms of subsequent course enrollment and performance, controlling for college-introductory-course fixed effects for all outcome measures and further controlling for next-college-course-section fixed effects for next course grade with all available covariates. The IV estimates echo the estimates based on the two-way fixed effects model, though with a noticeably larger effect size.[19]

In addition to the instrumental variable approach, we also conduct a series of robustness checks to address several remaining concerns. First, the dataset includes multiple institutions and colleges which vary in terms of both their enrollment sizes and in the proportion of course enrollments with different types of instructors (e.g. the proportion of temporary adjuncts ranges from 5% to 63% in two-year colleges and 8% to 43% in four-year colleges). Therefore, we conduct two robustness checks to ensure that the results are not only driven by particular schools. Specifically, we re-run analyses based on a sample excluding the 3 colleges with the largest student enrollments, as well as on a sample excluding the 3 colleges with the largest enrollments with temporary adjuncts. Despite small variations, the qualitative messages remain the same.

Similarly, since the dataset includes multiple cohorts of students, we also examine whether the pooled effects are driven by a certain cohort and if such effects follow clear trends over time. Among the six cohorts examined, the percentage of introductory courses taken with different types of instructors remains fairly stable over time, fluctuating within a narrow range without demonstrating any apparent time trends. Nevertheless, we conduct the analysis by cohort

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[19] We also use two alternative approaches to construct the IV to test the robustness of the IV estimates: (1) the fluctuation in the proportion of total student enrollment by different types of instructors over time, and (2) the fluctuation in the headcount of different types of instructors in each department over time. We run the robustness checks on both Table 2.6 that focuses on student-level outcomes and Table 10 that focuses on student-by-field-level outcomes. The results from these robustness checks are shown in Appendix VII, and are fairly consistent across the three different ways of constructing the IV.

and the estimated effects do not show any clear time trends; instead, the effect size only fluctuates slightly around the estimates using the pooled sample.

In addition, based on the descriptive statistics presented in chapter one, temporary adjuncts are noticeably more likely than other types of instructors to be “career enders”, who first started in a college instructor position when 55 or older (15% and 7% of temporary adjuncts in two-year and four-year colleges respectively, compared to 4% of long-term non-tenure faculty in both settings; none of the tenure-track or tenured faculty is “career ender”). These individuals are likely to be on the declining part of the life-cycle human capital profile, slowly transitioning into retirement and take up a teaching job they may enjoy in the meantime. Thus, their impacts on students may be substantially different from other non-tenure track faculty. We thus conduct a robustness check that drops all “career-enders” from the sample, and the results are presented in Appendix Table 2.7A. Indeed, while the negative impacts of temporary adjuncts on subsequent course enrollment and performance remain significant, the size of the effects generally attenuates after career-enders are excluded from the analyses.

Finally, 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 decisions, such as course withdrawal and enrollment in additional classes, are most plausibly affected by instructors. 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.

*D. Potential Mechanisms*

The overall results so far suggest that having one’s first course in a field with non-tenure track instructors have positive impacts on students’ introductory courses but negative impacts on students' subsequent persistence and performance in the same field, where more pronounced impacts are identified on field persistence. Yet, there is no definite mechanism by which these effects may operate. As shown in chapter one, different types of instructors are distinct in key individual characteristics that are likely to be related to their productivity. To explore the extent to which the impacts of different types of instructors on introductory course performance and persistence into the next course can be explained by observable instructor characteristics, we further use an instructor value added approach to examine the extent to which the "value-added" by different instructors could be explained by observable instructor characteristics focusing on two outcome measures: current course grades and next course enrollment.

This is implemented through a two-step process: first, we construct the empirical Bayes estimate for each instructor's value added following similar approaches used in the existing literature (Kane & Staiger, 2008; Chetty, Friedman, & Rockoff, 2014). Specifically, for each outcome measure, we begin by residualizing each outcome based on regressions that control for all variables in equation (1), except for the academic rank of the instructor. In addition, we also include in the model years working as an instructor that vary over time within an instructor. Since instructors may teach multiple classes in our dataset, we calculate the average classroom residuals for each instructor-by-class and then center all the values at the grand mean. We then estimate instructor value added by forming a precision-weighted average of the average classroom residuals for each instructor, weighted by the inverse of the class-level variance. As a result, larger classes with greater sample sizes would have less variance and therefore receive greater weighting in the calculation. Finally, considering that these estimated instructor effects are noisy estimates of the true instructor value added, we implement the Bayes shrinkage by multiplying the noisy estimate of instructor value added by its reliability (or the shrinkage factor), where the reliability of a noisy estimate is the ratio of the between-instructor variance to the sum of between-instructor variance and the estimation error variance for a particular instructor. Through the shrinkage process, instructors with less precise estimates of the value added would thus be pulled toward the grand mean of instructor value added among all instructors.

In our second step, we use the value added calculated for each instructor from our step one as the dependent variable and include a vector of observable instructor characteristics as predictors in the OLS model, including: i) an instructor's highest educational credential received, ii) whether the instructor ever taught in multiple institutions, iii) whether he/she worked full time as an instructor during at least half of the terms employed in an institution. We also include two variables to capture an instructor's industry experience: i) whether an instructor ever worked in non-teaching industry positions prior to working in the current college, and ii) his/her average annual earnings from non-teaching positions between 2001 and 2012 (inflation adjusted). This is to explore the possibility raised by some researchers (e.g. Jacobs, 1998) that many adjuncts are in fact skilled professionals in a relevant industry, and are employed to enhance the quality and prestige of institutions and bring skills and talents that complement those possessed by the regular faculty. Although our descriptive information on earnings distribution does not support this assertion and in fact provides suggestive evidence that non-tenure track instructors typically receive limited earnings from non-teaching industry positions and therefore may not be skilled professionals with special expertise and outstanding productivity, we still include the industry work experience indicator to capture potential differences between instructors who came from a non-teaching industry position and instructors who never worked in industry before.

One potential problem with this indicator is that the labor market data only tracks instructors back to 2001. Therefore, if an instructor was hired prior to 2001, we are not able to tell whether he/she worked in a non-teaching industry position before. About one third of non-tenure track instructors in both two-year and four-year settings in our analytical sample were hired before 2001; we therefore create a dummy variable indicating whether the instructor was hired during or prior to 2001 and include it as a predictor in the model.

Finally, some researchers point out that one potential benefit of hiring temporary employees is that they may provide a flexible and low-cost way to screen for effective workers to be hired on a full-time long-term basis (e.g. Autor, 2000; Bettinger & Long, 2011). To examine whether there might be differences in productivity between instructors who failed to continue their employment after first year and those who managed to continue teaching in the institution, we include an individual-level variable to indicate whether the instructor continued his teaching position in the institution after his first-year of employment as a college instructor.

Table 2.9 presents the impacts of different types of instructors on a student's introductory course grades with and without controlling for observable instructor characteristics. For each setting, the first column (column 1 and column 3) presents the estimated differences in instructor value added by academic rank; the next column (column 2 and column 4) presents the results after further adding observable instructor characteristics.

First, the estimates based on the value added approach presented in column 1 and column 3 of Table 2.9 echo the results from our main analyses presented in Table 2.4, where non-tenure track instructors, especially temporary adjuncts, have significantly higher value added on student current course grades. Yet, adding observable instructor characteristics reduces the effect size of the estimated difference between different types of instructors by approximately one quarter in two-year colleges, and one fifth (such as the difference between temporary adjuncts and long-term non-tenure instructors) to more than a half in four-year colleges (such as the difference between tenured-track assistant professors and long-term non-tenure instructors). In both settings, instructor's highest educational credentials are negatively correlated with students' grades in their introductory courses. Specifically, instructors who have received a doctorate or master's degree (versus having bachelor's degree or lower as the highest degree) are associated with lower instructor value added on student current course grades, although the negative association between having a master's degree and instructor value added is only significant in the four-year setting. In addition, instructors who were part-time employed, who also worked in non-education positions, and who continued to be employed by ASCS after the first year tend to give higher grades to students in two-year institutions.

Table 2.10 further presents the estimated differences between instructor value added on a student's probability of taking another course in the same field. The results presented in column 1 and column 3 again echo the findings from our main analyses presented in Table 2.5, where non-tenure track instructors, especially temporary adjuncts, have significantly lower value added on student subsequent enrollment. In column 2 and column 4, we further add observable instructor characteristics into the model, and the instructor-level analyses reveal several interesting patterns: first, similar to the results on contemporaneous student achievement, adding observable instructor characteristics to the model also reduces the estimated difference between different types of introductory course instructors, although the explanatory power of the predicting variables are much stronger in the four-year setting. In particular, including observable instructor characteristics explains away more than half of the gaps between temporary adjuncts and long-term non-tenure instructors on subsequent enrollment in four-year institutions.

Moreover, while instructors with higher educational credentials tend to give lower grades to students in their introductory courses, these instructors have significantly higher value added on students' subsequent interest in the same field in four-year institutions. Results in Table 2.10 also suggest that instructors who are employed full time are positively associated with students' subsequent course enrollment in the same field of study in four-year colleges. Such positive relationship is also observed in the two-year setting, although we are not able to precisely estimate it. Finally, instructors who also worked in the K-12 sector have lower value added on students' subsequent enrollment in the same field of study on average. One possibility is that previous or current K-12 teachers may be more likely to be assigned to teaching entry-level college courses that intend to help students transition into college. Their relatively diminished involvement in teaching and developing more advanced coursework may limit their capacity in broadening introductory course content such that it prepares students for follow-on learning effectively. Indeed, among non-tenure track faculty, less than half of instructors with K-12 teaching experiences have taught advanced coursework, compared to more than two thirds of instructors who never worked in the K-12 sector. As a result, these instructors may lack both the awareness and knowledge of how to integrate introductory course content into the full spectrum of learning.

## V. Discussion and Conclusion

Understanding the relative impacts of different types of college instructors on students' initial experience in a field of study is of great policy importance, in part because higher education is increasingly relying on non-tenure track instructors, and in part because early academic experience during one's introduction to a field of study may substantially influence a student's subsequent academic choices and outcomes. This study analyzes student course taking behaviors and performances with a large swath of introductory and follow-on courses using a statewide college administrative dataset that includes all the public two-year and four-year institutions. In contrast to existing literature, where all non-tenure track faculty are typically combined into one group and compared with tenure track/tenured faculty, we recognize potential heterogeneity in non-tenure track faculty by nature of employment and differentiate between adjuncts hired on a temporary basis and those with long-term contracts with an institution.

Although the increasing reliance on non-tenure track faculty has been well documented in the existing literature, we are still surprised at the extensive use of non-tenure track faculty in this public college system, where less than one third of all faculty in four-year colleges are hired in tenure track positions and only one two-year college includes tenure track positions. Between the two types of non-tenure track faculty, both two-year and four-year colleges are particularly heavily relying on temporary adjunct instructors, which consists of 75% of all faculty in two-year colleges and 39% in four-year colleges. The over-reliance on non-tenure track faculty is worrisome, as available instructor characteristics suggest that non-tenure track faculty, especially those hired on temporary positions, are typically not as experienced or educated as faculty hired in tenure track positions.

Our subsequent analysis relating different types of instructors and student academic outcomes supports this concern: while having one's introduction to a field of study with a non-tenure track faculty is on average associated with higher current course grade, these students are less likely to attempt another course in the same field, and, among students who do so, non-tenure track faculty in introductory courses also have negative impacts on a student's next-course performance within the same field of study. The positive impacts on current course performance and negative impacts on subsequent outcomes are especially strong among adjuncts who are hired on temporary basis. One potential explanation for this result is that non-tenure track instructors, especially those employed on temporary basis, due to job insecurity, may reduce the difficulty of course content, lower course expectations, or relax grading criteria in order to earn good student evaluations. While these measures can help students earn higher and potentially inflated grades in contemporaneous courses, they might harm students' interests in, and preparation for, follow-on learning in more advanced coursework. This story cautions against using student course evaluations or student current course grades as the sole criterion for evaluating instructional effectiveness, and highlights the necessity of incorporating students' subsequent performance into consideration and employing additional measures of instructional quality to complement student course evaluations.

Considering that optimizing students' college retention is imperative when it comes to economic opportunity for disadvantaged students, of greater concern is the finding that taking introductory courses with temporary adjuncts may also increase the chance that community college students drop out completely from college during their early academic career compared with taking courses with instructors with longer-term employment contracts. If the negative impacts of temporary adjuncts on students' college persistence identified in the current study also holds true in two-year colleges in other states, it would imply that the continued increase and heavy reliance on temporary adjuncts could harm community college students' educational outcomes and labor market opportunities. Therefore, while the negative impacts of temporary adjuncts on students' subsequent interests and performance warrant policy attention in general, the negative correlations between temporary adjuncts and college persistence in the particular setting of open-access two-year colleges are particularly worrisome, considering that college persistence is imperative for economic opportunity, especially among disadvantaged populations.

Yet, one finding from the current study that somewhat alleviates the concern is that the negative impacts of non-tenure track faculty on students' subsequent academic interest are substantially reduced by observable instructor-level characteristics in four-year institutions, indicating that objective and easy-to-measure instructor characteristics could be indeed informative about student academic performance. First, instructors with higher educational credentials, especially a doctorate, are positively related to student follow-on course enrollment and performance at four-year colleges. By the time of the study, the percentage of instructors having a doctorate is low among both types of non-tenure track faculty in ASCS. Considering that it is fairly easy to collect information on instructors' educational background during the hiring process, colleges may wish to include the highest educational credentials as important selection criterion for non-tenure track instructors.

In addition, we also find that instructors' full-time employment status positively predict students' subsequent interest in a field, which supports the widely shared assertion regarding the lower productivity of part-time college instructors due to their limited access to college resources and faculty support, minimal involvement with departmental program alignment and curriculum design, reduced engagement with the students, scant loyalty for the institution and an increasing sense of frustration with their circumstances (Brewster, 2000; Jacoby, 2005; Schmidt, 2008). As colleges attempt to encourage faculty to improve their teaching practices and increase faculty-student engagement, institutions that heavily rely on part-time faculty would face additional challenges to improving student persistence. Future studies may wish to explore effective strategies to support and engage part-time faculty.

Finally, some researchers point out that one potential benefit of hiring temporary employees is that they may provide a flexible and low-cost way to identify effective workers for long-term employment (e.g. Autor, 2000; Bettinger & Long, 2011). Yet, we do not find any difference in students' persistence in a field between instructors who continue to be employed in a college after first year of employment and instructors who fail to do so. This finding implies that the feasibility of massive hiring of temporary adjuncts to function as a cost-saving screening mechanism may be much more complicated and obscure than expected.

# Chapter Three

# The Impact of Faculty Gender on Female Students’ Labor Market Outcomes

## I. Introduction

Does faculty gender affect female students’ labor market outcomes? A growing body of literature has documented the impact of instructors’ gender on student outcomes, with an emphasis on the role of female instructors in promoting female student performance in Science, Technology, Engineering, and Mathematics (STEM). This line of research has focused primarily on immediate academic outcomes, such as test scores in the K-12 sector, course grades, and the choice of major in college. In contrast, relatively little is known about the long-run impact of instructor gender, particularly with respect to labor market outcomes such as occupation choice, employment, and earnings. This is important because previous studies have discussed a few channels through which instructor gender may affect student outcomes, but it is not clear whether such impacts will necessarily affect outcomes years after the interaction between the instructor and the student. For example, instructor gender could primarily affect contemporaneous performance on standardized exams or course grades rather than deep learning or subsequent course choosing behavior, in which case the effects could diminish over time.

Increasing female faculty representation has been regarded as an important policy goal to improve female students’ participation in STEM. However, a lack of evidence on the long-run impact of female faculty members on female students’ labor market outcomes has limited the implication of such faculty recruitment and assignment policies. The previous literature has demonstrated that female college instructors could significantly improve female students’ academic outcomes in STEM subjects, such as contemporaneous course grades, subsequent course enrollment in STEM, major interest, and graduation with a STEM degree (Bettinger &

Long, 2005; Canes & Rosen, 1995; Carrell, Page, & West, 2010; Hoffmann & Oreopoulos, 2007; Neumark & Gardecki, 1996; Rothstein, 1995). However, gender disparity in STEM participation continues in the workforce through channels such as occupation choice. For example, about 40 percent (or 2.7 million) of men with STEM college degrees work in STEM jobs, whereas only 26 percent (or 0.6 million) of women with STEM degrees work in STEM jobs (U.S. Department of Commerce, 2011). It is important to examine the labor market impact to decide whether increasing female faculty representation could be an economically meaningful policy goal to promote female persistence in STEM education and the workforce.

This paper documents the existence of long-term effects of faculty gender on female students' occupational choices, employment, and earnings 6 years after the initial term of college enrollment. I link students' college transcripts to earnings data from Unemployment Insurance (UI) records in an anonymous state for all public two-year and four-year colleges. Several important features of these data allow me to identify the labor market impact of faculty gender. First, students' transcripts can be matched with the profiles of the instructors who taught each corresponding course section. The instructor profile includes information such as instructors' gender, race, degree attainment, academic rank, and employment status. Such rich information of instructor characteristics also allows me to explore the mechanisms of any instructor gender effects. Second, the UI records match students' quarterly earnings with an industry code. Therefore, I am able to examine the impact of the college faculty on both occupational choice and earnings. Third, the data include detailed information on students' major declaration for each term. I am able to examine the impacts of faculty gender across different major fields.

The methodological challenge to estimating the impacts of faculty gender on student outcomes in college is student self-selection into courses and sections by faculty characteristics.

To address these endogeneity concerns, I apply the method pioneered by Bettinger and Long (2005), which utilizes an instrumental variable (IV) approach controlling the sets of courses that students take during their initial enrollment terms (the course-portfolio fixed effect).[20] This method minimizes potential selection bias in three ways. First, I focus on the impact of faculty of courses during a student's initial term of college enrollment, when the least amount of information about faculty members is available, and thus it is less likely that there is sorting into course sections based on faculty gender. Second, by including a course-portfolio fixed effect, I only compare outcomes for students who take the same set of courses in the first term, eliminating selections between courses. Third, the IV exploits term-by-term variations of total course enrollments with female faculty members in each department to address self-selection within courses. This identification draws on variations from fluctuations in departmental faculty gender compositions over time and compares the outcomes of otherwise similar female students who take their introductory courses with faculty members of different genders only due to entering college in different terms.

I start the inquiry by examining the impact of female faculty on female students' academic outcomes, including contemptuous course grade, subsequent course enrollment and performance, major choice, and credential completion. Consistent with the results from earlier experimental or quasi-experimental work (e.g. Carrell, Page & West, 2010), I find that female

[20] Recent studies exploring the impact of faculty demographic characteristics on student outcomes mainly utilize three types of identification strategies: experimental methods (Carrell, Page & West, 2010; Carrell & West, 2010), two-way fixed effects models that draw on variations within student and within courses (e.g., Fairlie, Hoffmann & Oreopoulos, 2014; Figlio, Schapiro & Soter, 2015; Hoffmann & Oreopoulos, 2009a, 2009b; Lusher, Campbell & Carrell, 2015; Ran & Xu, 2017), and instrumental variable methods that exploit the term-by-term fluctuation of faculty composition (Bettinger & Long, 2005a, 2005b, 2010). The instrumental variable approach is the most appropriate for the setting of this study: the experimental method is not suitable for the study since students in the college system choose their own course curriculum and course sections. The main outcomes for the study – employment and earnings six years after initial college enrollment – are at student level, making it infeasible to utilize variation within student.

students received higher grades (around 0.34 on a 4.0 scale, or one letter grade higher) in course sections taught by female faculty in four year colleges. In addition, a 10 percentage points increase in the proportion of credits taken with female faculty during first term leads to about 0.5 more credit enrollments in future STEM courses for female students who declared a major in a STEM subject. Not surprisingly, a 10 percentage points increase in the proportion of credits taken with female faculty during first term improves these students' likelihood of still majoring in a STEM subject in their last term of enrollment by 1.6 percentage points and earning a credential in STEM by approximately 1.0 percentage points.

The results show that greater exposure to female instructors during the first term of college enrollment has a positive impact on female students' labor market outcomes in four-year colleges. Estimates indicate a 10 percentage points increase in the proportion of credits taken with female instructors during the first term improves female students' likelihood of being employed 6 years after the first term of college enrollment by 1.7 percentage points (or 2.6%), and the chance of being employed in industries with a concentration of STEM jobs by 2.6 percentage points (or 10%) for STEM majors.[21] In addition, greater exposure to female faculty members during the first term in four-year colleges has a significant impact on earnings 6 years after enrollment: a 10 percentage points increase in the proportion of credits taken with female instructors during the first term improves annual earnings after 6 years by $649 (or 0.042SD). Most of the positive impacts of female instructors on labor market outcomes come from their impacts on the likelihood of employment, since the impacts on annual earnings are no longer statistically significant after conditioning on employment. No significant impact of faculty gender on labor market outcomes for female students is found in two-year colleges.

[21] Industries with a concentration of STEM jobs are defined as industries with more than half jobs consisting of STEM occupations.

I then examine the mechanisms through which faculty gender affects female students' labor market outcomes. I find that a fair proportion of the impacts of faculty gender on female students' employment outcomes could be explained by their influence on female students' major choices. After controlling for credential completion and the time spent to get the degree, the impact of faculty gender on female students' likelihood of employment six years after are still significant and the magnitude of the impacts only dropped by less than 7%; however, after controlling for the subject areas of the credential earned (CIP codes of the degree), the magnitude of the impacts reduced by about one third and were no longer statistically significant.

Next, I attempt to distinguish the role of faculty gender itself from the impact of other faculty characteristics that are correlated with faculty gender. As shown below, female faculty members are less likely to have long-term employment relationships with colleges and are also less likely to be employed fulltime by colleges. These characteristics could also affect student outcomes (Bettinger & Long, 2010; Ran & Xu, 2017). I estimate each faculty member's average "value-added" for female students using a shrinkage estimator. I find that even after controlling for other faculty characteristics, such as employment status (full-time vs. part-time), experience in both college teaching and other industry, and degree attainment, female instructors' value-added effects on female students' probability of employment are still significantly higher than male instructors in four-year colleges. In addition, these positive impacts of female instructors over male instructors are stronger in STEM fields.

These findings are in line with the existing literature examining the effects of teacher-student demographic matching. These studies showed mounting evidence that a demographically similar teacher could affect students' immediate academic outcomes, such as test scores, attendance, suspensions, and teacher perceptions of student performance, as well as non-cognitive outcomes, such as student engagement and the formation of beliefs in self-ability (Bettinger & Long, 2005; Carrington et al., 2008; Saft & Pianta, 2001; Dee, 2004, 2005, 2007; Eble & Hu, 2017; Egalite et al., 2015; Ehrenberg et al., 1995; Gershenson et al., 2016; Hoffmann & Oreopoulos, 2009a, 2009b; Holmlund & Sund, 2008; Holt & Gershenson, 2015; Lindsay & Hart, 2017; Lavy & Schlosser, 2011; Solanki & Xu, 2017). This paper shows that female faculty members still have powerful impacts on female students' occupational choice and employment outcomes 6 years after exposure to these faculty members. This suggests that the impact of demographically similar instructors does not decay over time, and their effects are sustained when students make choices later in their lives with regard to occupations. In addition, all previous studies examining student and faculty gender matching at the postsecondary level used samples of four-year elite research universities. Findings from this paper expand this line of inquiry to community colleges and four-year colleges with teaching as the primary focus.

The rest of this paper is structured as follows: the institutional context and data are described in Section II. The method and identification strategy are discussed in Section III. Section IV presents the main results, robustness checks, and mechanisms, and Section V concludes the study.

## II. Institution Context and Data Description

### A. Institution Context

In this paper, I use data on three cohorts of first-time-in-college students (FTIC) who first entered one of the public postsecondary institutions in an anonymous state college system (referred to as ASCS hereafter) between fall 2005 and summer 2008.[22] The students were tracked until the summer of 2013, or at least 6 years after the students' initial enrollment. The state system includes 22 public two-year colleges and 11 public four-year colleges. Both the two-year community college system and four-year public college system in ASCS comprise a mix of large and small colleges, as well as institutions located in rural, suburban, and urban settings.

Table 3.1 compares the institutional characteristics of the ASCS fall 2005 enrolling cohort with a national sample, based on statistics reported to the Integrated Postsecondary Education Data Systems (IPEDS) database. Compared with the national average, ASCS institutions tend to enroll higher proportions of female students, African American students, and students who are eligible for need-based financial aid. Both two-year and four-year colleges in ASCS are subject to lower graduation rates for women and men than the nationally representative samples. In addition, ASCS institutions generally hire a higher proportion of female faculty and staff than the national average in both two-year and four-year sectors.

B. Data Description

The dataset used in this paper contains information on static student characteristics, course-section level transcripts, student credential completion over time, and quarterly earnings drawn from unemployment insurance (UI) records. Static student characteristics include demographic information, their intended major at college entry, high school attributes (high school attended and high school GPA), and their pre-enrollment academic performance (standard test scores such as ACT and SAT, and placement test scores in reading, writing, and math if applicable). Transcripts are detailed at the course-section level, with information on credits

[22] The first time in college status is retrieved directly from the information available in the state college system. About 65% of two-year college students and 59% of four-year college students are first time in college.

enrolled and earned, grades received, course level (remedial, college-level, or postgraduate level), course subject and CIP code, and delivery method. Each transcript record includes a variable indicating the instructor ID for the corresponding course section. This instructor ID can be further linked to a separate instructor file, which includes characteristics such as the instructor's gender, race, academic rank (professor, associate professor, assistant professor, lecturer, or other), employment status (full-time vs. part-time), and credit hours teaching each semester.

The UI records include quarterly earnings for every individual who worked in a non-federal civilian job within this state from the first quarter of 2001 to the fourth quarter of 2013, which could be matched to both students and faculty in the sample. One important feature of the UI records is that I can observe each job an individual held during a quarter with a 6-digit NAICS industry code and the earnings associated with the job. Since I cannot directly observe one's occupation, I define any STEM industry as an industry with more than half of the industry workers in STEM occupations.[23] The UI records are limited in two ways. First, a few categories of employment, such as federal employment and self-employment, are not included in the UI data. This is not likely to be a big concern for the current study since less than 1.6% of employees are estimated to be federal employees in this state (Bureau of Labor Statistics, 2016). Second, students who move to another state after college are not observable in the UI data. This is again less of a concern for the current study: according to an estimation by the U.S. Census Bureau in 2016, less than 4.3% of residents in this state with some college, an AA degree, or a bachelor's degree move outside of the state.

[23] A complete list of STEM industries is presented in Appendix A. The statistics on the share of industry workers in STEM occupations during 2012 are drawn from https://www.brookings.edu/wp-content/uploads/2015/02/Advanced-Industries-Data-and-Methods-Appendix.pdf

*Instructor Sample Description.* Table 3.2 shows the characteristics of all instructors who have taught at least one introductory course; that is, the course that students in the analytic sample took during their first term of enrollment. In both two-year and four-year colleges, female instructors in introductory courses are similar in terms of age and racial composition to male instructors in these courses. As for degree attainment, female instructors in two -year colleges have lower proportions with bachelor's degrees or lower (26.5% vs. 36.6%) and doctorate degrees or equivalent (8.6% vs. 49.4%), but have higher proportions with master degrees (64.9% vs. 49.4%) compared with male instructors. In four-year colleges, female instructors generally have lower degree attainments than male instructors, especially for terminal degree attainment (26.7% vs. 48.4%).

One distinction between female and male instructors is their employment status, especially in four-year colleges. Despite having similar teaching loads—around 10 credits per semester in two-year colleges and 9 credits per semester in four-year colleges—female instructors are less likely to have long-term employment relationships with colleges and are also less likely to be employed full time by colleges. In four-year colleges, 24.1% of female instructors are in tenure-line positions, compared with 43.0% for male instructors. In fact, about 46.0% of female instructors are hired as temporary adjunct faculty whose employment contacts are renewed on a semester-by-semester basis, while 35.5% of male instructors are on similar contracts.[24] In addition, 57.3% of female instructors are employed full time by colleges, which is about 10% lower than their male counterparts.

[24] ASCS divides faculty into two major categories in two-year colleges and four categories in four-year colleges. With only one exception, none of the 22 two-year colleges have tenure track faculty positions, and faculty members are categorized by the contractual form with the college into temporary adjunct and long-term non-tenure track faculty. Temporary adjuncts are typically hired with contracts that are less than one year and the contract with long-term non-tenure faculty are renewed every two to three years. In four-year institutions, there

C. Student Sample and Key Outcome Measures

In this paper, I am interested in three set of outcomes: employment likelihood, occupational choice, and annual earnings. The measurement of employment likelihood outcome is defined as whether the student has any employment records during the sixth year after initial college enrollment. The occupation choice outcome is for students who declared a STEM major during the first term. It is equal to 1 if the student is employed in an industry where more than 30% of the jobs are classified as STEM occupations during the sixth year after initial college enrollment.[25] The annual earning is the sum of quarterly earnings across all jobs held by the students during the sixth year after initial college enrollment and it is imputed as 0 if the student does not have employment records during that year.

Table 3.2 presents the statistics of student characteristics and outcomes for the analytic sample. I focus on the 15,796 female students in two-year colleges and 19,623 female students in four-year colleges, which contribute 56% and 53% of total two-year and four-year FTIC enrollments, respectively. Consistent with national statistics, female students generally outperform male students academically in both two-year and four-year colleges: higher proportions of female students enroll in college in each cohort; female students also have higher high school GPAs on average. The only exception is that female students are more likely to take remedial courses than male students in both two-year and four-year colleges.

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are four categories of academic ranks: temporary adjunct, long-term non-tenure track, tenure track assistant professors, and tenured faculty. For more information on academic ranks of faculty in ASCS, refer to Ran and Xu (2017).

[25] I also conduct sensitivity test by defining STEM industries as the ones with more than 50% or 40% of the jobs classified as STEM occupations. The results are not qualitatively different from the results presented in the paper.

I am able to observe students' major declarations for each semester in which students enroll within ASCS, allowing me to track the changes in students' major choices. As shown in Panel A of Table 3.2, 19.0% of female students in two-year colleges and 34.3% in four-year colleges major in STEM fields during their first semester, respectively, which are slightly higher than the proportions of male students. However, when I exclude health-related programs, the proportions of female students in STEM fields during the first term drop substantially—1.9% in two-year colleges and 7.0% in four-year colleges. This suggests that the vast majority of women in STEM concentrate in health-related programs, and men in STEM are distributed more evenly across programs. The proportions of female students declaring a STEM major during their last semester of enrollment are higher than the proportions in the first semester in two-year colleges but lower than that in the first semester in four-year colleges, suggesting STEM enrollment attrition in four-year colleges.

Panel B to D in Table 3.2 uses information from students' college transcripts and UI data to summarize course schedule during the first semester (Panel B), student-level academic outcomes within 6 years after initial enrollment (Panel C), and labor market outcomes 6 years after initial enrollment (Panel D). Female students take about two-thirds of their first-semester courses with female instructors in two-year colleges, and approximately half of first-term courses with female instructors in four-year colleges. In both sectors, this number is significantly higher for female students than male students.

I further examine the distribution of the proportion of credits taken with female instructor. The results are presented in Figure 3.1 and Figure 3.2. The raw distributions suggest that almost 40% of female students took all of their first-term courses with female faculty during the first term in two-year colleges, but female students in four-year colleges are more likely to take courses from both female and male faculty. The conditional distributions presents the variation of the variable of interest after controlling for course-portfolio. It suggest that significant amount of variation in four-year college come from course-portfolio itself. After conditional on the course-portfolio, the standard deviation of the variable of interest reduced.

Female students perform better in general persistence and completion outcomes, but significantly worse in any STEM field-related outcomes than male students. Female students are more likely to continue to enroll in the second academic year, enroll and earn more credits, and to obtain any type of credential or degree 6 years after their initial enrollment than their male counterparts. However, female students in four-year colleges enroll and earn 3 to 4 fewer credits in STEM fields than male students, which is equivalent to one course. In addition, female students are less likely to obtain a credential in STEM fields. In fact, less than 1% of female students in two-year colleges and around 5% of female students in four-year colleges did so, compared to 3.2% and 10.6% of male students in two-year and four-year colleges, respectively.

In terms of labor market outcomes, female students are slightly more likely to be employed 6 years after initial enrollment than male students. Women are also slightly more likely to be employed in any STEM industry. However, female students' annual earnings are considerably lower than male students both for all students in the analytic sample and conditional on employment. This is likely due to two factors. First, discrimination in labor market makes females earn less than male counterparts working in similar jobs. Second, female students are less likely to enter higher-paying occupations (for example, jobs that require credentials in STEM fields). This second factor can be observed in the statistics in Panel C, which show that despite earning more credits and having a higher overall completion rate, female students earn fewer credits in STEM fields and are less likely to earn any STEM credentials compared with male students.

## III. Method

In this paper, the goal is to estimate the impact of exposure to female faculty during the first semester in college on female students' labor market outcomes. The basic strategy relates female student *i*'s outcomes at college *j* in cohort *t* to the proportion of female faculty that the student had during her initial term of enrollment in college:

$$Y_{ijt} = \alpha + \beta\, Female\ Instr_{ijt} + \gamma \boldsymbol{X}_i + P_{ijt} + \delta_t + STEM_{ijt} + \varepsilon_{ijt}. \quad (1)$$

The variable of interest $Female\ Instr_{ijt}$ is the proportion of credits a female student took with female faculty members during the initial term of enrollment. The vector $\boldsymbol{X}$ includes student characteristics such as demographic attributes (e.g., age at enrollment and race), academic preparedness (e.g., remedial status and high school GPA), first-term enrollment status (e.g., whether students entered in the fall and whether they entered as full-time students), and the student's earnings during the quarter before first term of college enrollment. In addition to these student characteristics, I also include college fixed effects ($\theta_j$) and cohort fixed effects ($\delta_t$) to control for sorting across different colleges, and statewide time shocks in faculty demographics that might affect female students' academic and labor market outcomes. In addition, undergraduate students who enter STEM fields have differential attrition rates (Chen, 2013) and labor market outcomes (Carnevale, Cheah & Hanson, 2015). I include an indicator for whether the student initially declared as a STEM major to account for such differences.

OLS estimates of equation (1) are likely to be biased by unobserved student characteristics that predict both faculty assignments and college and labor market outcomes after conditioning on observable student characteristics, major declaration, and college FE. For the postsecondary settings that this study is based on, two remaining sources of selection are of particular concern. The first one is between-course selection. Students choose their own course work in college. Female students who choose course sets that are heavily concentrated in departments with a higher proportion of female faculty members may have different academic and labor market outcomes compared to those who choose different course sets. This problem has been partly addressed by focusing on courses that students take during their initial terms of enrollment, when students have the least information about the faculty. However, remaining variations may still exist across these introductory courses. The second source is selection due to students' differential sorting by instructor gender within a course. For example, female students who are more aware of gender stereotypes may intentionally seek out course sections taught by female faculty members. To address these two types of selection, I adopt course portfolio fixed effects combined with the instrumental variable strategy pioneered by Bettinger and Long (2005), which I discuss in greater depth below.

A. Address Selection Between Courses Using Course Portfolio Fixed Effects

To control for students' self-selection into different course work, I include college-course portfolio fixed effects ($P_{ijt}$), as in equation (2):

$$Y_{ijt} = \alpha + \beta\ Female\ Instr_{ijt} + \gamma \boldsymbol{X}_i + P_{ijt} + \delta_t + STEM_{ijt} + \varepsilon_{ijt}, \qquad (2)$$

where $P_{ijt}$ is a vector of dummy variables representing every possible course combination in each department that students may have taken in their first semester within a college. For example, one portfolio may include 3 credits in English, 6 credits in math, and 3 credits in economics in college A. Another portfolio may include 6 credits in English and 3 credits in math in college B.[26] By including college-course portfolio fixed effects, I am comparing students who took the same set of courses in their initial term of enrollment. This eliminates any bias coming from students' self-section between different courses.[27] There are 2,667 distinguish sets of course portfolios for the 15,796 female students in two-year colleges and 7,063 sets of course portfolios for the 19,623 female students in four-year colleges.

B. Address Selection Within Courses Using Instrumental Variables

After controlling for college-course portfolio fixed effects, the remaining source of bias is due to students' differential sorting by instructor gender within a course. To directly explore the extent of this problem, I conduct a balance check that relates the proportion of credits taken with female instructors to a wide range of student characteristics controlling for college-course portfolio fixed effects. The results presented in Columns 1 and 2 of Table 3.4 suggest that students taking more credits with female instructors generally look similar to those who took less credits with female instructors in terms of academic preparation and enrollment status.

To address possible selection bias due to student sorting by instructor gender, I further combine the college-course portfolio fixed effects with an instrumental variable approach employed in Bettinger and Long (2005), where I use term-by-term fluctuations in the proportion of course enrollments with the different genders of instructors in each department as an

[26] Note that college fixed effects ($\theta_j$) are automatically dropped when college-course portfolio fixed effects are added to the model, as it is an attribute of the course.

[27] An alternative way to construct college-course portfolio fixed effects is to create a dummy variable for each possible combination of all courses that a student takes in the first term. For example, one portfolio is English 101, Math 101, and Economics 101; another portfolio is English 102, Calculus 101, and Economics 102. A Portfolio fixed effects strategy that is constructed this way is stronger than the method used throughout the paper. However, this increases the number of distinguished sets of course portfolio into 8,887 in two-year colleges and 15,843 in four-year colleges. Even though this does not affect the "un-biasness" of the estimation, it utilizes significantly less variation of the data and affects the generalizability of the results. Since the results from both ways of constructing course portfolio show similar patterns, I present the estimation using the course portfolio by number of credits in each department as the main results. Results using the alternative way of constructing a college-course portfolio are available upon request.

instrument for students' enrollments with female instructors. The distribution of student enrollments across courses taught by female faculty members may not be random, but the temporary shifts may occur in the number of sections offered in a particular course taught by females. Hence, the probability that a student gets a female instructor can be random due to sabbaticals, new hiring, and faculty member retirements.

The instrumental variable is constructed this way: first, I compute three steady states of the average proportion of course enrollments taught by females in each department for the fall, spring, and summer terms, respectively, to address the possible seasonality of the female faculty. I then calculate the deviation of the proportion of course enrollments taught by female faculty members in the department in a particular semester to the steady state. Finally, to get the instrumental variable at the student level, I aggregate the deviation of each department to the student level, weighting by the proportion of credits the student took in each department during her initial semester.

Within this framework, I run the following first-stage regression to explain the likelihood that a student has a female instructor:

$$Female\ Instr_{ijt} = \alpha + \varphi\ Deviation\ Female\ Instr_{ijt} + \gamma \boldsymbol{X}_i + P_{ijt} + \delta_t + STEM_{ijt} + \varepsilon_{ijt}, \quad (3)$$

where $\varphi$ measures the effect of the weighted deviation in course enrollments taught by female faculty members on the likelihood that student *i* will take course portfolio $P_{ijt}$ in college $j$, and cohort *t* has a greater extent of exposure to female faculty members during her first term in college. Since students within a college-course portfolio who enter college during the same term will have the same value for the instrumental variable, the identification for the IV approach draws on the variation from fluctuations in departmental faculty gender compositions over time.

## IV. Results

A. Impacts on Course Performances, Subsequent Enrollments, and Employment Outcomes

*Course Performances* I first examine the impact of female instructors on female students' course performances. I estimate the impact of female instructors for both all first-term courses and first-term STEM courses. The results in Table 3.5 reported here are based on the instrumental variable combined with the course fixed effects model. In four year colleges, when taught by female instructor, female students are more likely to pass the course (as opposed to fail the class) by 8 percentage points (or 9%), and increase their course grades by 0.33 on a 4.0 scale (0.24 SD), which is approximately one letter grade up.[28] Perhaps due to much smaller sample sizes, and weaker identifying power, the impact of female faculty on current course performance in the first term STEM courses remain significant at the 10% level only for the course grades outcome, but with a larger magnitude (0.34 SD). These results are consistent with previous studies examining the impact of instructor gender on students' course grades (e.g. Carrell, Page, & West, 2010; Hoffmann & Oreopoulos, 2007).

In the setting of the current study, female students receiving higher grades in classes taught by female instructors can be due to several reasons. First, female instructors have better perceptions or expectations of female students and hence give female students better grades compared to male instructors.[29] Faculty's expectations towards students may affect the students'' perceptions about their own abilities and alter their decisions regarding human capital investment. Second, female instructors may have different pedagogical styles that better suit female students.

[28] All models present in Table 6 are results unconditional on course persistence. Students who did not persist to the end of the course are treated as if they failed the class and received a failing grade. Regressions conditional on persistence show similar patterns. These results are available upon request.

[29] A number of studies examine how teachers' demographic characteristics affect their expectations on students in the K-12 sector (e.g. Dee, 2004, 2005, 2007; Gershenson et. all, 2015), suggesting teachers generally have higher expectations towards students who have similar demographic characteristics.

Third, female students may see female faculty as role models and are extra motivated in classes taught by them. Whether or not the higher grades received by female students in classes taught by female faculty lead to actual human capital gains, a higher grade can send a positive signal and change the student's perception of their ability, consequently improving the student's subsequent performance (Diamond and Persson, 2016).

*Subsequent Enrollments and Performance* Table 3.6 presents the IV estimates of female instructors in female students' first term courses on their subsequent course enrollment and performance. The outcomes examined here include the number of subsequent credits enrolled and the GPA of all subsequent courses, and the number of subsequent credits enrolled in STEM subjects and the GPA of all subsequent STEM courses for students who declared a STEM major in their first term. These results suggest that, in four-year colleges, if a female student enrolled in more courses with female faculty during the first term, she is going to enroll in more credits and receive higher GPAs in subsequent terms, even though the impacts are not quite significant. For female students who majored in STEM subjects, a 10 percentage points increase in credits taken with female faculty increases the future number of credits enrolling in STEM courses by around half credits points (0.02SD). In two-year colleges, the proportion of credits taken with female faculty during first term does not have any significant impacts on female students' subsequent course enrollment or performance.

Results in Table 3.7 suggest that female faculty in the first term have significantly positive impacts on enrollment persistence for female students, and STEM major retention and degree completion for female STEM students in four-year colleges. For example, a 10 percentage points increase in credits taken with female faculty in the first term improves the likelihood of continual enrollment into the second academic year for female students by 1.8

percentage points (or 2%); it also increases the likelihood of still majoring in a STEM subject in the last term of enrollment by 1.6 percentage points (or 2%) and earning a STEM credential within 6 years by 1.0 percentage points (or 4%) for female students who declared a STEM major during the first term.

*Labor Market Outcomes* Table 3.8 presents the IV estimates of female instructors in female students' first term courses on the primary outcomes of interest – students' probability of employment six years after the enrollment, occupational choice for students who major in STEM subjects, and their annual earnings. The results reveal several interesting patterns. First, I find positive effects of first term female faculty on female students' likelihood of employment six years later in four-year colleges. As shown in Table 3.8, a 10 percentage points increase in first term female faculty composition corresponds to 1.7 percentage points (or 2.6%) increase in the likelihood of employment. Second, I find that greater exposure to female faculty during the first term for female students who declared STEM majors leads to higher probability of being employed in an industry with more STEM occupations. In four-year colleges, a 10 percentage points increase in first term female faculty composition can increase the probability of being employed in a STEM industry by around 2.7 percentage points (or 10%). In addition, I also find significant positive effects of first term female faculty on female student's annual earnings. A 10 percentage points increase in first term female faculty composition increases female students' annual earnings six years after the enrollment by $649 (or 0.042SD) unconditional on employment in four-year colleges.

There are a few different ways how female faculty may affect students' occupational choice and annual earnings. It could largely be due to their impact on employment itself. On the other hand, it could be that female faculty improve female students' productivity, which leads to higher levels of earnings even given an equal chance of employment. To disentangle these different effects, I estimate the impact of female faculty on female students' labor market outcomes conditional on employment. The results are presented in Column 4 and 5 of Table 3.8. The effects of female faculty on the likelihood of fulltime employment, the number of quarters being fulltime employed, and annual earnings are no longer statistically significant conditional on employment, which suggest that the impacts of female faculty on female students' labor market outcomes mostly come from their effects on being employed itself. However, the effect on being employed in STEM industries for female students majoring in STEM subjects stays statistically significant on the margin (10% level). For all female STEM majors who are employed, a 10 percentage points increase in first term female faculty composition leads to a 3.4 percentage points (or 8.6%) increase in the likelihood of working in a STEM industry.

Results presented in Table 3.8 treat the impact of female faculty on female students' labor market outcomes as linear. However, this model assumption may not hold in reality. For example, for a female student who took 3 courses during her first term, the impact of having one course with a female instructor (as opposed to having no courses with female instructors) may not be the same as the impact of having all three courses with female instructors (as opposed to having two courses with female instructors). Therefore, I estimate the impact of female faculty on labor market outcomes using two alternative ways to construct the key variable of interest. First, I estimate an "exposure effect" of female faculty, where the key independent variable is defined as having at least one female faculty during the first term. The results show that exposure to at least one female faculty increases female students' probability of employment six years later by 10 percentage points (or 15%). Second, I use an alternative way of constructing the variable of interest: it is defined as the number of courses with female faculty during the first term, instead of the proportion of credits with female faculty. The results show that having one more courses with female faculty increases the likelihood of employment by 7.2 percentage points (or 10.4%) on average. These results are policy relevant since they suggest that the marginal benefit of having a second (or third, fourth..) female instructor is substantially smaller than having at least one female instructor during the first term. Given the limited supply of female faculty in STEM fields, it may be more cost effective for colleges to ensure that female students have the minimal exposure to female faculty during their initial enrollment terms.

*Impact on Male Students* Why do female faculty have positive impacts on female students' academic and labor market outcomes?  There are two types of explanations behind these positive outcomes. On one hand, it could be because female faculty are simply more effective teachers comparing to male faculty, and they are able to improve the results for all students including both men and women. On the other hand, it could be because female faculty are particularly effective when teaching female students but they do not have any significant impact on male students. This would happen when the gender matching effect between faculty and student is positive. It is important to distinguish between the two possible mechanisms since they lead to different policy implications.

To test this, I run the same type of analyses from Table 3.5 to Table 3.8 on male student sample. The results in Table 3.4A confirm that female faculty do not have any significant impacts on male students' labor market outcomes six years after initial enrollment. These results combined show that the positive impacts of female faculty on female student are mainly due to the gender matching between faculty and students, instead of better teaching quality of female faculty.

In Panel A of Table 3.4 A, the results suggest that except for first-term course grades in four-year colleges, female faculty generally do not have any significant impacts on male students' course outcomes when they first started taking college-level courses. In courses within STEM subjects, where female faculty have the largest positive impacts on female students, male students' course outcomes are not sensitive to faculty gender. However, when looking at subsequent course enrollments and performance (Table 3.4 Panel B), female faculty have small positive impacts on the number of courses enrolled and average GPA in these courses for male students in two-year colleges. Again, for students who declared a major in STEM subjects during the first term, faculty gender composition does not affect male students' subsequent enrollment and performance. When it comes to enrollment persistence and credential completion six years after initial enrollment, as the results shown in Table 3.4 Panel C, faculty gender composition during the first term does not affect male students either overall or in STEM majors.

The labor market outcomes for male students are reported in the Panel D of Table 3.4. It again suggests that exposure to female faculty during the first term of college study does not affect male students' employment and earning outcomes six years after. All these results combined show that even though female faculty may affect male students' immediate academic outcomes such as course grades, they do not have long-run impacts on enrollment, credential completion, and labor market outcomes. This is contrast to the persistent positive impacts across various outcome measurements I find for female students who are exposed to more female faculty in four-year colleges. It implies that gender matching is more likely to be the reason behind the positive impacts.

It should be noted that gender matching could still function in a few different ways. It could be due to role model effects where female students are inspired by faculty who resemble their own characteristics, especially in STEM fields where female were historically underrepresented (Bettinger & Long, 2005). It could also be because female faculty have teaching styles that are more effective when educating women. The possibility of this mechanism is explored in the following section looking at faculty's gender specific value-added. Another reason could be that female students interact more frequently with female faculty during office hour after class or even in subsequent semesters after finishing the course. Due to data limitation, I am not able to directly test this hypothesis. But it is a meaningful direction to explore for future studies.

B. The Validity of IV and Robustness Checks

One key assumption underlying the IV estimates is that variations in faculty gender composition should not reflect departmental changes that may directly affect student learning or labor market outcomes in channels other than course enrollments with faculty of a different gender. For example, if a department is faced with decreased funding and financial constraints, the department starts to hire more female faculty, who are more likely to be part-time employed and cost less for the department in terms of salary, while at the same time reducing academic and institutional support to the students. In this case, the exclusive restriction assumption of IV estimates is violated and the results are biased. To shed light on the extent of this concern, I construct two tests. First, I examine the trend in the use of female faculty over time in each college-department combination. I do not identify any significant time trend in the majority of these combinations, indicating that the fluctuations in faculty gender composition might plausibly be idiosyncratic in the current study context.

Second, I regress the proportion of female faculty on a set of variables including the average size of a class section, the proportion of course section offered online, and the proportion of faculty who are temporary adjunct and non-tenure track, and who hold a master degree and a doctoral degree for a college-department at a particular term, as shown in Table 3.9. The results suggest that the variations of the proportion of female faculty do not correlate with other measures of faculty quality or course offerings.

One threat to the internal validity of the research design is student self-selection into course sections with different faculty gender during a particular term. As shown in Table 3.4, after controlling for college-course portfolio fixed effects, students in course sections with female faculty look fairly similar to those in male faculty sections. Nevertheless, I construct a robustness check to test the robustness of the results by dropping the course-terms for which sections are taught by instructors with different genders. As a consequence, the only remaining source of identifying variation is across terms. The results are presented in Appendix Table 3.2A and show similar patterns as the results of the instrumental variable model in Table 5.

C. Mechanism of Impacts on Employment

There are several channel through which female faculty could affect female students' employment outcome. First, they could affect credential completion, which has a direct impact on likelihood of employment and earnings; second, they could affect how much time students spent to complete the degree; third, they could affect major choice. I then examine what are the mechanisms that female faculty affect employment likelihood by controlling for the intermediate factors.

In Table 3.10, Column 1 presents the original result of impact of female faculty on the likelihood of employment six years after initial college enrollment, as shown in Table 3.8 Column 1 Panel B; Column 2 presents the result after controlling for whether the student completed a credential within six years; Column 3 presents the result after controlling for whether the student completed a credential within six years, and the number of semesters the student spent to earn that credential; and Column 4 presents the result after controlling for whether the student completed a credential within six years, the number of semesters the student spent to earn that credential, and fixed effects for the subject area of the credential earned.

I find that a fair proportion of the impacts of faculty gender on female students' employment outcomes could be explained by their influence on female students' major choices. After controlling for credential completion and the time spent to get the degree, the impact of faculty gender on female students' likelihood of employment six years after are still significant and the magnitude of the impacts only dropped by less than 7%; however, after controlling for the subject areas of the credential earned (CIP codes of the degree), the magnitude of the impacts reduced by about one third and were no longer statistically significant. This suggest that female faculty mainly affect employment outcome by altering major choice.

D. Gender Specific Value-Added

As discussed in previous sections, there are some significant differences between female and male faculty in terms of employment status. As shown in Table 3.3, female faculty are less likely to be in tenure-line positions and less likely to be employed fulltime. These are also characteristics that affect students' learning performances (Bettinger & Long, 2010; Ran & Xu, 2017) and could potentially affect students' long-term outcomes. It is important to disentangle the impacts of female faculty on labor market outcomes detected in previous sections that are due to the gender match between instructors and students or the other characteristics such as employment status that are correlated with faculty gender.

I implement a two-step process to estimate the role of faculty gender and other characteristics on their effectiveness in teaching female students. First, I estimate instructor fixed effects using a shrinkage estimator for male and female students separately.[30] I follow the method used in Kane & Staiger (2008) and Chetty, Friedman, & Rockoff (2014) to construct the empirical Bayes estimate for each instructor's value for female students. Specifically, for the employment outcome, I begin by residualizing each outcome based on regressions that control for all variables in equation (2), except for the instructor gender. In addition, I also include in the model years working as an instructor that vary over time within an instructor. Since instructors may teach multiple classes in the dataset, I then calculate the average classroom residuals for each instructor-by-class and then center all the values at the grand mean. I estimate instructor value added by forming a precision-weighted average of the average classroom residuals for each instructor, weighted by the inverse of the class-level variance. As a result, larger classes with greater sample sizes would have less variance and therefore receive greater weighting in the calculation. Finally, considering that these estimated instructor effects are noisy estimates of the true instructor value added, I implement the Bayes shrinkage by multiplying the noisy estimate of instructor value added by its reliability (or the shrinkage factor), where the reliability of a

[30] In this model, the outcome is whether the student is employed six years after the initial college enrollment term. Each observation is a student-course enrollment combination and the standard error is clustered at student- and instructor- level. Other than instructor fixed effects, the model controls for student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a resident of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned a GED, or equivalent, three indicators for whether the student was placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before the student first enrolled in college.

noisy estimate is the ratio of the between-instructor variance to the sum of between-instructor variance and the estimation error variance for a particular instructor. Through the shrinkage process, instructors with less precise estimates of the value added would thus be pulled toward the grand mean of instructor value added among all instructors.

Second, I regress the gender-specific "valued-added" on a set of instructor characteristics including their gender, race, degree attainment, academic rank, employment status, and teaching experience. As shown in Table 3.11, female instructors are more effective in increasing female students' likelihood of employment by approximately 0.18 SD than male instructors, and the positive effects of female faculty are much stronger in STEM subjects. In addition, even after controlling for other instructor characteristics, female instructors remain more effective than their male counterparts. This suggest that the positive effect of female faculty on female students' labor market outcomes are largely due to gender match itself rather than other faculty characteristics associated with gender.

## V. Conclusion

Even though women have surpassed their male counterparts in undergraduate enrollment and bachelor's degree attainment in the past few decades, the gender income gap persists. This is partly due to that fact that fewer women enter and stay in fields of study that lead to higher wages such as STEM. This is not only worrisome for income inequality today, but also has important implications for gender equity agendas and economic growth in the future, since STEM fields are projected to have the largest growth in new job openings for the next few decades (BLS, 2017). Increasing the representation of female faculty has been a common policy prescription to inspire young women to enter and stay in STEM fields. A number of studies have examined the impact of female faculty on academic achievement and major interests in college (e.g. Bettinger & Long, 2005; Carrell, Page, & West, 2010; Hoffmann & Oreopoulos, 2007). However, none of the existing studies explores the effect of female faculty on female students' occupation choice and earning outcomes. This paper intends to fill this gap in the literature.

In this study, I have discussed the impacts of faculty gender on female students' labor market outcomes. In four-year colleges, female students who take a female-faculty-heavy course load during the first term are more likely to be employed and have higher earnings six years after initial college enrollment. In addition, female students who major in STEM fields and take more credits with female faculty during the first term are more likely to be employed in an industry with more jobs classified as STEM occupations. These evidences suggest that the well-established gender-match effects are not limited to short-term academic outcomes such as test scores or course grades. Rather, they extend to labor market outcomes several years after the interaction between the instructor and the student. These results suggest that assigning female faculty to female students can help close the gender gap in STEM fields both in college and in the workforce.

The positive impacts of female faculty on labor market outcomes are only identified in four-year colleges. There are several potential reasons for the lack of effect in two-year colleges. First, previous literature found that female faculty members are particularly effective teaching high performing female students in math and science courses. It could be possible that for female students enrolling in two-year colleges who are not as academically prepared, assignment to female faculty alone is not enough to improve their academic and labor market outcomes. Second, as shown in this paper, exposure to at least one female faculty has a much stronger marginal effect compared to having additional female faculty after the first one. In the setting of the current study, female students already take two thirds of their first term courses with female faculty on average in two-year colleges. This suggests that policy makers and college administrators have to think about the heterogeneous effects of faculty-student gender match and utilize it in the most cost-effective way when there are limited supplies of female faculty in certain subject areas.

There are a few directions for future research. First, it is important to continue to explore the mechanisms through which faculty gender affect students' labor market outcomes. Previous research mentioned a few candidates on how student-instructor gender match affect learning outcomes, including role model effects (Bettinger & Long, 2005), teacher perception and expectation (e.g. Gershenson et al. 2016), and impacts on non-cognitive measures (Solanki & Xu, 2017). I discussed how faculty gender could affect students' labor market outcomes through impacts within classrooms such as course grades and subsequent course taking behaviors in this paper. However, faculty and student interactions outside the classroom could also affect students' occupation choice and employment opportunities through channels such as advising and networking. Future research could collect data on these activities to test whether gender-match effects exists for faculty and student engagement outside the classroom. Finally, it is essential to collect better labor market outcome measurements. The measurement for occupational choice in this paper is not perfect since I cannot directly observe each individual's occupation. It is possible that in industries with more jobs classified as STEM occupations, females are disproportionally more likely to be pushed away from real STEM occupations with higher pay and work in other positions such as non-technical administrative positions. Future research could collect data on occupation directly to assess whether this is the case. In addition, following earning outcomes for a longer period of time will allow researchers to examine whether the impact of faculty gender only affects early labor market outcomes or have effects on the earning trajectory for women beyond their early careers.

# FIGURES

**Figure 1.1. Number of Instructional Staff Employed in the Anonymous State College System (ASCS)**

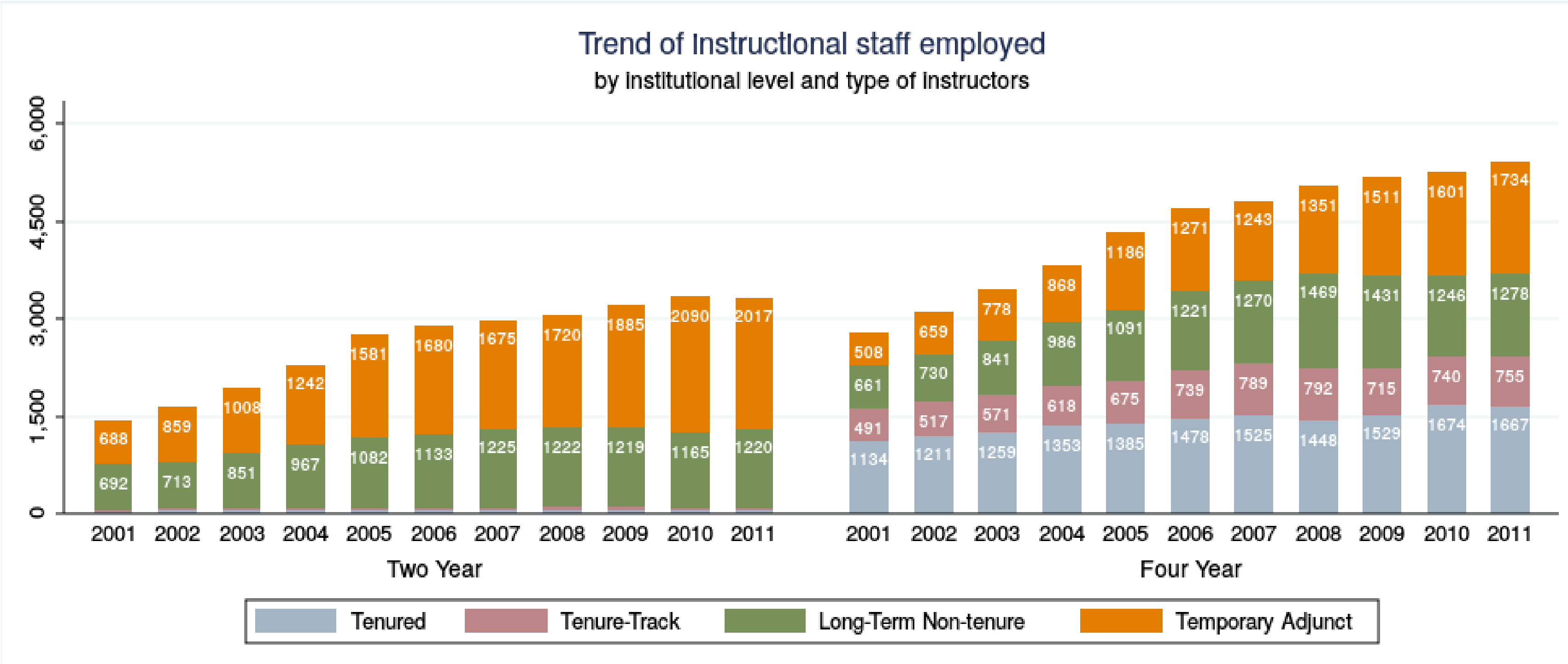


**Figure 1.2. Proportion of Contingent Faculty Employed by ASCS and Non-ASCS Positions**

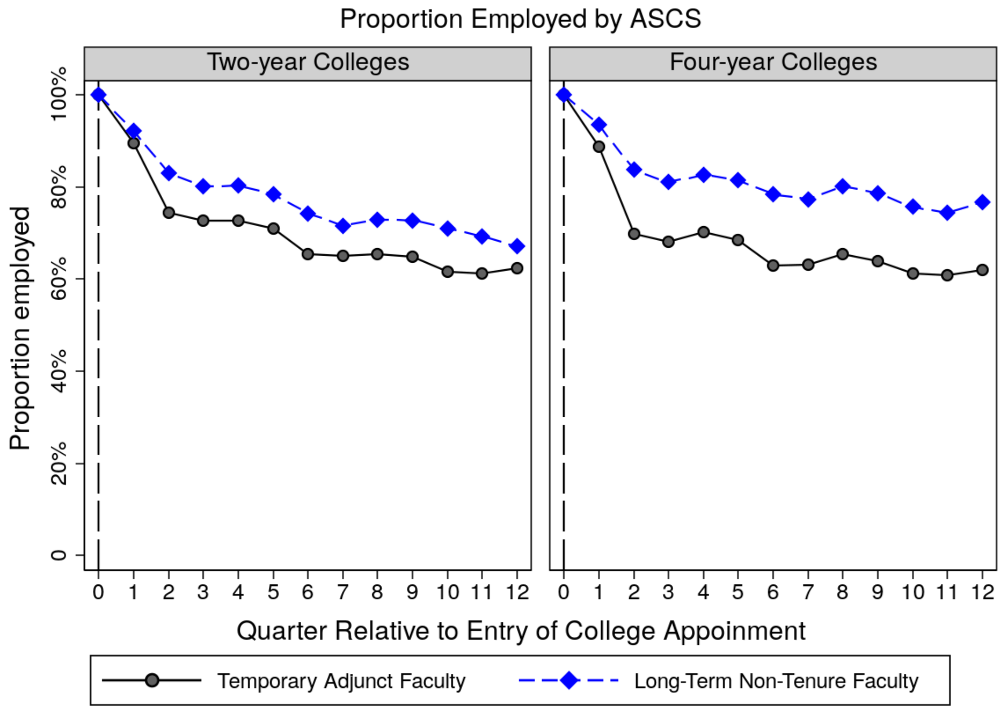
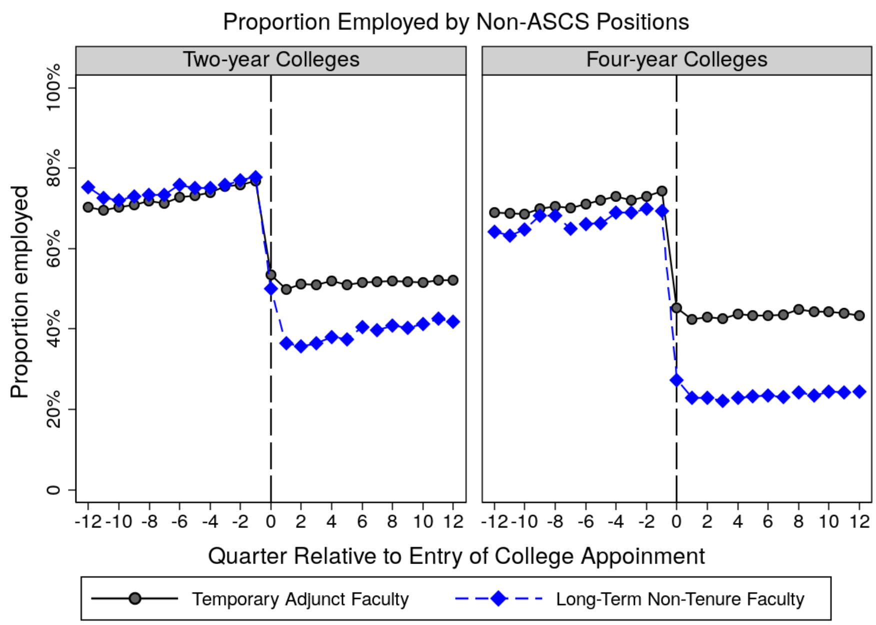


**Figure 1.3. Proportion of Contingent Faculty Employed by Non-ASCS Positions**

**Panel A. All Colleges**




**Panel B. Exclude Colleges Located in Borderline Counties**

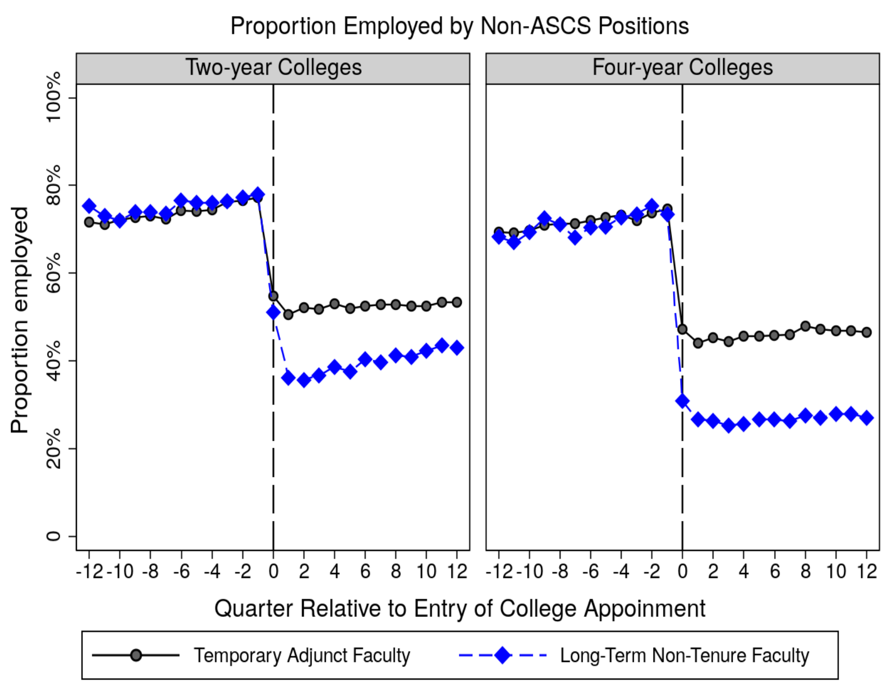


**Figure 1.4 Earning Trajectory of ASCS Contingent Faculty**

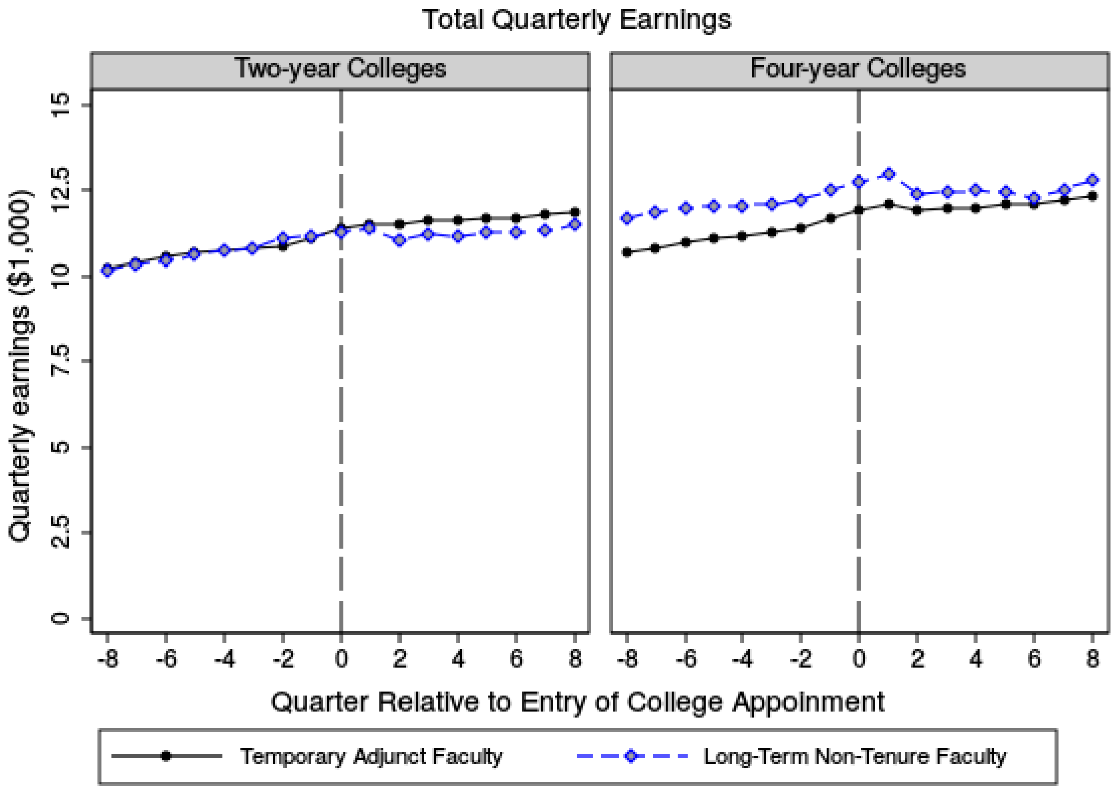


**Figure 1.5 Non-ASCS Position Earning Trajectory of Contingent Faculty**

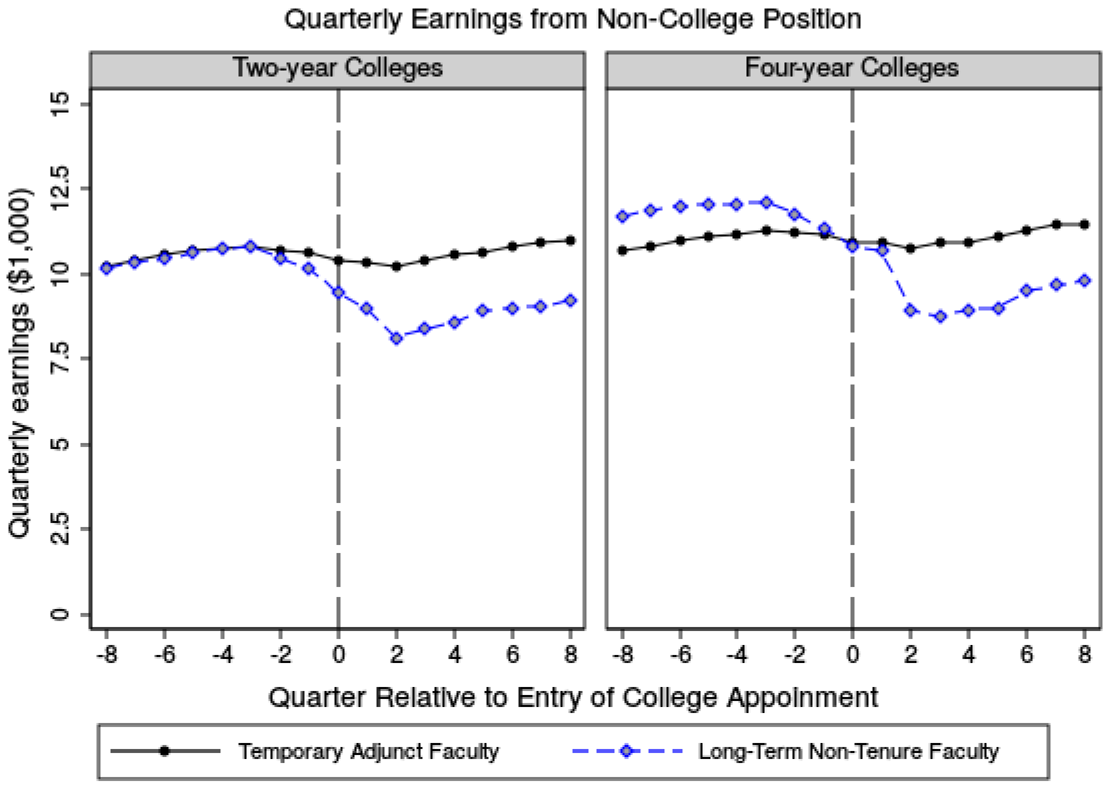
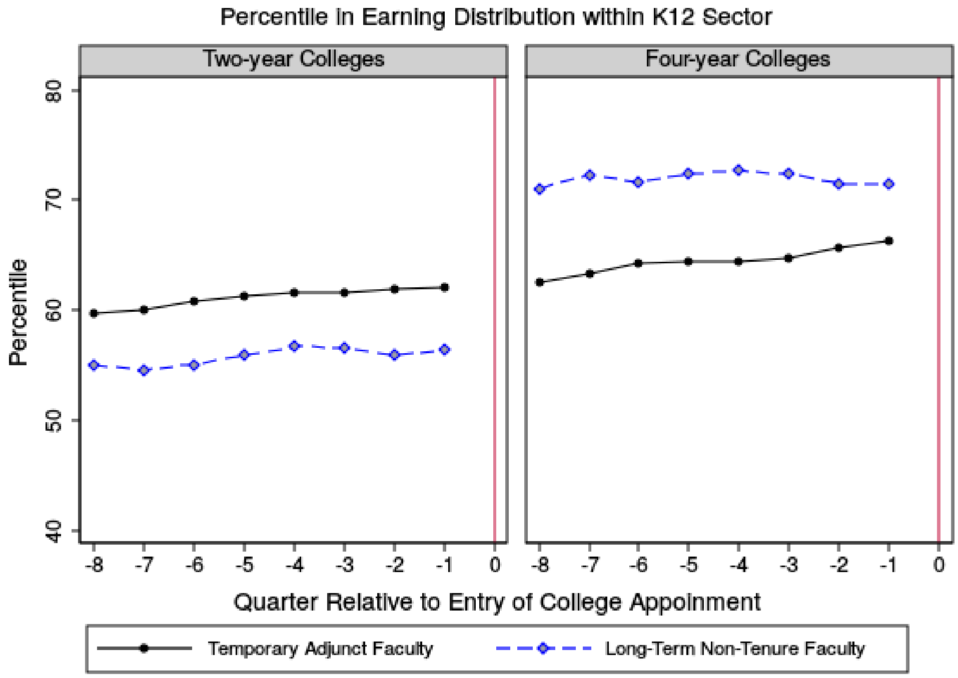


**Figure 1.6 Percentile in Industry Earning Distribution Prior to ASCS Appointment**



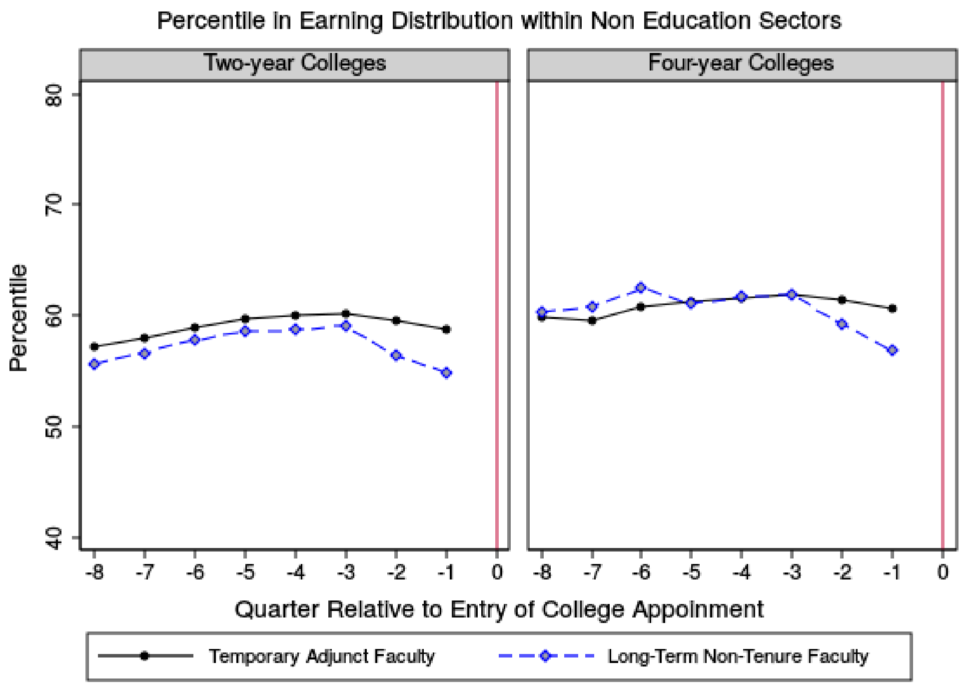
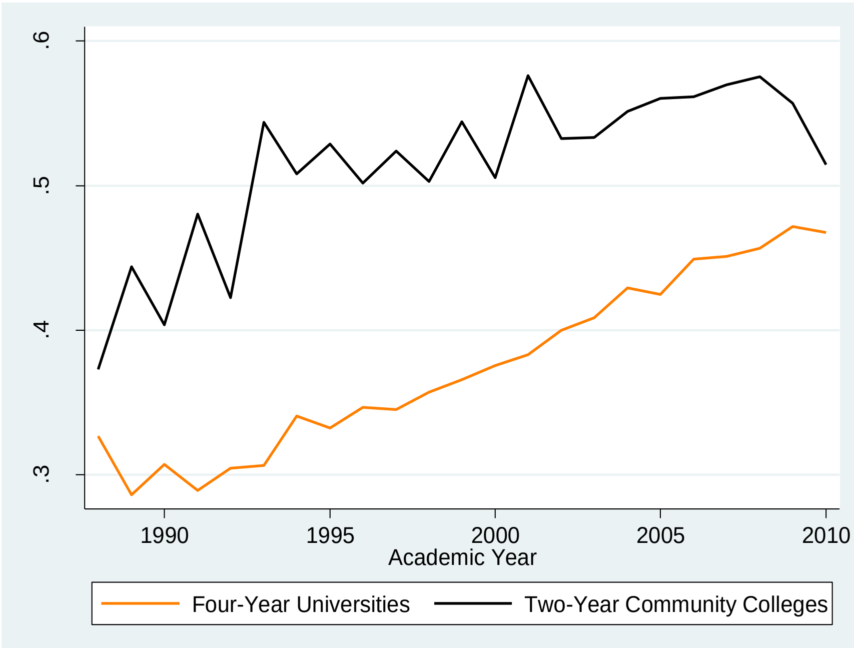



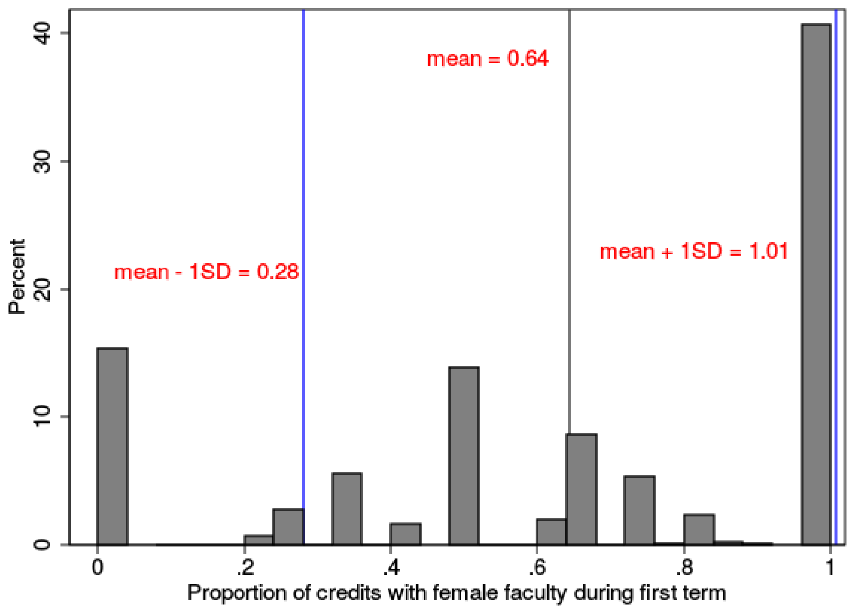
**Figure 2.1 Changes of the Proportion of Part-time Faculty in Four- and Two-year Public Higher Education Institutions between 1988 and 2010**




Data Source: IPEDS 1987-2010

Figure 3.1 Raw Distribution of the Proportion of Credits Taken with Female Instructors During the First Term

Panel A. Two-year Colleges




Panel B. Four-year Colleges

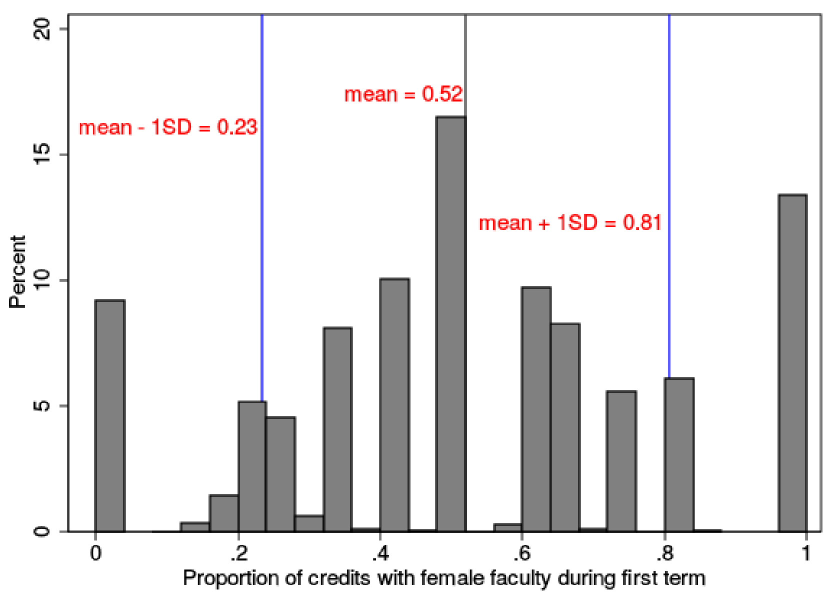
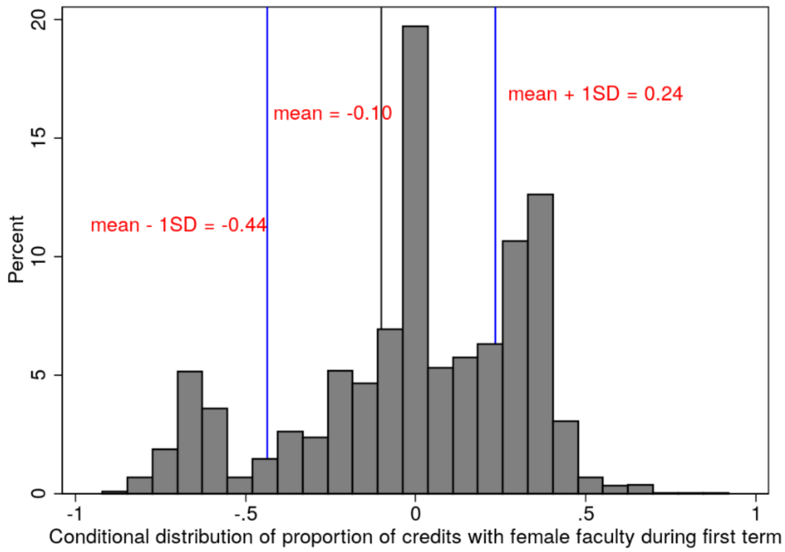


Figure 3.2 Conditional Distribution of the Proportion of Credits Taken with Female Instructors During the First Term

Panel A. Two-year Colleges




Panel B. Four-year Colleges

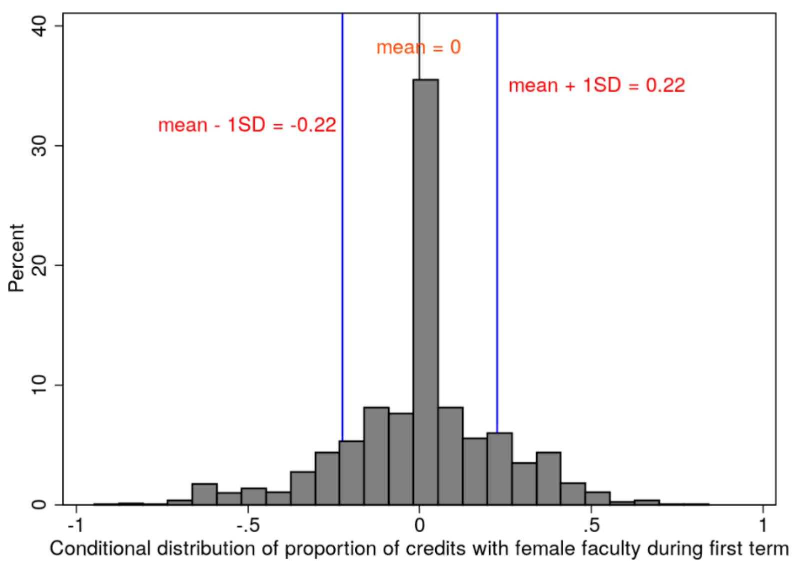
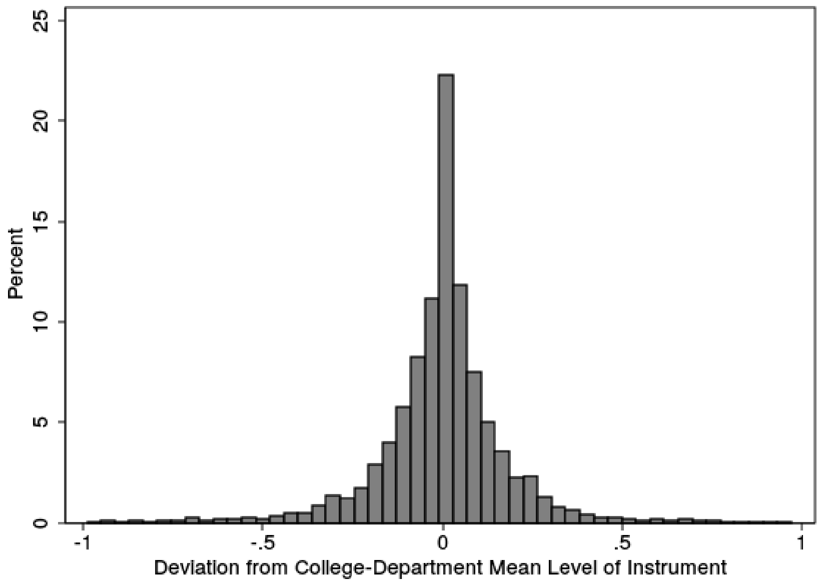
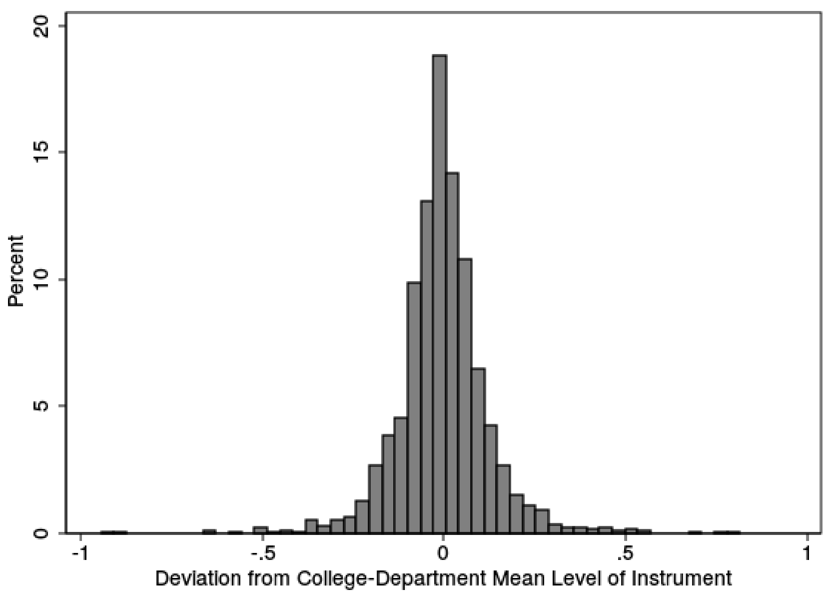


Figure 3.3 Distribution of Instrument Variable

Panel A. Two-year Colleges




Panel B. Four-year Colleges



# TABLES

Table 1.1 Institution Characteristics, 2005 Enrolling Cohort: National Sample VS. ASCS

| | National Sample | | ASCS | |
|---|---|---|---|---|
| | Public 4-Year | Public 2-Year | Public 4-Year | Public 2-Year |
| ***Panel A: Enrollment*** | | | | |
| Full-time enrollment | 8,141 | 2,352 | 5,377 | 1,011 |
| Percent of GRS cohort[a] | 16.3% | 12.7% | 16.7% | 13.3% |
| 12-month undergraduate headcount | 10,494 | 9,533 | 7,174 | 3,235 |
| Graduation rate, total cohort | 44.2% | 25.5% | 35.8% | 19.2% |
| ***Panel B: Student demographics & SES*** | | | | |
| *Percent of total enrollment that are* | | | | |
| White, non-Hispanic | 66.9% | 66.4% | 69.6% | 77.4% |
| Black, non-Hispanic | 12.9% | 13.7% | 22.9% | 18.1% |
| Hispanic | 7.0% | 9.4% | 1.5% | 2.2% |
| Asian or Pacific Islander | 4.5% | 3.7% | 1.4% | 0.9% |
| American Indian or Alaska Native | 1.1% | 1.5% | 1.2% | 0.9% |
| Race/ethnicity unknown | 4.6% | 4.5% | 1.0% | 0.5% |
| Citizenship: Non-resident Alien | 3.0% | 0.8% | 2.3% | 0.0% |
| Gender: Female | 57.1% | 59.4% | 59.3% | 63.6% |
| Financial aid: Receiving any FA | 77.9% | 65.9% | 79.4% | 84.0% |
| ***Panel C: Institution finance*** | | | | |
| Tuition and fees, 2005-06 | 5,240 | 2,129 | 4,405 | 1,732 |
| *Expenses per FTE:* | | | | |
| Instruction | 8,946 | 4,045 | 11,306 | 3,667 |
| Research | 7,322 | 14 | 4,685 | 0 |
| Public service | 1,488 | 184 | 1,323 | 187 |
| Academic support | 1,742 | 795 | 1,646 | 579 |
| Student service | 1,159 | 973 | 892 | 878 |
| Institutional support | 4,547 | 1,403 | 3,605 | 1,382 |
| Other expenses | 12,394 | 2,534 | 6,484 | 3,105 |
| *Percent of core revenues* | | | | |
| Tuition and fees | 27.4% | 18.2% | 18.1% | 12.3% |
| State appropriations | 36.2% | 35.2% | 40.2% | 42.6% |
| Local appropriations | 0.4% | 12.8% | 1.0% | 5.4% |
| ***Panel D: Average salary equated to 9-month contracts of FT instructional faculty*** | | | | |
| Professors [b] | 80,230 | 62,374 | 70,855 | 51,519 |
| Associate professors [b] | 62,656 | 52,979 | 57,919 | 44,164 |
| Assistant professors | 53,244 | 46,161 | 48,765 | 40,667 |
| Non-tenure track instructors | 42,548 | 46,341 | 37,835 | 38,763 |
| N [c] | 613 | 1055 | | |

Note: Author derived data from the IPEDS Data Center 2005 data collection. Both national and ASCS samples include public degree-granting not-for-profit institutions. All dollar figures are CPI-adjusted to 2012 dollars.
[a] GRS cohort refers to full-time, first-time degree/ certificate-seeking students.
[b] Only one two-year institution in the state system has tenure track positions.
[C] Number of institutions in ASCS not shown for anonymity.

## Table 1.2 ASCS Instructor Descriptive Statistics

| | Two Year Colleges | | Four Year Colleges | | | |
|---|---|---|---|---|---|---|
| | Temporary adjunct | Long-term non-tenure | Temporary adjunct | Long-term non-tenure | Tenure track | Tenured |
| ***Panel A: Basic Information*** | | | | | | |
| Female | 56.60% | 58.57% | 59.55% | 62.96% | 37.64% | 22.88% |
| Race: White | 87.85% | 91.58% | 85.77% | 85.27% | 78.68% | 86.57% |
| Race: Black | 10.05% | 6.62% | 7.25% | 7.66% | 6.51% | 7.31% |
| Race: Hispanic | 0.83% | 0.76% | 1.58% | 1.24% | 1.35% | 0.72% |
| Race: Asian | 0.90% | 0.66% | 2.15% | 3.21% | 8.75% | 3.96% |
| Race: Other [a] | 0.36% | 0.38% | 3.25% | 2.62% | 4.71% | 1.44% |
| Age in 2012 | 49.41 | 50.35 | 45.90 | 49.41 | 49.06 | 64.82 |
| | (12.20) | (10.86) | (12.49) | (11.56) | (10.39) | (7.83) |
| Career enders[b] | 14.69% | 4.21% | 6.84% | 3.78% | NA | NA |
| Degree attainment: Master degree[c] | 55.50% | 34.75% | 62.41% | 65.22% | 11.24% | 13.59% |
| Degree attainment: Doctor degree[c] | 6.93% | 5.32% | 15.78% | 15.30% | 88.76% | 86.41% |
| ***Panel B: Employment Information*** | | | | | | |
| Taught in more than 1 institution | 8.26% | 6.69% | 9.49% | 7.13% | 5.89% | 6.50% |
| Fulltime employed[d] | 22.16% | 63.58% | 30.15% | 68.52% | 99.23% | 94.89% |
| Total years of teaching in 2012 | 6.53 | 8.1 | 5.48 | 9.48 | 10.23 | 16.57 |
| | (5.17) | (6.01) | (4.14) | (6.19) | (6.30) | (4.80) |
| Worked in K12 sector prior to work in college | 29.15% | 22.39% | 18.34% | 6.51% | 1.22% | 0.23% |
| Worked in non-education sector prior to work in college | 71.11% | 64.48% | 47.62% | 19.91% | 3.52% | 0.58% |
| Average credit hours teaching | 7.48 | 11.28 | 6.62 | 9.66 | 11.17 | 10.45 |
| | (5.81) | (6.93) | (4.35) | (4.69) | (3.81) | (4.85) |
| ***Panel C: Earnings ($):*** | | | | | | |
| Salary per credit | 1,255 | 2,095 | 1,644 | 3,405 | 5,298 | 7,321 |
| Proportion of earning from college teaching | 47.81% | 61.90% | 54.12% | 78.87% | 96.58% | 97.97% |
| Annual earnings from the college | | | | | | |
| percentile: 10th | 1,643 | 2,232 | 1,914 | 6,022 | 37,799 | 53,426 |
| percentile: 25th | 3,142 | 6,943 | 4,001 | 20,529 | 47,076 | 65,131 |
| percentile: 50th | 7,726 | 29,571 | 10,944 | 37,749 | 60,262 | 79,708 |
| percentile: 75th | 27,251 | 43,550 | 31,791 | 52,619 | 76,971 | 99,577 |
| percentile: 90th | 46,379 | 56,542 | 49,482 | 69,505 | 96,227 | 127,968 |
| Annual earnings from other jobs | | | | | | |
| percentile: 10th | 0 | 0 | 0 | 0 | | |
| percentile: 25th | 718 | 0 | 0 | 0 | | |
| percentile: 50th | 21,536 | 12,198 | 13,474 | 0 | NA | NA |
| percentile: 75th | 41,787 | 34,616 | 37,551 | 19,529 | | |
| percentile: 90th | 57,737 | 49,649 | 57,078 | 44,314 | | |
| N | 3,728 | 1,211 | 3,064 | 2,320 | 1,562 | 861 |

Note: Data include instructors who have taught at least one course between fall 2005 to summer 2012 in ASCS. Standard deviation in parenthesis. All dollar figures are CPI-adjusted to 2012 dollars.
[a] The other race and ethnic groups include American Indian, Pacific Islander, multiple race, and unknown.
[b] Career enders refer to people who first started in a college instructor position when 55 or older.
[c] Reference category for degree attainment is bachelor's degree.
[d] Full-time employed defined as worked as full-time instructor during at least half of the terms employed in the institution.

## Table 1.3 Proportion of Student Course Enrollments by Type of Faculty and Department

| | Two-year Colleges | | Four-year Colleges | | |
|---|---|---|---|---|---|
| | Temporary Adjunct | N | Temporary Adjunct | Long-term non-tenure track | N |
| **STEM** | **39.2%** | **96,216** | **15.6%** | **48.1%** | **186,897** |
| Math | 32.9% | 24,909 | 11.8% | 65.7% | 49,492 |
| Science | 38.6% | 32,553 | 12.3% | 43.0% | 90,286 |
| Computer, Information, and Engineering | 38.2% | 23,157 | 23.7% | 35.8% | 26,535 |
| Allied Health and Nursing | 51.8% | 15,597 | 28.4% | 44.1% | 20,584 |
| | | | | | |
| **Non-STEM** | **50.3%** | **243,385** | **24.0%** | **37.7%** | **507,499** |
| English | 47.3% | 38,964 | 29.7% | 45.1% | 60,590 |
| Other Humanities | 56.4% | 50,961 | 22.3% | 42.2% | 150,175 |
| Economics, Business, and Marketing | 40.3% | 25,434 | 12.6% | 44.8% | 38,847 |
| Social Science | 51.5% | 85,553 | 23.2% | 28.2% | 191,085 |
| Education | 62.9% | 12,942 | 34.4% | 48.9% | 41,228 |
| CTE | 43.0% | 29,532 | 27.3% | 36.0% | 25,573 |

Note: Data include all student course enrollments in college-level credit-bearing courses at ASCS between 2005 fall and 2012 summer. The unit is at one record per student-course-section.

**Table 1.4 Faculty Descriptive Statistics by Subject Areas**

Panel A. Two-year Colleges

| | STEM | | Non STEM | |
|---|---|---|---|---|
| | Adjunct | Long-term non tenure | Adjunct | Long-term non tenure |
| Female | 55.7% | 55.3% | 56.5% | 52.6% |
| Race | | | | |
| 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% |
| Degree | | | | |
| 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 |
| | (12.8) | (11.6) | (12.3) | (11.7) |
| More than 1 institution | 2.4% | 1.3% | 1.2% | 1.5% |
| Fulltime | 64.9% | 72.9% | 72.0% | 77.1% |
| Worked in K12 | 18.2% | 9.9% | 21.0% | 12.2% |
| Worked in non education sector | 48.5% | 35.3% | 42.9% | 26.2% |
| Credit hours | 7.7 | 14.0 | 7.5 | 13.6 |
| | (6.7) | (9.4) | (7.2) | (9.1) |
| Earnings from college | 19,161 | 44,599 | 19,596 | 40,391 |
| Earnings from other job | 24,058 | 7,300 | 18,960 | 7,287 |
| N | 1,073 | 852 | 2,786 | 1,549 |

Panel B. Four-year Colleges

| | STEM | | | Non STEM | | |
|---|---|---|---|---|---|---|
| | Adjunct | Long-term non tenure | Regular | Adjunct | Long-term non tenure | Regular |
| 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% |
| Degree[b] | | | | | | |
| 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 | 50.0 | 43.5 | 45.0 | 50.5 |
| | (12.7) | (12.2) | (11.0) | (12.8) | (12.3) | (11.5) |
| More than 1 institution | 2.1% | 1.0% | 1.9% | 1.3% | 1.0% | 1.3% |
| Fulltime employed[c] | 80.7% | 87.2% | 87.9% | 84.8% | 91.3% | 91.4% |
| Worked in K12 | 15.4% | 7.6% | 1.0% | 16.4% | 8.6% | 1.1% |
| Worked in non education sector | 44.4% | 27.3% | 4.5% | 41.3% | 22.6% | 2.5% |
| Credit hours | 6.6 | 11.4 | 11.4 | 6.8 | 10.6 | 11.3 |
| | (5.6) | (6.4) | (6.9) | (5.5) | (5.9) | (5.6) |
| Earnings from college | 22,701 | 48,660 | 80,748 | 23,557 | 42,496 | 75,140 |
| Earnings from other job | 19,114 | 3,394 | 1,126 | 13,298 | 4,220 | 557 |
| N | 648 | 631 | 978 | 1,956 | 1,761 | 2,263 |

Notes: Data include instructors in the analytic sample, who has taught at least one course between fall 2005 to summer 2012.
[a] The rest includes American Indian, Pacific Islander, multiple race, and unknown.
[b] Reference category for degree attainment is bachelor's degree or below.
[c] Full-time employed defined as worked as full-time instructor during more than half of the terms employed in the institution.

**Table 1.5 Employment before ASCS Appointment by Industry**

| % | Two-year Colleges | | Four-year Colleges | |
|---|---|---|---|---|
| | Temporary Adjunct | Long-term Non tenure track | Temporary Adjunct | Long-term Non tenure track |
| K-12 | 33.12 | 24.97 | 29.58 | 24.67 |
| Health care and social assistance | 19.94 | 31.64 | 24.83 | 25.69 |
| Retail trade | 7.85 | 5.61 | 8.32 | 8.85 |
| Public administration | 6.84 | 6.14 | 6.16 | 2.18 |
| Manufacturing | 5.18 | 6.54 | 4.24 | 5.08 |
| Professional, Scientific, and Technology | 5.04 | 4.14 | 6.9 | 10.16 |
| Other | 22.03 | 20.96 | 19.97 | 23.37 |

Note: Data used to create this table includes temporary adjunct and long-term non-tenure instructors who had earning records in non-college positions before they started college teaching positions in my UI database. Contingent faculty excluded from this table include: 1) temporary adjunct and long-term non-tenure instructors who had never worked in non-college positions before they started teaching in a college (13% of all non-tenure track faculty in two-year and 36% in four-year); and 2) temporary adjunct and long-term non-tenure instructors who worked in non-college positions before 2001 and therefore could not be observed in the labor market dataset available to us (26% of all non-tenure track faculty in two-year and 30% in four-year).

**Table 1.6 Top Industries of Employment Among Non-Tenure-Track Faculty before ASCS Appointments**

| Two Year Colleges | | Four Year Colleges | |
|---|---|---|---|
| ***Humanities*** | ***521*** | ***Humanities*** | ***457*** |
| Elementary and Secondary Schools | 34.74% | Elementary and Secondary Schools | 22.98% |
| Health care and Social Assistance | 8.02% | Junior Colleges | 3.50% |
| Retail Trade | 6.75% | Newspaper Publishers | 3.06% |
| | | | |
| ***Social Sciences*** | ***381*** | ***Social Sciences*** | ***227*** |
| Elementary and Secondary Schools | 19.69% | Elementary and Secondary Schools | 19.63% |
| Health care and Social Assistance | 23.55% | General Medical and Surgical Hospitals | 5.48% |
| Public Administration | 6.10% | Other Individual and Family Services | 5.48% |
| | | Outpatient Mental Health and Substance Abuse Center | 5.02% |
| | | | |
| ***Math/Natural Science*** | ***335*** | ***Math/Natural Science*** | ***179*** |
| Elementary and Secondary Schools | 30.15% | Elementary and Secondary Schools | 27.93% |
| General Medical and Surgical Hospitals | 6.27% | General Medical and Surgical Hospitals | 6.15% |
| | | | |
| ***Computer, Information, and Engineering*** | ***291*** | ***Computer, Information, and Engineering*** | ***162*** |
| Elementary and Secondary Schools | 11.68% | Elementary and Secondary Schools | 8.02% |
| | | Junior Colleges | 7.41% |
| | | | |
| ***Health*** | ***527*** | ***Health*** | ***400*** |
| General Medical and Surgical Hospitals | 46.49% | General Medical and Surgical Hospitals | 49.75% |
| Offices of Physicians | 6.64% | Offices of Physicians | 6.25% |
| Ambulance Services | 4.93% | Offices of Dentists | 3.50% |
| Elementary and Secondary Schools | 3.80% | | |
| Nursing Care Facilities | 2.28% | | |
| | | | |
| ***Business*** | ***323*** | ***Business*** | ***194*** |
| Elementary and Secondary Schools | 10.12% | Commercial Banking | 6.45% |
| Warehouse Clubs and Supercenters | 4.33% | Offices of Lawyers | 5.38% |
| Commercial Banking | 3.41% | | |
| | | | |
| ***Education and Childcare*** | ***224*** | ***Education and Childcare*** | ***316*** |
| Elementary and Secondary Schools | 52.68% | Elementary and Secondary Schools | 65.51% |
| | | | |
| ***Other*** | ***719*** | ***Other*** | ***403*** |
| Elementary and Secondary Schools | 14.05% | Elementary and Secondary Schools | 15.14% |
| Executive and Legislative Offices | 8.48% | Junior Colleges | 5.71% |
| Offices of Lawyers | 2.78% | Executive and Legislative Offices | 5.71% |

Note: Data used to create this table includes temporary adjunct and long-term non-tenure instructors who had earning records in non-college positions before they started college teaching positions in my UI database. Non-tenure track faculty excluded from this table include: 1) temporary adjunct and long-term non-tenure instructors who had never worked in non-college positions before they started teaching in a college (13% of all non-tenure track faculty in two-year and 36% in four-year); 2) temporary adjunct and long-term non-tenure instructors who worked in non-college positions before 2001 and therefore could not be observed in the labor market dataset available to us (26% of all non-tenure track faculty in two-year and 30% in four-year). Finally, any industries with fewer than 10 instructors are not presented in the Table.

**Table 2.1 Student Descriptive Statistics, Starting Cohort 2005 - 2010**

| | Two Year Colleges | Four Year Colleges |
|---|---|---|
| Female | 56.19% | 53.22% |
| Age when started | 24.28 | 19.45 |
| | (8.58) | (3.96) |
| Race | | |
| White | 72.29% | 70.94% |
| Black | 21.75% | 20.42% |
| Hispanic | 3.75% | 2.62% |
| Asian | 1.14% | 1.89% |
| High school diploma | 75.16% | 92.72% |
| High school GPA | 2.71 | 3.20 |
| | (0.60) | (0.58) |
| Enter in fall term | 67.53% | 89.66% |
| Placed as college ready in | | |
| Math | 26.20% | 65.55% |
| English | 49.73% | 75.96% |
| Reading | 58.05% | 78.19% |
| Taken remedial courses | 64.68% | 40.21% |
| N | 68,692 | 87,212 |

Note: Data include students in the analytic sample, who first enrolled in any of the institution in the ASCS and took at least one college-level course between fall 2005 and summer 2012. Standard deviation in parentheses.

**Table 2.2 Course Descriptive Statistics, Academic Year (AY) 2005 - 2012**

| | Two-year colleges | | Four-year Colleges | | | |
|---|---|---|---|---|---|---|
| | Temporary adjunct | Long-term non-tenure | Temporary adjunct | Long-term non-tenure | Tenure track | Tenured |
| ***Panel A. Course-section characteristics*** | | | | | | |
| Face to face section | 75.35% | 85.07% | 93.06% | 94.58% | 91.94% | 93.19% |
| Number of credits for the course | 3.02 | 3.00 | 2.89 | 2.88 | 2.96 | 2.94 |
| | (0.51) | (0.76) | (0.64) | (0.68) | (0.62) | (0.69) |
| Class size | 20.51 | 22.32 | 43.89 | 58.20 | 46.46 | 62.38 |
| | (7.26) | (9.25) | (45.60) | (75.46) | (36.98) | (68.21) |
| Observations | 90,507 | 234,376 | 140,577 | 307,704 | 97,088 | 185,039 |
| **Panel B.** ***Contemporaneous course outcomes*** | | | | | | |
| Persisted to the end of the course | 83.96% | 83.38% | 92.14% | 91.29% | 90.18% | 90.04% |
| Pass the course | 72.03% | 71.98% | 82.21% | 81.70% | 80.30% | 79.38% |
| Earned a C or better in the course | 67.26% | 66.86% | 77.86% | 76.47% | 74.11% | 73.23% |
| Course grade given persistence (0 to 4 grading scale) | 2.68 | 2.61 | 2.84 | 2.76 | 2.65 | 2.61 |
| | (1.39) | (1.35) | (1.29) | (1.28) | (1.27) | (1.28) |
| Observations | 90,507 | 234,376 | 140,577 | 307,704 | 97,088 | 185,039 |
| **Panel C.** ***Subsequent outcomes*** | | | | | | |
| *Student-field outcomes* | | | | | | |
| Took additional course in the same field | 36.05% | 38.63% | 40.44% | 44.85% | 43.04% | 43.84% |
| Took additional course and pass in the same field | 25.62% | 28.49% | 32.76% | 37.06% | 36.22% | 36.83% |
| Observations | 90,507 | 234,376 | 140,577 | 307,704 | 97,088 | 185,039 |
| *Student-Next Class Outcomes* | | | | | | |
| Persisted to the end of the course | 82.84% | 84.20% | 89.95% | 90.13% | 90.88% | 91.00% |
| Pass the next course in the subject | 70.78% | 73.88% | 80.46% | 81.66% | 83.59% | 83.41% |
| Earned a C or better in the next course | 65.61% | 68.47% | 74.21% | 74.72% | 76.91% | 76.78% |
| Course grade given persistence (0 to 4 grading scale) | 2.61 | 2.65 | 2.72 | 2.72 | 2.77 | 2.77 |
| | (1.39) | (1.33) | (1.30) | (1.27) | (1.23) | (1.24) |
| Observations | 33,562 | 95,001 | 54,984 | 131,712 | 38,635 | 81,148 |

Note: The contemporaneous course sample is restricted to the first college-level course taken by each student in each field of study. We exclude courses with pass/fail grades. Standard deviation in parentheses.

**Table 2.3 Probability of Taking an Introductory Course with Different Types of Instructors**

| | Two Year Colleges | Four Year Colleges | | |
|---|---|---|---|---|
| | Temporary adjunct | Temporary adjunct | Tenure track | Tenured |
| *Demographics:* | | | | |
| Female | 0.0004 | 0.0050*** | -0.0009 | -0.0033*** |
| | (0.0020) | (0.0010) | (0.0007) | (0.0009) |
| Race[a]: Asian | 0.0087 | -0.0007 | -0.0033 | 0.0046 |
| | (0.0056) | (0.0030) | (0.0020) | (0.0031) |
| Race[a]: Black | 0.0108*** | -0.0086*** | 0.0017 | 0.0040** |
| | (0.0036) | (0.0023) | (0.0014) | (0.0018) |
| Race[a]: Hispanic | 0.0038 | 0.0001 | 0.0032 | -0.0035 |
| | (0.0034) | (0.0024) | (0.0022) | (0.0027) |
| Race[a]: Other race | -0.0025 | -0.0016 | 0.0036 | -0.0029 |
| | (0.0054) | (0.0043) | (0.0028) | (0.0033) |
| Age when taking the course | 0.0004*** | 0.0021*** | -0.0007*** | -0.0009*** |
| | (0.0001) | (0.0003) | (0.0001) | (0.0002) |
| Residence of the state | -0.0026 | 0.0046 | -0.0045* | -0.0002 |
| | (0.0038) | (0.0037) | (0.0026) | (0.0028) |
| *High School Attributes* | | | | |
| Earned high school diploma | 0.0016 | 0.0097** | 0.0028 | -0.0039 |
| | (0.0031) | (0.0041) | (0.0026) | (0.0037) |
| Earned GED or equivalent | 0.0053 | 0.0163*** | -0.0011 | -0.0057 |
| | (0.0038) | (0.0048) | (0.0046) | (0.0043) |
| High school GPA | 0.0020*** | 0.0002 | 0.0005 | -0.0013 |
| | (0.0007) | (0.0008) | (0.0007) | (0.0008) |
| *Placement Test Information* | | | | |
| Placed as college ready in math | 0.0010 | -0.0006 | 0.0022** | 0.0008 |
| | (0.0017) | (0.0016) | (0.0010) | (0.0015) |
| Placed as college ready in English | -0.0002 | 0.0010 | 0.0005 | 0.0010 |
| | (0.0016) | (0.0018) | (0.0011) | (0.0014) |
| Placed as college ready in reading | 0.0002 | -0.0018 | -0.0006 | 0.0010 |
| | (0.0015) | (0.0015) | (0.0010) | (0.0014) |
| Entered in fall term | 0.0010 | -0.0030 | -0.0010 | 0.0021 |
| | (0.0016) | (0.0021) | (0.0014) | (0.0018) |
| *College Enrollment Information* | | | | |
| Enrolled as fulltime student in first term | -0.0142*** | -0.0070*** | 0.0029** | 0.0057*** |
| | (0.0024) | (0.0020) | (0.0011) | (0.0014) |
| First term degree seeking | -0.0017 | -0.0046** | -0.0012 | -0.0009 |
| | (0.0025) | (0.0023) | (0.0011) | (0.0018) |
| Degree intent[b]: Bachelor's degree | 0.0164 | -0.0071 | 0.0040 | 0.0106** |
| | (0.0102) | (0.0044) | (0.0049) | (0.0050) |
| Degree intent[b]: Associate degree | 0.0032 | 0.0129* | -0.0191*** | -0.0091 |
| | (0.0034) | (0.0076) | (0.0064) | (0.0064) |
| Degree intent[b]: Transfer | -0.0072 | -0.0039 | 0.0034 | 0.0085 |
| | (0.0044) | (0.0076) | (0.0064) | (0.0074) |
| Degree intent[b]: Certificate | -0.0029 | 0.0534 | -0.0281*** | -0.0392*** |
| | (0.0051) | (0.0401) | (0.0086) | (0.0133) |
| Degree intent[b]: Technical certificate | 0.0004 | 0.0436*** | -0.0326*** | -0.0467*** |
| | (0.0042) | (0.0142) | (0.0071) | (0.0104) |

| | | | | |
|---|---|---|---|---|
| *Course-section Characteristics* | | | | |
| Credit hours | -0.0071 | -0.0075 | 0.0005 | 0.0170*** |
| | (0.0332) | (0.0046) | (0.0011) | (0.0063) |
| Face to face section | -0.0481*** | 0.0373** | 0.0130 | -0.0652*** |
| | (0.0114) | (0.0152) | (0.0090) | (0.0126) |
| Enrollment size | -0.0038*** | -0.0007*** | 0.0000 | 0.0007*** |
| | (0.0005) | (0.0002) | (0.0001) | (0.0002) |
| Observations | 324,883 | 730,408 | 730,408 | 730,408 |
| R-squared | 0.6299 | 0.5236 | 0.5679 | 0.5618 |

Note: All regressions control for high school fixed effects, college-course-term fixed effects, cohort fixed effects, and fixed effects for declared major upon initial college enrollment. The base group for regressions in both two-year and four-year colleges are long-term non-tenure faculty. Standard errors are clustered at college level due to multiple observations within a college. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

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

[b] Base group for degree intent is seeking other credential such as diploma.

**Table 2.4 Impact of Different Types of Instructors on Introductory Course Performance**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Persist to the end of the course | Pass the course | Grade | Persist to the end of the course | Pass the course | Grade |
| Temporary adjunct | 0.0123***<br>(0.0027) | 0.0183***<br>(0.0033) | 0.1351***<br>(0.0161) | 0.0129***<br>(0.0020) | 0.0226***<br>(0.0029) | 0.1572***<br>(0.0170) |
| Tenure track instructor | | | | -0.0057**<br>(0.0029) | -0.0137***<br>(0.0042) | -0.0998***<br>(0.0211) |
| Tenured instructor | | | | -0.0135***<br>(0.0025) | -0.0217***<br>(0.0036) | -0.1702***<br>(0.0168) |
| Sample mean | 0.84 | 0.72 | 2.19<br>(1.58) | 0.91 | 0.81 | 2.47<br>(1.45) |
| Observations | 324,883 | 324,883 | 324,883 | 730,408 | 730,408 | 730,408 |
| R-squared | 0.4158 | 0.5031 | 0.5842 | 0.3196 | 0.4473 | 0.5924 |

Note: Base group for both two-year and four-year colleges are long-term non-tenure faculty. All models control for student individual fixed effects and college-course fixed effects. Other controls for all models include the student's age when taking the introductory course in a specific field, course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, other students' average high school GPA in the course section, as well as whether the course is within student's declared major with an indicator for missing major declaration. Standard errors are two-way clustered at the student and college-subject level. Classes on pass fail grading system are excluded. Robust standard errors in parentheses:*** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table 2.5 Impact of Different Types of Instructors in Introductory Courses on Subsequent Enrollment in the Subject Area**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | | | Two-year colleges | | | | Four-year colleges | |
| | Take additional course | Take additional course and pass | Average pass rate of the next course | Average grade of the next course | Take additional course | Take additional course and pass | Average pass rate of the next course | Average grade of the next course |
| Temporary adjunct | -0.0162*** | -0.0107*** | 0.0036 | 0.0125** | -0.0169*** | -0.0164*** | 0.0011 | 0.0118*** |
| | (0.0039) | (0.0034) | (0.0027) | (0.0061) | (0.0034) | (0.0034) | (0.0013) | (0.0041) |
| Tenure track instructor | | | | | 0.0103** | 0.0099** | -0.0006 | -0.0044 |
| | | | | | (0.0043) | (0.0040) | (0.0016) | (0.0054) |
| Tenured instructor | | | | | 0.0145*** | 0.0123*** | -0.0013 | -0.0116** |
| | | | | | (0.0048) | (0.0045) | (0.0013) | (0.0046) |
| Sample mean | 0.37 | 0.27 | 0.73 | 2.23 | 0.43 | 0.36 | 0.81 | 2.44 |
| | | | | (0.59)[a] | | | | (0.62)[a] |
| Observations | 324,883 | 324,883 | 128,563 | 128,563 | 730,408 | 730,408 | 306,479 | 306,479 |
| R-squared | 0.4064 | 0.3752 | 0.5167 | 0.6023 | 0.3745 | 0.3510 | 0.4792 | 0.6418 |

Note: [a] Standard deviation of analytic sample mean in parentheses.
The base group for all regressions is long-term non-tenure faculty. All models control for student individual fixed effects and college-introductory course fixed effects. Other controls include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are two-way clustered at the student and college-subject level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

**Table 2.6 Impact of Different Types of Instructors in First Semester on Persisting into the 2nd Term**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year Colleges | | | Four-year Colleges | | |
| | OLS | College-course-set FE | College-course-set FE + IV | OLS | College-course-set FE | College-course-set FE + IV |
| | Outcome: Persistence into the 2nd academic term | | | | | |
| *Key Predictors: % of credits taken with different type of faculty during the 1st term (*multiplied by 10) | | | | | | |
| Temporary adjunct | -0.0032 | -0.0012 | -0. 0140*** | -0. 0030* | -0. 0005 | -0. 0015 |
| | (0.0029) | (0.0001) | (0. 0053) | (0. 0016) | (0. 0009) | (0.0024) |
| Tenure track instructor | | | | 0. 0005 | 0. 0007 | 0.0013 |
| | | | | (0. 0010) | (0. 0016) | (0. 0044) |
| Tenured instructor | | | | -0. 0007 | -0. 0013 | -0.0037 |
| | | | | (0. 0008) | (0. 0009) | (0. 0038) |
| Sample mean | | 0.60 | | | 0.79 | |
| Observations | 68,692 | 68,692 | 68,692 | 87,212 | 87,212 | 87,212 |
| R-squared | 0.0831 | 0.0739 | 0.0494 | 0.0800 | 0.0742 | 0.0731 |
| Student characteristics | YES | YES | YES | YES | YES | YES |
| College-course-set FE | | YES | YES | | YES | YES |

Note: The base group for all regressions is long-term non-tenure faculty. All models control for student characteristics listed in Table 5. The college-course set FE models control for the fixed effects for the set of courses student took in the first term of enrollment. For example, one course set could be Econ 101 and Math 101 in College A; another course set could be English 101, Math 101, and Biology 101 in College B. The instrumental variable (IV) is defined as term-by-term fluctuations of faculty composition in each department, weighted by the number of credits enrolled in each department during a student's initial term in college. Standard errors are clustered at the college level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

**Table 2.7 Impact of Different Types of Instructors in Introductory Courses on Subsequent Course Grades in the Subject Area**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Persist to the end of the course | Pass the course | Grade | Persist to the end of the course | Pass the course | Grade |
| Temporary adjunct | 0.0049<br>(0.0053) | -0.0003<br>(0.0056) | -0.0200<br>(0.0176) | -0.0035<br>(0.0022) | -0.0075***<br>(0.0027) | -0.0230***<br>(0.0088) |
| Tenure track instructor | | | | 0.0023<br>(0.0022) | -0.0010<br>(0.0027) | -0.0031<br>(0.0087) |
| Tenured instructor | | | | 0.0018<br>(0.0026) | 0.0045<br>(0.0033) | 0.0162<br>(0.0102) |
| Sample mean | 0.84 | 0.73 | 2.21<br>(1.57) [a] | 0.90 | 0.82 | 2.48<br>(1.45) [a] |
| Observations | 128,563 | 128,563 | 128,563 | 306,479 | 306,479 | 306,479 |
| R-squared | 0.7427 | 0.7783 | 0.8284 | 0.5556 | 0.6297 | 0.7460 |

Note: [a] Standard deviation of analytic sample mean in parentheses.
The base group for all regressions is long-term non-tenure faculty. All models control for student individual fixed effects, college-introductory course fixed effects, and next-college-course-section fixed effects. Other controls for all models include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are two-way clustered at the student and college-subject level. Robust standard errors in parentheses:*** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table 2.8 Impact of Different Types of Instructors in Introductory Courses on Subsequent Course Enrollment and Grades in the Subject Area – Alternative Identification Strategy with Instrumental Variables**

| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
|---|---|---|---|---|---|---|
| | | *Two-year Colleges* | | | *Four-year Colleges* | |
| Outcome | Grade in introductory courses | Take additional class | Grade in next course in the subject | Grade in introductory courses | Take additional class | Grade in next course in the subject |
| Temporary adjunct | 0.0494 | -0.1196*** | -0.2229 | 0. 5087*** | -0.3199*** | -0.0332 |
| | (0.0842) | (0.0410) | (0.3634) | (0.1333) | (0.0528) | (0.1054) |
| Tenure track instructor | | | | -0. 2245** | 0.0865 | 0.1655 |
| | | | | (0.1104) | (0.0631) | (0.1618) |
| Tenured instructor | | | | -0. 1196 | 0.0432 | -0.0864 |
| | | | | (0. 1031) | (0.0520) | (0.0970) |
| Observations | 324,883 | 324,883 | 128,563 | 730,408 | 730,408 | 306,479 |
| R-squared | 0.1549 | 0.1726 | 0.4919 | 0.2715 | 0.1907 | 0.4605 |
| College-intro-course FE | YES | YES | YES | YES | YES | YES |
| Next-college-course-section FE | | | YES | | | YES |

Note: The base group for all regressions is long-term non-tenure faculty. All regressions control for students' characteristics listed in Table 5. The instrumental variable (IV) 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 proportion of course sections offered by that particular type of instructor between 2005 and 2012, weighted by the number of credits enrolled for each course. Standard errors are clustered at the college level: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table 2.9 Impact of Introductory Course Professor on Current Course Grades using Empirical Bayes Estimator (Instructor Value-added)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Two-Year Colleges | | Four-year Colleges | |
| Temporary adjunct | 0.1719*** | 0.1296*** | 0.1045*** | 0.0841** |
| | (0.0334) | (0.0346) | (0.0332) | (0.0373) |
| Tenure track | | | -0.2333*** | -0.1079** |
| | | | (0.0393) | (0.0453) |
| Tenured | | | -0.3177*** | -0.1550*** |
| | | | (0.0344) | (0.0439) |
| Degree level - master (reference: bachelor) | | -0.0021 | | -0.2932*** |
| | | (0.0357) | | (0.0440) |
| Degree level - PhD (reference: bachelor) | | -0.0980* | | -0.4227*** |
| | | (0.0581) | | (0.0503) |
| Taught in more than 1 institution | | -0.0613* | | 0.0054 |
| | | (0.0331) | | (0.0286) |
| Full time employed | | -0.1390*** | | 0.0322 |
| | | (0.0377) | | (0.0376) |
| Worked in non-education industry previously | | 0.0885** | | 0.0586 |
| | | (0.0412) | | (0.0389) |
| Worked in K-12 | | -0.0389 | | 0.0147 |
| | | (0.0458) | | (0.0519) |
| Start teaching in the college before 2001 | | 0.0010 | | -0.0332 |
| | | (0.0443) | | (0.0341) |
| Earnings from non-education industry ($10,000) | | 0.0050 | | -0.0001 |
| | | (0.0073) | | (0.0072) |
| Employed at ASCS after the 1st year | | 0.0757** | | -0.0064 |
| | | (0.0379) | | (0.0390) |
| Observations | 4,476 | 4,476 | 6,547 | 6,547 |
| R-squared | 0.0065 | 0.0162 | 0.0271 | 0.0433 |

Note: The sample includes all instructors who have taught at least one introductory course from fall 2005 to summer 2012. The analysis is conducted through a two-step process. First, we construct the empirical Bayes estimate for each instructor's value added on student current course outcomes by taking into account the variance and the number of observations for each instructor. To residualize the outcome, we use regressions that control for all variables in equation (1), except for the academic rank of the instructor. In the second step, we use the value added calculated for each instructor from our step one as the dependent variable and include a vector of observable instructor characteristics as predictors in the OLS model.

Standard errors are clustered at the college level: *** p<0.01, ** p<0.05, * p<0.1

**Table 2.10 Impact of Introductory Course Professor on Next Course Enrollment using Empirical Bayes Estimator (Instructor Value-added)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Two-Year Colleges | | Four-year Colleges | |
| Temporary adjunct | -0.0649* | -0.0493 | -0.0585* | -0.0258 |
| | (0.0341) | (0.0317) | (0.0308) | (0.0344) |
| Tenure track | | | 0.0815** | 0.0526 |
| | | | (0.0398) | (0.0465) |
| Tenured | | | 0.1374*** | 0.1155*** |
| | | | (0.0340) | (0.0431) |
| Degree level - master (reference: bachelor) | | -0.0436 | | 0.1396*** |
| | | (0.0363) | | (0.0411) |
| Degree level - PhD (reference: bachelor) | | -0.0218 | | 0.1424*** |
| | | (0.0479) | | (0.0483) |
| Taught in more than 1 institution | | 0.0135 | | -0.0107 |
| | | (0.0321) | | (0.0282) |
| Full time employed | | 0.0483 | | 0.0754** |
| | | (0.0362) | | (0.0351) |
| Worked in non-education industry previously | | 0.0416 | | 0.0339 |
| | | (0.0398) | | (0.0375) |
| Worked in K-12 | | 0.0274 | | -0.2249*** |
| | | (0.0463) | | (0.0481) |
| Start teaching in the college before 2001 | | 0.0607 | | -0.0196 |
| | | (0.0390) | | (0.0326) |
| Earnings from non-education industry ($10,000) | | 0.0002 | | -0.0058 |
| | | (0.0075) | | (0.0068) |
| Employed at ASCS after the 1st year | | -0.0240 | | 0.0497 |
| | | (0.0383) | | (0.0375) |
| Observations | 4,476 | 4,476 | 6,547 | 6,547 |
| R-squared | 0.0005 | 0.0020 | 0.0035 | 0.0108 |

Note: The sample includes all instructors who have taught at least one introductory course from fall 2005 to summer 2012. The analysis is conducted through a two-step process. First, we construct the empirical Bayes estimate for each instructor's value added on student next course enrollment by taking into account the variance and the number of observations for each instructor. To residualize the outcome, we use regressions that control for all variables in equation (1), except for the academic rank of the instructor. In the second step, we use the value added calculated for each instructor from our step one as the dependent variable and include a vector of observable instructor characteristics as predictors in the OLS model.
Standard errors are clustered at the college level: *** p<0.01, ** p<0.05, * p<0.1

Table 3.1 Institution Characteristics, 2005 Enrolling Cohort: National Sample VS. ASCS

| | National Sample | | ASCS | |
|---|---|---|---|---|
| | Public 4-Year | Public 2-Year | Public 4-Year | Public 2-Year |
| Panel A: Student Characteristics | | | | |
| *Percent of total enrollment that are* | | | | |
| Gender: Female | 57.1% | 59.4% | 59.3% | 63.6% |
| Race | | | | |
| White, non-Hispanic | 66.9% | 66.4% | 69.6% | 77.4% |
| Black, non-Hispanic | 12.9% | 13.7% | 22.9% | 18.1% |
| Hispanic | 7.0% | 9.4% | 1.5% | 2.2% |
| Asian or Pacific Islander | 4.5% | 3.7% | 1.4% | 0.9% |
| American Indian or Alaska Native | 1.1% | 1.5% | 1.2% | 0.9% |
| Race/ethnicity unknown | 4.6% | 4.5% | 1.0% | 0.5% |
| Financial aid: Receiving any FA | 77.9% | 65.9% | 79.4% | 84.0% |
| Graduation rate [a] - men | 40.0% | 23.9% | 30.3% | 16.5% |
| Graduation rate - women | 47.5% | 26.7% | 40.8% | 20.6% |
| Obtained bachelor's degree within 6 years - men | 40.8% | NA | 30.4% | NA |
| Obtained bachelor's degree within 6 years - women | 48.6% | NA | 36.9% | NA |
| Panel B: Faculty and Staff Characteristics | | | | |
| *Percent that are female* | | | | |
| All faculty and staff | 47.8% | 54.2% | 48.9% | 58.0% |
| Full-time faculty | 42.4% | 52.3% | 46.9% | 58.0% |
| New hired faculty | 51.1% | 59.4% | 53.8% | 62.1% |

Note: Author derived data from the IPEDS Data Center 2005 data collection. Both national and ASCS samples include public degree-granting not-for-profit institutions.

[a] The IPEDS graduation rate is calculated as the number of students who completed their program within a specific percentage of normal time to completion divided by the total number of students in the entering cohort.

Table 3.2 Student Descriptive Statistics, Starting Cohort 2005- 2007

| | Two-Year Colleges | | Four-Year Colleges | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| ***Panel A - Demographic and Academic Attributes*** | | | | |
| Age when first enrolled | 23.43 | 24.00 | 19.12 | 19.39 |
| | (7.92) | (8.38) | (3.01) | (4.00) |
| Race | | | | |
| White | 78.7% | 76.0% | 73.1% | 72.9% |
| Black | 15.3% | 19.0% | 18.1% | 19.1% |
| Hispanic | 3.7% | 3.0% | 2.6% | 2.5% |
| Asian | 1.1% | 1.0% | 2.0% | 1.7% |
| Other race [a] | 1.2% | 1.0% | 4.3% | 3.9% |
| High school GPA | 2.49 | 2.63 | 3.10 | 3.28 |
| | (0.71) | (0.79) | (0.66) | (0.61) |
| Missing high school GPA | 35.6% | 31.3% | 7.8% | 8.4% |
| High school graduate | 79.1% | 77.9% | 95.3% | 95.1% |
| Enrolled as fulltime during the first term | 70.0% | 73.0% | 92.4% | 90.9% |
| Enter in the fall semester | 74.5% | 74.7% | 92.5% | 92.6% |
| Taken remedial courses | 53.2% | 68.6% | 39.4% | 41.3% |
| *Major declaration first semester* | | | | |
| STEM | 10.7% | 19.0% | 31.3% | 34.3% |
| STEM (excluding health related) | 5.9% | 1.9% | 21.5% | 7.0% |
| *Major declaration last semester* | | | | |
| STEM | 14.4% | 22.6% | 27.7% | 30.6% |
| STEM (excluding health related) | 3.3% | 2.3% | 17.8% | 4.9% |
| ***Panel B - First Term Faculty Composition*** | | | | |
| % of female instructor during first term | 42.5% | 64.4% | 45.0% | 52.0% |
| ***Panel C - Academic Outcomes*** | | | | |
| *After first term of enrollment* | | | | |
| Persist into 2nd academic year | 56.1% | 68.9% | 79.4% | 84.5% |
| Number of credits enrolled | 28.34 | 36.29 | 67.63 | 71.82 |
| | (35.77) | (37.09) | (47.80) | (45.25) |
| Number of credits earned | 21.78 | 28.60 | 56.21 | 62.31 |
| | (31.64) | (34.05) | (45.97) | (44.87) |
| Number of STEM credits enrolled | 7.25 | 7.64 | 19.78 | 15.75 |
| | (14.13) | (10.67) | (26.09) | (18.70) |
| Number of STEM credits earned | 5.33 | 5.60 | 16.00 | 12.98 |
| | (12.16) | (9.00) | (23.95) | (17.27) |
| *Six years after first term of enrollment* | | | | |
| Obtained any credential | 30.5% | 33.1% | 41.6% | 50.9% |
| Obtained any degree | 14.6% | 21.8% | 38.8% | 47.2% |
| Obtained any STEM credential | 3.2% | 0.7% | 10.6% | 5.1% |
| ***Panel D - Labor Market Outcomes*** | | | | |
| *Six years after first term of enrollment* | | | | |
| Employed | 64.9% | 67.6% | 60.1% | 65.3% |
| Fulltime employed | 43.8% | 34.8% | 37.2% | 38.1% |
| Employed in STEM industry | 5.3% | 7.5% | 5.5% | 8.7% |
| Employed in STEM-related industry | 18.9% | 16.8% | 17.3% | 18.4% |
| Annual earning (with zeros) | $15,948 | $11,905 | $13,551 | $13,150 |
| | ($18915) | ($14068) | ($17594) | ($15274) |
| Annual earning (without zeros) | $24,575 | $17,610 | $22,551 | $20,136 |
| | ($18421) | ($13867) | ($17669) | ($14716) |
| N | 12,554 | 15,796 | 17,552 | 19,623 |

Note: Data include students in the analytic sample, who first enrolled in any of the institution in the ASCS and took at least one college-level course between fall 2005 and summer 2007. Standard deviation in parentheses.
[a] The other race and ethnic groups include American Indian, Pacific Islander, multiple race, and unknown.

Table 3.3 ASCS Instructor Descriptive Statistics by Gender

| | Two-Year Colleges | | Four-Year Colleges | |
|---|---|---|---|---|
| | Male instructors | Female instructors | Male instructors | Female instructors |
| Age | 47.80 | 45.27 | 44.41 | 41.52 |
| | (12.13) | (11.27) | (13.27) | (12.70) |
| Race | | | | |
| White | 87.9% | 85.1% | 80.2% | 79.4% |
| Black | 5.7% | 8.5% | 6.7% | 7.2% |
| Hispanic | 0.9% | 1.1% | 1.3% | 1.3% |
| Asian | 0.5% | 0.9% | 3.8% | 2.6% |
| Other race [a] | 5.0% | 4.5% | 8.1% | 9.5% |
| Highest Degree | | | | |
| Bachelor's degree or lower | 36.6% | 26.5% | 19.5% | 22.4% |
| Master degree | 49.4% | 64.9% | 32.1% | 50.9% |
| Doctor degree or equivalent | 14.0% | 8.6% | 48.4% | 26.7% |
| Academic rank | | | | |
| Temporary adjunct | 56.9% | 59.9% | 35.5% | 46.0% |
| Non tenure track | 39.7% | 37.3% | 21.5% | 29.9% |
| Tenure track | 1.4% | 1.1% | 14.6% | 11.7% |
| Tenured | 2.0% | 1.7% | 28.4% | 12.5% |
| Fulltime [b] | 44.3% | 42.6% | 67.1% | 57.3% |
| Credit hours | 10.84 | 10.17 | 9.52 | 9.13 |
| | (7.75) | (7.03) | (5.30) | (5.36) |
| Teach in more than 1 institution | 2.4% | 2.0% | 1.1% | 1.2% |
| N | 1,575 | 1,903 | 2,717 | 2,334 |

Note: Data include instructors who have taught at least one introductory course between fall 2005 to summer 2008 in ASCS. Standard deviation in parenthesis.

[a] The other race and ethnic groups include American Indian, Pacific Islander, multiple race, and unknown.

[b] Full-time employed defined as worked as full-time instructor during at least half of the terms employed in the institution.

Table 3.4 Randomization Check and Instrument Variable First Stage Results

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Balance Test | | IV - First Stage | |
| % of credits with female faculty in first term | Two-year colleges | Four-year colleges | Two-year colleges | Four-year colleges |
| ***Instrument Variables:*** | | | | |
| Variation of proportion: female instructor | | | 0.9746*** | 0.7317*** |
| | | | (0.0716) | (0.0949) |
| ***Demographics:*** | | | | |
| Race[a]: Black | -0.0081 | 0.0086 | -0.0139 | 0.0091 |
| | (0.0106) | (0.0087) | (0.0110) | (0.0086) |
| Race[a]: Hispanic | 0.0169 | 0.0107 | 0.0128 | 0.0111 |
| | (0.0174) | (0.0159) | (0.0169) | (0.0159) |
| Race[a]: Asian | -0.0714** | 0.0329* | -0.0717** | 0.0322* |
| | (0.0337) | (0.0178) | (0.0322) | (0.0177) |
| Age at the time of course enrollment | -0.0004 | 0.0020** | -0.0004 | 0.0021** |
| | (0.0004) | (0.0010) | (0.0004) | (0.0010) |
| ***High School Attributes*** | | | | |
| Earned high school diploma | -0.0129 | 0.0205 | -0.0089 | 0.0254 |
| | (0.0110) | (0.0196) | (0.0105) | (0.0194) |
| High school GPA[b] | -0.0006 | -0.0083 | 0.0011 | -0.0084 |
| | (0.0054) | (0.0054) | (0.0053) | (0.0053) |
| ***Enrollment & Remedial Courses*** | | | | |
| Enrolled as fulltime in first term | -0.0149 | -0.0325** | -0.0167 | -0.0321** |
| | (0.0166) | (0.0160) | (0.0150) | (0.0155) |
| Entered in fall term | 0.0037 | -0.0088 | 0.0026 | -0.0053 |
| | (0.0087) | (0.0151) | (0.0086) | (0.0145) |
| Taken Remedial courses | 0.0164 | -0.0032 | 0.0209 | -0.0036 |
| | (0.0204) | (0.0112) | (0.0193) | (0.0113) |
| Observations | 15,796 | 19,623 | 15,796 | 19,623 |

Note: All regressions control for college-course portfolio fixed effects and college-cohort fixed effects. Standard errors are clustered at college-course portfolio level. There are 2,667 college-course portfolios in two-year colleges and 7,063 college-course portfolio in four-year colleges.
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
[a] Base group for race is white, non-Hispanic; other race includes American Indian, Pacific Islander, multiple race, and unknown.
[b] I include an indicator for missing high school GPA in all regressions

Table 3.5 Impact of Female Instructor on Current Course Performance for Female Students

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | **All Courses** | | | **STEM Courses** | |
| | Persist to the end of the course | Pass the course | Course grade | Persist to the end of the course | Pass the course | Course grade |
| ***Panel A: Two-Year Colleges*** | | | | | | |
| Female faculty | 0.0256 | 0.0155 | 0.0813 | -0.0045 | -0.0033 | 0.1211 |
| | (0.0176) | (0.0222) | (0.0868) | (0.0375) | (0.0464) | (0.1603) |
| Sample mean | 85.10% | 75.70% | 2.32 | 82.8% | 64.4% | 2.06 |
| | | | (1.55) | | | (1.56) |
| Number of courses | | 2,552 | | | 474 | |
| Observations | | 55,978 | | | 11,149 | |
| ***Panel B: Four-Year Colleges*** | | | | | | |
| Female faculty | 0.0433** | 0.0798*** | 0.3360*** | 0.0637 | 0.0824 | 0.5144** |
| | (0.0208) | (0.0300) | (0.1244) | (0.0498) | (0.0630) | (0.2407) |
| Sample mean | 92.60% | 87.00% | 2.77 | 89.2% | 73.5% | 2.39 |
| | | | (1.37) | | | (1.46) |
| Number of courses | | 2,132 | | | 501 | |
| Observations | | 110,219 | | | 28,602 | |

Note: Sample includes course enrollment during the first term. All models control for college-course fixed effects and college-cohort fixed effects. Other controls for all models include the student's age when taking the course, race (white as the reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, and an indicator for whether the student first declared as a STEM major, course section characteristics of the introductory course including enrollment size, delivery method (face-to-face vs. online), term taking the course, other students' average high school GPA in the course section, as well as whether the course is within student's declared major with an indicator for missing major declaration. Standard errors are clustered at college*course level. Classes on pass fail grading system are excluded.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Table 3.6 Impact of Female Instructor on Subsequent Course Enrollments and Performances for Female Students

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **All Students** | | **STEM Students** | |
| | Number of subsequent course enrolled | Average GPA in subsequent courses | Number of subsequent course enrolled in STEM | Average GPA in subsequent courses in STEM |
| ***Panel A: Two-Year Colleges*** | | | | |
| % of female instructors in 1st term | -1.6059 | 0.1652 | -0.0555 | -0.0034 |
| | (2.5971) | (0.1300) | (0.7993) | (0.0975) |
| Sample mean | 36.3 | 1.60 | 8.3 | 1.18 |
| | (37.1) | (1.35) | (10.6) | (1.36) |
| Number of course portfolio | 2,667 | 2,667 | 756 | 756 |
| Observations | 15,796 | 15,796 | 3,006 | 3,006 |
| ***Panel B: Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | 8.3431 | 0.0301 | 5.3121* | 0.1697 |
| | (8.4300) | (0.2361) | (2.7502) | (0.2036) |
| Sample mean | 71.8 | 2.21 | 23.7 | 1.97 |
| | (45.3) | (1.25) | (24.2) | (1.30) |
| Number of course portfolio | 7,063 | 7,063 | 756 | 756 |
| Observations | 19,623 | 19,623 | 3,006 | 3,006 |

Note: Sample includes students who enroll in at least one course after the first term of enrollment. All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. For example, one portfolio could be 1 course in English and 2 courses in math in College A. Another portfolio could be 2 courses in English, 1 course in math, and 1 course in Biology in College B. Other controls for all models include the student's age when first enrolled, race (white as the reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, and an indicator for whether the student first declared as a STEM major. Standard errors are clustered at college-course portfolio level.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.

Table 3.7 Impact of Female Instructor on Enrollment Persistence and Credential Completion for Female Students

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **All Students** | | **STEM Students** | |
| | Persist enrollment into 2nd AY | Earned a credential within 6 years | Major in STEM in last term | Earned a credential in STEM within 6 years |
| ***Panel A: Two-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.0317 | 0.0479 | 0.0864 | -0.0254 |
| | (0.0399) | (0.0359) | (0.0854) | (0.0245) |
| Sample mean | 68.9% | 33.1% | 73.3% | 22.3% |
| Number of course portfolio | 2,667 | 2,667 | 756 | 756 |
| Observations | 15,796 | 15,796 | 3,006 | 3,006 |
| ***Panel B: Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.1836** | 0.0435 | 0.1557* | 0.0952* |
| | (0.0755) | (0.0866) | (0.0827) | (0.0513) |
| Sample mean | 84.5% | 50.9% | 70.1% | 26.2% |
| Number of course portfolio | 7,063 | 7,063 | 3,176 | 3,176 |
| Observations | 19,623 | 19,623 | 6,722 | 6,722 |

Note: Sample includes students who enroll in at least one course after the first term of enrollment. All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. For example, one portfolio could be 1 course in English and 2 courses in math in College A. Another portfolio could be 2 courses in English, 1 course in math, and 1 course in Biology in College B. Other controls for all models include the student's age when first enrolled, race (white as the reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, and an indicator for whether the student first declared as a STEM major. Standard errors are clustered at college-course portfolio level.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.

Table 3.8 Impact of First-Term Female Instructor on Employment and Earning Six Years after First Semester for Female Students

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | | **Unconditional on Employment** | | **Conditional on Employment** | |
| | Employed | Annual Earnings | Employed in STEM Industry (STEM Majors Only) | Annual Earnings | Employed in STEM Industry (STEM Majors Only) |
| ***Panel A: Two-Year Colleges*** | | | | | |
| % of female instructors in 1st term | 0.0529 | 115.6275 | -0.0138 | -1,213.0586 | -0.0244 |
| | (0.0458) | (789.9105) | (0.0740) | (1,025.2261) | (0.1114) |
| Sample mean | 67.6% | $11,905 | 22.3% | $17,610 | 31.9% |
| | | ($14,067) | | ($13,866) | |
| Number of course portfolio | 2,667 | 2,667 | 756 | 2,123 | 612 |
| Observations | 15,796 | 15,796 | 3,006 | 10,679 | 2,101 |
| ***Panel B:Four-Year Colleges*** | | | | | |
| % of female instructors in 1st term | 0.1723** | 6,487.5913*** | 0.2655** | 985.6874 | 0.3434** |
| | (0.0823) | (2,048.2985) | (0.1268) | (2,586.0473) | (0.1747) |
| Sample mean | 65.3% | $13,150 | 26.2% | $20,136 | 39.1% |
| | | ($15,274) | | ($14,716) | |
| Number of course portfolio | 7,063 | 7,063 | 3,176 | 5,260 | 2,362 |
| Observations | 19,623 | 19,623 | 6,722 | 12,815 | 4,504 |

Note: All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. For example, one portfolio could be 1 course in English and 2 courses in math in College A. Another portfolio could be 2 courses in English, 1 course in math, and 1 course in Biology in College B. Other controls for all models include the student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED, or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before first enrolled in college, and the student's earning during the quarter before first term of college enrollment. Standard errors are clustered at college*course portfolio level. Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Table 3.9 Correlation of Proportion of Female Faculty and Other Department Characteristics

| % of female faculty in the department | (1) Two-year Colleges | (2) Four-year Colleges |
|---|---|---|
| % of course offered through online | 0.0004 | 0.0137 |
| | (0.0121) | (0.0151) |
| Average number of students in each course-section | 0.0006 | 0.0002 |
| | (0.0007) | (0.0003) |
| % of white instructors | 0.0239 | -0.0221 |
| | (0.0422) | (0.0143) |
| % of instructors who hold master degrees | -0.0206 | 0.0134 |
| | (0.0170) | (0.0269) |
| % of instructors who hold doctoral degrees | -0.0655** | 0.0053 |
| | (0.0262) | (0.0191) |
| % of tenured faculty | | 0.0067 |
| | | (0.0272) |
| % of tenure-track faculty | | 0.0275 |
| | | (0.0229) |
| % of temporary adjunct faculty | 0.0130 | -0.0205 |
| | (0.0141) | (0.0347) |
| % of fulltime faculty | 0.0084 | -0.0369 |
| | (0.0135) | (0.0261) |
| Constant | -0.0225 | 0.0217 |
| | (0.0427) | (0.0257) |
| Observations | 5,330 | 2,828 |

Note: Analyses are at college-department-term level. Both regressions control for college-department fixed effects, therefore the variations are drawn from within a department overtime. Robust standard errors in parentheses:*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.10 Mechanism of Female Instructors' Impacts on Employment

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Employed Six Years after Initial College Enrollment Term | | | |
| ***Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.1723** | 0.1669** | 0.1678** | 0.1137 |
| | (0.0823) | (0.0816) | (0.0813) | (0.0896) |
| Sample mean | | 65.30% | | |
| Control for credential completion | No | Yes | Yes | Yes |
| Control for number of semesters spent to earn credential | No | No | Yes | Yes |
| Control for credential subject fixed effects | No | No | No | Yes |
| Number of course portfolio | | 7,063 | | |
| Observations | | 19,623 | | |

Note: The result is for female students in four-year colleges. All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. Column 1 presents the original result of impact of female faculty on the likelihood of employment six years after initial college enrollment, as shown in Table 3.8 Column 1 Panel B; Column 2 presents the result after controlling for whether the student completed a credential within six years; Column 3 presents the result after controlling for whether the student completed a credential within six years, and the number of semesters the student spent to earn that credential; and Column 4 presents the result after controlling for whether the student completed a credential within six years, the number of semesters the student spent to earn that credential, and fixed effects for the subject area of the credential earned. Other controls for all models include the student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED, or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before first enrolled in college, and the student's earning during the quarter before first term of college enrollment. Standard errors are clustered at college*course portfolio level. Robust standard errors in parentheses:*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.11 Faculty Gender Specific Value-Added Effects on Earning Six Years after First Semester in Four-Year Colleges

| | (1) All instructors | (2) Non STEM instructors | (3) STEM instructors | (4) All instructors | (5) Non STEM instructors | (6) STEM instructors |
|---|---|---|---|---|---|---|
| Female instructor | 0.1733*** | 0.1293*** | 0.3022*** | 0.1485*** | 0.1119*** | 0.2670*** |
| | (0.0356) | (0.0394) | (0.0775) | (0.0374) | (0.0409) | (0.0841) |
| White instructor | | | | 0.1332*** | 0.1535*** | 0.0753 |
| | | | | (0.0514) | (0.0570) | (0.1114) |
| Obtained terminal degree | | | | -0.0512 | -0.0063 | -0.1752* |
| | | | | (0.0474) | (0.0522) | (0.1047) |
| Non tenure track instructor | | | | -0.0599 | -0.0702 | -0.0182 |
| | | | | (0.0552) | (0.0594) | (0.1315) |
| Tenure track or tenured instructor | | | | -0.0771 | -0.0991 | 0.0074 |
| | | | | (0.0679) | (0.0748) | (0.1511) |
| Fulltime | | | | 0.0099 | 0.0105 | -0.0331 |
| | | | | (0.0607) | (0.0650) | (0.1472) |
| Number of institutions taught | | | | 0.0263 | 0.0354 | -0.0048 |
| | | | | (0.0398) | (0.0417) | (0.1056) |
| Has worked in non education industry before teaching | | | | -0.0024 | -0.0038 | -0.0011 |
| | | | | (0.0551) | (0.0605) | (0.1227) |
| Has worked in K-12 sector before college teaching | | | | -0.0311 | 0.0759 | -0.4055** |
| | | | | (0.0794) | (0.0845) | (0.1954) |
| Average credit hours teaching fall/spring semesters | | | | 0.0071 | 0.0048 | 0.0096 |
| | | | | (0.0044) | (0.0051) | (0.0089) |
| Proportion of earnings from college teaching | | | | 0.0755 | 0.1416 | -0.0802 |
| | | | | (0.1098) | (0.1206) | (0.2463) |
| Observations | 3,152 | 2,266 | 886 | 3,152 | 2,266 | 886 |
| R-squared | 0.0075 | 0.0047 | 0.0169 | 0.0121 | 0.0120 | 0.0260 |

Note: The dependent variable is the shrinkage estimator of introductory course instructors' fixed effects (value-added) for the impact on earnings six years after first enrollment for *female students* in four-year colleges. The regressions used to estimate the gender-specific shrinkage estimator includes course fixed effects. Other controls include the student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED, or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before first enrolled in college. The standard errors for the first stage model are clustered at student- and course- level.
Standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

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# APPENDICES

Table 2.1A Results of Models Controlling College-introductory-course-term Fixed Effects

Panel A: Impact of Different Types of Instructors on Introductory Course Performance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Persist to the end of the course | Pass the course | Grade | Persist to the end of the course | Pass the course | Grade |
| Temporary adjunct | 0.0131*** (0.0023) | 0.0176*** (0.0027) | 0.1450*** (0.0109) | 0.0161*** (0.0017) | 0.0263*** (0.0023) | 0.1839*** (0.0109) |
| Tenure track instructor | | | | -0.0044*** (0.0001) | -0.0140*** (0.0001) | -0.0958*** (0.0006) |
| Tenured instructor | | | | -0.0134*** (0.0018) | -0.0230*** (0.0023) | -0.1702*** (0.0106) |
| Sample mean | 0.84 | 0.72 | 2.19 (1.58) | 0.91 | 0.81 | 2.47 (1.45) |
| Observations | 324,883 | 324,883 | 324,883 | 730,408 | 730,408 | 730,408 |
| R-squared | 0.4704 | 0.5484 | 0.6292 | 0.3523 | 0.4764 | 0.6245 |

Note: Base group for both two-year and four-year colleges are long-term non-tenure faculty. All models control for student individual fixed effects and college-introductory-course-term fixed effects. Other controls include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are three-way clustered at the student, college-subject, and term level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Panel B. Impact of Different Types of Instructors in Introductory Courses on Subsequent Enrollment in the Subject Area

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Take additional course | Take additional course and pass | Average grade of the second class | Take additional course | Take additional course and pass | Average grade of the second class |
| Temporary adjunct | -0.0136*** | -0.0094*** | 0.0057 | -0.0086*** | -0.0063** | 0.0172*** |
| | (0.0043) | (0.0036) | (0.0068) | (0.0032) | (0.0028) | (0.0047) |
| Tenure track instructor | | | | 0.0068* | 0.0051 | -0.0007 |
| | | | | (0.0040) | (0.0040) | (0.0070) |
| Tenured instructor | | | | 0.0060* | 0.0038 | -0.0176*** |
| | | | | (0.0031) | (0.0034) | (0.0049) |
| Sample mean | 0.37 | 0.27 | 2.23 | 0.43 | 0.36 | 2.44 |
| | | | (0.59) | | | (0.62) |
| Observations | 324,883 | 324,883 | 128,563 | 730,408 | 730,408 | 306,479 |
| R-squared | 0.4948 | 0.4533 | 0.6701 | 0.4408 | 0.4096 | 0.6825 |

Note: The base group for all regressions is long-term non-tenure faculty. All models control for student individual fixed effects, college-introductory course-term fixed effects. Other controls include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are three-way clustered at the student, college-subject, and term level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Panel C. Impact of Different Types of Instructors in Introductory Courses on Subsequent Course Grades in the Subject Area

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Persist to the end of the course | Pass the course | Grade | Persist to the end of the course | Pass the course | Grade |
| Temporary adjunct | 0.0041 | -0.0050 | -0.0361* | -0.0046* | -0.0094*** | -0.0326*** |
| | (0.0064) | (0.0069) | (0.0219) | (0.0026) | (0.0031) | (0.0099) |
| Tenure track instructor | | | | 0.0010 | -0.0053* | -0.0172* |
| | | | | (0.0024) | (0.0029) | (0.0093) |
| Tenured instructor | | | | 0.0009 | 0.0019 | 0.0051 |
| | | | | (0.0033) | (0.0038) | (0.0116) |
| Sample mean | 0.84 | 0.73 | 2.21 | 0.90 | 0.82 | 2.48 |
| | | | (1.57) | | | (1.45) |
| Observations | 128,563 | 128,563 | 128,563 | 306,479 | 306,479 | 306,479 |
| R-squared | 0.8037 | 0.8318 | 0.8711 | 0.5937 | 0.6626 | 0.7690 |

Note: The base group for all regressions is long-term non-tenure faculty. All models control student individual fixed effects, college-introductory course-term fixed effects, and next-college- -course-section fixed effects. Other controls include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are three-way clustered at the student, college-subject, and term level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 2.2A Results of Models Only Including Course-Term without Selection on Types of Instructors

Panel A: Impact of Different Types of Instructors on Introductory Course Performance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Persist to the end of the course | Pass the course | Grade | Persist to the end of the course | Pass the course | Grade |
| Temporary adjunct | 0.0140*** | 0.0122** | 0.0925*** | 0.0026 | 0.0075 | 0.0490** |
| | (0.0047) | (0.0058) | (0.0223) | (0.0040) | (0.0050) | (0.0224) |
| Tenure track instructor | | | | -0.0033 | -0.0098* | -0.1011*** |
| | | | | (0.0042) | (0.0054) | (0.0239) |
| Tenured instructor | | | | -0.0106*** | -0.0139*** | -0.1506*** |
| | | | | (0.0036) | (0.0052) | (0.0218) |
| Observations | 138,732 | 138,732 | 138,732 | 212,548 | 212,548 | 212,548 |
| R-squared | 0.4854 | 0.5506 | 0.6318 | 0.4286 | 0.5127 | 0.6507 |

Note: The sample includes the introductory courses offering only one type of instructors. Base group for both two-year and four-year colleges are long-term non-tenure faculty. All models control for student individual fixed effects and college-introductory course fixed effects. Other controls for all models include the student's age when taking the introductory course, course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, other students' average high school GPA in the course section, as well as whether the course is within student's declared major with an indicator for missing major declaration. Standard errors are two-way clustered at the student and college-subject level. Classes on pass fail grading system are excluded. Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Panel B. Impact of Different Types of Instructors in Introductory Courses on Subsequent Enrollment in the Subject Area

| | (1) | (2) | (3) | | (4) | (5) | (6) | |
|---|---|---|---|---|---|---|---|---|
| | Two-year colleges | | | | Four-year colleges | | | |
| | Take additional course | Take additional course and pass | Average pass rate of the next course | Average grade of the next course | Take additional course | Take additional course and pass | Average pass rate of the next course | Average grade of the next course |
| Temporary adjunct | -0.0039 | -0.0006 | 0.0153** | 0.0061 | -0.0082** | -0.0074* | 0.0059* | 0.0183** |
| | (0.0063) | (0.0060) | (0.0066) | (0.0135) | (0.0044) | (0.0044) | (0.0031) | (0.0083) |
| Tenure track instructor | | | | | 0.0100 | 0.0156** | -0.0012 | -0.0129 |
| | | | | | (0.0062) | (0.0061) | (0.0032) | (0.0122) |
| Tenured instructor | | | | | 0.0130*** | 0.0109** | -0.0031 | -0.0201** |
| | | | | | (0.0046) | (0.0048) | (0.0029) | (0.0090) |
| Observations | 80,033 | 80,033 | 20,136 | 20,136 | 218,361 | 218,361 | 74,836 | 74,836 |
| R-squared | 0.6298 | 0.5922 | 0.6447 | 0.7638 | 0.5649 | 0.5340 | 0.6002 | 0.7471 |

Note: The sample includes students whose introductory course in a subject area offering only one type of instructors during the term they took the course. The base group for all regressions is long-term non-tenure faculty. All models control for student individual fixed effects and college-introductory course fixed effects. Other controls include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are two-way clustered at the student and college-subject level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 2.3A Impact of Different Types of Instructors on Introductory Course Performance: Grade Distribution

| Outcome | (1) Grade: A or equivalent | (2) Grade: B or better | (3) Grade: C or better | (4) Grade: D or better | (5) Grade given Persistence |
|---|---|---|---|---|---|
| | *Two-year Colleges* | | | | |
| Temporary adjunct | 0.0489*** | 0.0419*** | 0.0261*** | 0.0183*** | 0.1314*** |
| | (0.0057) | (0.0050) | (0.0037) | (0.0033) | (0.0145) |
| Observations | 324,883 | 324,883 | 324,883 | 324,883 | 271,415 |
| R-squared | 0.4853 | 0.5096 | 0.5081 | 0.5031 | 0.6137 |
| | *Four-year Colleges* | | | | |
| Temporary adjunct | 0.0511*** | 0.0486*** | 0.0349*** | 0.0226*** | 0.1448*** |
| | (0.0072) | (0.0052) | (0.0038) | (0.0029) | (0.0147) |
| Tenure track instructor | -0.0355*** | -0.0315*** | -0.0191*** | -0.0137*** | -0.0945*** |
| | (0.0070) | (0.0067) | (0.0053) | (0.0042) | (0.0182) |
| Tenured instructor | -0.0568*** | -0.0566*** | -0.0351*** | -0.0217*** | -0.1572*** |
| | (0.0055) | (0.0056) | (0.0047) | (0.0036) | (0.0149) |
| Observations | 730,408 | 730,408 | 730,408 | 730,408 | 664,499 |
| R-squared | 0.4914 | 0.5009 | 0.4679 | 0.4473 | 0.6172 |
| Student FE | YES | YES | YES | YES | YES |
| College-intro-course FE | YES | YES | YES | YES | YES |

Note: The base group for all regressions is long-term non-tenure faculty. All regressions control for whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are two-way clustered at the student and college-subject level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 2.4A Impact of Different Types of Instructors in Introductory Courses on Subsequent Course Grades: Grade Distribution

| Outcome | (1) Grade: A or equivalent | (2) Grade: B or better | (3) Grade: C or better | (4) Grade: D or better | (5) Grade given Persistence |
|---|---|---|---|---|---|
| | *Two-year Colleges* | | | | |
| Temporary adjunct | -0.0136** | -0.0048 | -0.0014 | -0.0003 | -0.0531*** |
| | (0.0056) | (0.0065) | (0.0058) | (0.0056) | (0.0176) |
| Observations | 128,563 | 128,563 | 128,563 | 128,563 | 107,791 |
| R-squared | 0.7974 | 0.7978 | 0.7842 | 0.7783 | 0.8649 |
| | *Four-year Colleges* | | | | |
| Temporary adjunct | -0.0042 | -0.0039 | -0.0074*** | -0.0075*** | -0.0123 |
| | (0.0033) | (0.0035) | (0.0028) | (0.0027) | (0.0080) |
| Tenure track instructor | -0.0024 | 0.0017 | -0.0015 | -0.0010 | -0.0082 |
| | (0.0030) | (0.0032) | (0.0029) | (0.0027) | (0.0070) |
| Tenured instructor | -0.0025 | 0.0086** | 0.0056 | 0.0045 | 0.0173* |
| | (0.0033) | (0.0040) | (0.0036) | (0.0033) | (0.0089) |
| Observations | 306,479 | 306,479 | 306,479 | 306,479 | 277,131 |
| R-squared | 0.6957 | 0.6819 | 0.6490 | 0.6297 | 0.7703 |
| Student FE | YES | YES | YES | YES | YES |
| College-intro-course FE | YES | YES | YES | YES | YES |
| Next-college-course-section FE | YES | YES | YES | YES | YES |

Note: The base group for all regressions is long-term non-tenure faculty. All regressions control for whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are two-way clustered at the student and college-subject level. Robust standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.5A Results of First Stage IV Regressions (Probability of Taking the First Course in a Subject Area with Different Types of Instructors)

| Outcome | Two-year Colleges<br>Temporary adjunct | Four-year Colleges<br>Temporary adjunct | Tenure track instructors | Tenured instructors |
|---|---|---|---|---|
| *A. First stage for introductory course grade & subsequent course enrollment* | | | | |
| Variation of proportion: temporary adjunct | 0.3373*** | 0.7498*** | -0.0013 | 0.0044 |
| | (0.0313) | (0.0937) | (0.0300) | (0.0491) |
| Variation of proportion: tenure track | | 0.1047** | 0.4733*** | 0.1498*** |
| | | (0.0515) | (0.0486) | (0.0402) |
| Variation of proportion: tenured | | 0.1279*** | 0.0788** | 0.5205*** |
| | | (0.0364) | (0.0282) | (0.0401) |
| F-statistics | 116.06 | 23.61 | 35.55 | 60.82 |
| Observations | 324,883 | 730,408 | 730,408 | 730,408 |
| R-squared | 0.4653 | 0.3253 | 0.3209 | 0.3644 |
| *B. First stage for next course grade* | | | | |
| Variation of proportion: temporary adjunct | 0.1765*** | 0.4923*** | 0.0456* | 0.0282 |
| | (0.0258) | (0.0459) | (0.0247) | (0.0274) |
| Variation of proportion: tenure track | | 0.0633** | 0.3581*** | 0.1839*** |
| | | (0.0280) | (0.0424) | (0.0417) |
| Variation of proportion: tenured | | 0.0687** | 0.0935* | 0.4847*** |
| | | (0.0243) | (0.0320) | (0.0402) |
| F-statistics | 46.97 | 38.55 | 26.82 | 54.47 |
| Observations | 128,563 | 306,479 | 306,479 | 306,479 |
| R-squared | 0.6615 | 0.3901 | 0.3772 | 0.5191 |

Note: The base group for all regressions is long-term non-tenure track faculty. All regressions control for students' characteristics listed in Table 5 and college-introductory-course fixed effects. Other controls include whether the student entered college in fall and whether the subject was his/her initial declared major with an indicator of missing major declaration. Standard errors are clustered at college-subject level: *** p<0.01, ** p<0.05, * p<0.1

Table 2.6A Robustness Tests on Alternative Ways to Construct the Instrumental Variable

Panel A: Impact of Different Types of Instructors in Introductory Courses on Subsequent Course Enrollment: Robustness Check of Table 2.8

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year Colleges | | | Four-year Colleges | | |
| | Outcome: Take a second course in the subject area | | | | | |
| | IV: variation in sections taught by different instructors | IV: variation in enrollment with different instructors | IV: variation in instructor headcount | IV: variation in sections taught by different instructors | IV: variation in enrollment with different instructors | IV: variation in instructor headcount |
| Temporary adjunct | -0. 1196*** | -0.0949*** | -0.0322 | -0. 3199*** | -0.1406*** | -0.2002*** |
| | (0. 0410) | (0.0338) | (0.0423) | (0.0528) | (0.0437) | (0.0372) |
| Tenure track instructor | | | | 0.0865 | 0.2258*** | 0.0734* |
| | | | | (0. 0631) | (0.0609) | (0.0450) |
| Tenured instructor | | | | 0.0432 | 0.1669** | 0.0071 |
| | | | | (0. 0520) | (0.0657) | (0.0454) |
| Sample mean | 0.37 | | | 0.43 | | |
| Observations | 324,883 | 324,883 | 324,883 | 730,408 | 730,408 | 730,408 |
| R-squared | 0.1726 | 0.1733 | 0.1761 | 0.1907 | 0.2132 | 0.2178 |

Note: The base group for all regressions is long-term non-tenure faculty. All models control for student characteristics listed in Table 5. All models in this table control for college-by-introductory course FE. The IV for models in column (1) and (4) present the results from Table 10 on students' probability of taking additional courses, where the IV is constructed using the fluctuation in the proportion of course sections taught by different types of instructors. Column (2) and (4) construct the IV as the fluctuation in the proportion of total course enrollment by different types of instructors. Column (3) and (6) construct the IV as the fluctuation in the headcounts of different types of instructors in each department. Standard errors are clustered at the college level: *** p<0.01, ** p<0.05, * p<0.1.

Panel B: Impact of Different Types of Instructors during the First Term on Enrollment Persistence: Robustness Check of Table 2.6

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year Colleges | | | Four-year Colleges | | |
| | Outcome: Persist into the 2nd academic term | | | | | |
| | IV: variation in sections taught by different instructors | IV: variation in enrollment with different instructors | IV: variation in instructor headcount | IV: variation in sections taught by different instructors | IV: variation in enrollment with different instructors | IV: variation in instructor headcount |
| *Key Predictors: % of credits taken with different type of faculty during the 1st term* (multiplied by 10) | | | | | | |
| Temporary adjunct | -0. 0140*** | -0.0056* | -0.0154** | -0. 0015 | 0.0027 | 0.0051 |
| | (0. 0053) | (0.0032) | (0.0069) | (0.0204) | (0.0028) | (0.0102) |
| Tenure track instructor | | | | 0.0013 | -0.0057 | -0.0162 |
| | | | | (0. 0044) | (0.0074) | (0.0256) |
| Tenured instructor | | | | -0.0037 | 0.0010 | -0.0151 |
| | | | | (0. 0038) | (0.054) | (0.0231) |
| Sample mean | | 0.60 | | | 0.79 | |
| Observations | 68,692 | 68,692 | 68,692 | 87,212 | 87,212 | 87,212 |
| R-squared | 0.0494 | 0.0662 | 0.0530 | 0.0731 | 0.0683 | 0.0466 |

Note: The base group for all regressions is long-term non-tenure faculty. All models control for student characteristics listed in Table 5. All models in this table control for college-course set FE, i.e. fixed effects for the set of courses student took in the first term of enrollment in a particular college. For example, one course set could be Econ 101 and Math 101 at college X; another course set could be English 101, Math 101, and Biology 101 at college Y. The IV for models in column (1) and (4) present the results from Table 8 for the course set FE + IV model where the IV is constructed using the fluctuation in the proportion of course sections taught by different types of instructors. Column (2) and (4) construct the IV as the fluctuation in the proportion of total enrollment by different types of instructors over time. Column (3) and (6) construct the IV as the fluctuation in the headcount of different types of instructors in each department. Standard errors are clustered at the college level: *** p<0.01, ** p<0.05, * p<0.1.

Table 2.7A Robustness Checks by Dropping All Career Enders

Panel A: Impact of Different Types of Instructors on Introductory Course Performance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Two-year colleges | | | Four-year colleges | | |
| | Persist to the end of the course | Pass the course | Grade | Persist to the end of the course | Pass the course | Grade |
| Temporary adjunct | 0.0128*** | 0.0172*** | 0.1412*** | 0.0165*** | 0.0267*** | 0.1842*** |
| | (0.0033) | (0.0027) | (0.0110) | (0.0017) | (0.0023) | (0.0109) |
| Tenure track instructor | | | | -0.0039 | -0.0130*** | -0.0941*** |
| | | | | (0.0024) | (0.0023) | (0.0140) |
| Tenured instructor | | | | -0.0129*** | -0.0229 | -0.1724*** |
| | | | | (0.0018) | (0.0275) | (0.0106) |
| Observations | 321,259 | 321,259 | 321,259 | 711,587 | 711,587 | 711,587 |
| R-squared | 0.4701 | 0.5481 | 0.6288 | 0.3524 | 0.4767 | 0.6247 |

Note: The sample includes the introductory courses that student took with faculty who first started teaching younger than 55-year old. Base group for both two-year and four-year colleges are long-term non-tenure faculty. All models control for student individual fixed effects and college-introductory course fixed effects. Other controls for all models include the student's age when taking the introductory course, course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, other students' average high school GPA in the course section, as well as whether the course is within student's declared major with an indicator for missing major declaration. Standard errors are two-way clustered at the student and college-subject level. Classes on pass fail grading system are excluded. Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Panel B. Impact of Different Types of Instructors in Introductory Courses on Subsequent Enrollment in the Subject Area

| | Two-year colleges | | | | Four-year colleges | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | | (4) | (5) | (6) | |
| | Take additional course | Take additional course and pass | Average pass rate of the next course | Average grade of the next course | Take additional course | Take additional course and pass | Average pass rate of the next course | Average grade of the next course |
| Temporary adjunct | -0.0122*** | -0.0069* | 0.0033 | 0.0022 | -0.0083*** | -0.0100*** | 0.0002 | 0.0147*** |
| | (0.0042) | (0.0039) | (0.0027) | (0.0063) | (0.0031) | (0.0032) | (0.0014) | (0.0048) |
| Tenure track instructor | | | | | 0.0064 | 0.0071* | -0.0008 | -0.0025 |
| | | | | | (0.0041) | (0.0041) | (0.0016) | (0.0073) |
| Tenured instructor | | | | | 0.0058* | 0.0040 | -0.0014 | -0.0184*** |
| | | | | | (0.0032) | (0.0031) | (0.0013) | (0.0051) |
| Observations | 321,259 | 321,259 | 116,480 | 116,480 | 711,587 | 711,587 | 305,536 | 305,536 |
| R-squared | 0.5111 | 0.4667 | 0.5228 | 0.6819 | 0.4506 | 0.4182 | 0.4849 | 0.6856 |

Note: The sample includes the introductory courses that student took with faculty who first started teaching younger than 55-year old. The base group for all regressions is long-term non-tenure faculty. All models control for student individual fixed effects and college-introductory course fixed effects fixed effects. Other controls include whether the subject was student's initial declared major with an indicator for missing major declaration, the student's age when taking the introductory course and course section characteristics of the introductory course including enrollment size, delivery method, term taking the course, and other students' average high school GPA in the course section. Standard errors are two-way clustered at the student and college-subject level. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 3.1A Share of Industry Workers in STEM Occupation by NAICS Code

| NAICS code | NAICS Title | Share of Industry Workers in STEM occupations 2012 |
|---|---|---|
| 4832 | Inland Water Transportation | 74.0% |
| 5413 | Architectural, Engineering, and Related Services | 74.0% |
| 5415 | Computer Systems Design and Related Services | 74.0% |
| 5417 | Scientific Research and Development Services | 72.0% |
| 3341 | Computer and Peripheral Equipment Manufacturing | 71.0% |
| 5112 | Software Publishers | 70.0% |
| 5174 | Satellite Telecommunications | 68.0% |
| 8112 | Electronic and Precision Equipment Repair and Maintenance | 63.0% |
| 4831 | Deep Sea, Coastal, and Great Lakes Water Transportation | 62.0% |
| 5231 | Securities and Commodity Contracts Intermediation and Brokerage | 61.0% |
| 6219 | Other Ambulatory Health Care Services | 60.0% |
| 3364 | Aerospace Product and Parts Manufacturing | 59.0% |
| 2111 | Oil and Gas Extraction | 58.0% |
| 3327 | Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing | 58.0% |
| 5239 | Other Financial Investment Activities | 58.0% |
| 3335 | Metalworking Machinery Manufacturing | 57.0% |
| 3342 | Communications Equipment Manufacturing | 57.0% |
| 3345 | Navigational, Measuring, Electrometrical, and Control Instruments Manufacturing | 57.0% |
| 5179 | Other Telecommunications | 57.0% |
| 5182 | Data Processing, Hosting, and Related Services | 56.0% |
| 4860 | #N/A | 54.0% |
| 6221 | General Medical and Surgical Hospitals | 53.0% |
| 5171 | Wired Telecommunications Carriers | 52.0% |
| 8113 | Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance | 51.0% |
| 3251 | Basic Chemical Manufacturing | 50.0% |
| 3332 | Industrial Machinery Manufacturing | 50.0% |
| 3344 | Semiconductor and Other Electronic Component Manufacturing | 50.0% |
| 6215 | Medical and Diagnostic Laboratories | 49.0% |
| 2122 | Metal Ore Mining | 47.0% |
| 2211 | Electric Power Generation, Transmission and Distribution | 46.0% |
| 2213 | Water, Sewage and Other Systems | 46.0% |
| 3252 | Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing | 46.0% |
| 5259 | Other Investment Pools and Funds | 46.0% |
| 2362 | Nonresidential Building Construction | 45.0% |
| 6223 | Specialty (except Psychiatric and Substance Abuse) Hospitals | 45.0% |
| 3336 | Engine, Turbine, and Power Transmission Equipment | 44.0% |

| | | |
|---|---|---|
| | Manufacturing | |
| 5412 | Accounting, Tax Preparation, Bookkeeping, and Payroll Services | 44.0% |
| 2361 | Residential Building Construction | 43.0% |
| 5211 | Monetary Authorities-Central Bank | 43.0% |
| 3253 | Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing | 42.0% |
| 3333 | Commercial and Service Industry Machinery Manufacturing | 42.0% |
| 2212 | Natural Gas Distribution | 41.0% |
| 2382 | Building Equipment Contractors | 41.0% |
| 3241 | Petroleum and Coal Products Manufacturing | 41.0% |
| 3314 | Nonferrous Metal (except Aluminum) Production and Processing | 41.0% |
| 3339 | Other General Purpose Machinery Manufacturing | 41.0% |
| 4234 | Professional and Commercial Equipment and Supplies Merchant Wholesalers | 41.0% |
| 3254 | Pharmaceutical and Medicine Manufacturing | 40.0% |
| 5172 | Wireless Telecommunications Carriers (except Satellite) | 40.0% |
| 5191 | Other Information Services | 40.0% |
| 5232 | Securities and Commodity Exchanges | 40.0% |
| 3329 | Other Fabricated Metal Product Manufacturing | 39.0% |
| 3331 | Agriculture, Construction, and Mining Machinery Manufacturing | 39.0% |
| 3366 | Ship and Boat Building | 39.0% |
| 4881 | Support Activities for Air Transportation | 38.0% |
| 5416 | Management, Scientific, and Technical Consulting Services | 38.0% |
| 5511 | Management of Companies and Enterprises | 38.0% |
| 3353 | Electrical Equipment Manufacturing | 37.0% |
| 3359 | Other Electrical Equipment and Component Manufacturing | 37.0% |
| 3315 | Foundries | 36.0% |
| 3321 | Forging and Stamping | 36.0% |
| 3322 | Cutlery and Handtool Manufacturing | 36.0% |
| 3363 | Motor Vehicle Parts Manufacturing | 36.0% |
| 5152 | Cable and Other Subscription Programming | 36.0% |
| 6113 | Colleges, Universities, and Professional Schools | 36.0% |
| 6211 | Offices of Physicians | 36.0% |
| 8111 | Automotive Repair and Maintenance | 36.0% |
| 3323 | Architectural and Structural Metals Manufacturing | 35.0% |
| 5122 | Sound Recording Industries | 35.0% |
| 6214 | Outpatient Care Centers | 35.0% |
| 6212 | Offices of Dentists | 33.0% |
| 2383 | Building Finishing Contractors | 32.0% |
| 3312 | Steel Product Manufacturing from Purchased Steel | 32.0% |
| 3313 | Alumina and Aluminum Production and Processing | 32.0% |

| | | |
|---|---|---|
| 3324 | Boiler, Tank, and Shipping Container Manufacturing | 32.0% |
| 3343 | Audio and Video Equipment Manufacturing | 32.0% |
| 3365 | Railroad Rolling Stock Manufacturing | 32.0% |
| 3391 | Medical Equipment and Supplies Manufacturing | 32.0% |
| 4811 | Scheduled Air Transportation | 32.0% |
| 5151 | Radio and Television Broadcasting | 32.0% |
| 2131 | Support Activities for Mining | 31.0% |
| 2381 | Foundation, Structure, and Building Exterior Contractors | 31.0% |
| 3325 | Hardware Manufacturing | 31.0% |
| 3334 | Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing | 31.0% |
| 5251 | Insurance and Employee Benefit Funds | 31.0% |
| 3271 | Clay Product and Refractory Manufacturing | 30.0% |
| 3326 | Spring and Wire Product Manufacturing | 30.0% |
| 4236 | Household Appliances and Electrical and Electronic Goods Merchant Wholesalers | 30.0% |
| 6112 | Junior Colleges | 30.0% |

Table 3.2A Impact of First-Term Female Instructor on Employment and Earning Six Years after First Semester for Female Students – Robustness Check: Alternative Way of Constructing College*Course Portfolio

| | (1)<br>Employed | (2)<br>Employed in STEM Industry | (3)<br>Employed in STEM Industry (alternative definition) | (4)<br>Annual Earning |
|---|---|---|---|---|
| ***Panel A: Two-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.0006<br>(0.0011) | <0.0000<br>(0.0006) | -0.0003<br>(0.0010) | $-45<br>(32) |
| Sample mean | 67.6% | 7.50% | 16.80% | $11,905<br>($14068) |
| Number of course portfolio | | | **11,507** | |
| Observations | | | **15,796** | |
| ***Panel B: Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.0029<br>(0.0021) | 0.0032*<br>(0.0017) | 0.0041*<br>(0.0022) | $33<br>(52) |
| Sample mean | 65.3% | 8.70% | 18.40% | $13,150<br>($15274) |
| Number of course portfolio | | | **18,781** | |
| Observations | | | **19,623** | |

Note: All models control for college*course portfolio fixed effects. College*course portfolio is defined as the set of courses the student took during the first term of enrollment. For example, one course portfolio is English 101 and Calculus 101 in college A; another course portfolio is English 101, Biology 101, and pre-Calculus in College B. Other controls for all models include the student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED, or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before first enrolled in college. Standard errors are clustered at college*course portfolio level.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Table 3.3A Impact of First-Term Female Instructor on Employment and Earning Six Years after First Semester for Female Students – Robustness Check: Courses without Faculty Gender Selection

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Employed | Employed in STEM Industry | Employed in STEM Industry (alternative definition) | Annual Earning |
| ***Panel A: Two-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.0004 | -0.0001 | -0.0004 | $3.0 |
| | (0.0006) | (0.0003) | (0.0005) | (10) |
| Sample mean | 65.9% | 7.0% | 15.9% | $11,423 |
| | | | | (13,760) |
| Number of course portfolio | | | **2,368** | |
| Observations | | | **9,763** | |
| ***Panel B: Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.0032*** | 0.0004 | 0.0006 | $35 |
| | (0.0011) | (0.0005) | (0.0008) | (31) |
| Sample mean | 62.8% | 8.6% | 18.1% | $13,030 |
| | | | | (15,673) |
| Number of course portfolio | | | **6,057** | |
| Observations | | | **12,474** | |

Note: Data include all female students who took courses without faculty gender selection during their first term of enrollment. All models control for college*course portfolio fixed effects. Other controls for all models include the student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED, or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before first enrolled in college. Standard errors are clustered at college*course portfolio level.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Table 3.4A Impact of First-Term Female Instructor on Academic and Labor Market Outcomes for Male Students

Panel A. First-term Course Outcomes

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | **All Courses** | | | **STEM Courses** | |
| | Persist to the end of the course | Pass the course | Course grade | Persist to the end of the course | Pass the course | Course grade |
| ***Panel A: Two-Year Colleges*** | | | | | | |
| Female faculty | -0.0160 | -0.0168 | -0.0109 | -0.0742 | -0.0417 | 0.0134 |
| | (0.0278) | (0.0307) | (0.1071) | (0.0512) | (0.0475) | (0.1637) |
| Number of courses | | 2,712 | | | 597 | |
| Observations | | 47,838 | | | 10,263 | |
| ***Panel B: Four-Year Colleges*** | | | | | | |
| Female faculty | 0.0044 | 0.0708** | 0.2580** | 0.0174 | 0.0420 | 0.1065 |
| | (0.0282) | (0.0347) | (0.1308) | (0.0593) | (0.0640) | (0.2239) |
| Number of courses | | 2,203 | | | 583 | |
| Observations | | 99.546 | | | 29,619 | |

Note: Sample includes course enrollment during the first term for male students. All models control for college-course fixed effects and college-cohort fixed effects. Other controls for all models include the student's age when taking the course, race (white as the reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, and an indicator for whether the student first declared as a STEM major, course section characteristics of the introductory course including enrollment size, delivery method (face-to-face vs. online), term taking the course, other students' average high school GPA in the course section, as well as whether the course is within student's declared major with an indicator for missing major declaration. Standard errors are clustered at college*course level. Classes on pass fail grading system are excluded.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

Panel B. Subsequent Course Enrollments

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **All Students** | | **STEM Students** | |
| | Number of subsequent course enrolled | Average GPA in subsequent courses | Number of subsequent course enrolled in STEM | Average GPA in subsequent courses in STEM |
| ***Panel A: Two-Year Colleges*** | | | | |
| % of female instructors in 1st term | 4.9922* | 0.5396*** | 1.9339 | 0.1919 |
| | (2.7649) | (0.2040) | (1.2318) | (0.1178) |
| Number of course portfolio | 2,267 | | 471 | |
| Observations | 12,554 | | 1,342 | |
| ***Panel B: Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | -1.6463 | -0.2568 | -1.9490 | -0.2176 |
| | (9.0122) | (0.2911) | (3.9853) | (0.2244) |
| Number of course portfolio | 6,032 | | 2,581 | |
| Observations | 17,552 | | 5,492 | |

Note: Sample includes male students who enroll in at least one course after the first term of enrollment. All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. For example, one portfolio could be 1 course in English and 2 courses in math in College A. Another portfolio could be 2 courses in English, 1 course in math, and 1 course in Biology in College B. Other controls for all models include the student's age when first enrolled, race (white as the reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, and an indicator for whether the student first declared as a STEM major. Standard errors are clustered at college-course portfolio level.
Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.

Panel C. Persistence and Credential Completion

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **All Students** | | **STEM Students** | |
| | Persist enrollment into 2nd AY | Earned a credential within 6 years | Major in STEM in last term | Earned a credential in STEM within 6 years |
| ***Panel A: Two-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.1052 | -0.1040 | -0.0263 | -0.0152 |
| | (0.0691) | (0.0709) | (0.1740) | (0.0362) |
| Number of course portfolio | 2,267 | | 471 | |
| Observations | 12,554 | | 1,342 | |
| ***Panel B: Four-Year Colleges*** | | | | |
| % of female instructors in 1st term | 0.0340 | 0.0034 | -0.0529 | -0.0466 |
| | (0.0832) | (0.0817) | (0.2244) | (0.1768) |
| Number of course portfolio | 6,032 | | 2,581 | |
| Observations | 17,552 | | 5,492 | |

Note: Sample includes male students who enroll in at least one course after the first term of enrollment. All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. For example, one portfolio could be 1 course in English and 2 courses in math in College A. Another portfolio could be 2 courses in English, 1 course in math, and 1 course in Biology in College B. Other controls for all models include the student's age when first enrolled, race (white as the reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, and an indicator for whether the student first declared as a STEM major. Standard errors are clustered at college-course portfolio level.
Robust standard errors in parentheses:*** $p<0.01$, ** $p<0.05$, * $p<0$.

Panel D. Labor Market Outcomes

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | | **Unconditional on Employment** | | **Conditional on Employment** | |
| | Employed | Annual Earnings | Employed in STEM Industry (STEM Majors Only) | Annual Earnings | Employed in STEM Industry (STEM Majors Only) |
| ***Panel A: Two-Year Colleges*** | | | | | |
| % of female instructors in 1st term | 0.0229 | 328 | 0.0410 | -119 | 0.1091 |
| | (0.0611) | (2285) | (0.0973) | (2168) | (0.2107) |
| Number of course portfolio | 2,267 | 2,267 | 471 | 1,773 | 347 |
| Observations | 12,554 | 12,554 | 1,342 | 8,147 | 895 |
| ***Panel B: Four-Year Colleges*** | | | | | |
| % of female instructors in 1st term | 0.1615 | 4565 | 0.0073 | 1645 | -0.1707 |
| | (0.1017) | (3060) | (0.1737) | (4783) | (0.2905) |
| Number of course portfolio | 6,032 | 6,032 | 2,581 | 4,268 | 1,780 |
| Observations | 17,552 | 17,552 | 5,492 | 10,547 | 3,327 |

Note: All models control for college-course portfolio fixed effects and college-cohort fixed effects. College-course portfolio is defined as the number of courses student took in each subject area. For example, one portfolio could be 1 course in English and 2 courses in math in College A. Another portfolio could be 2 courses in English, 1 course in math, and 1 course in Biology in College B. Other controls for all models include the student's age when first enrolled, square of age when first enrolled, race (white as reference group), whether the student is a residence of the state, high school GPA, an indicator for missing high school GPA, whether the student earned high school diploma, whether the student earned GED, or equivalent, three indicators for whether the student placed as college ready in math, English, and reading, whether the student entered in fall semester, an indicator for whether the student first declared as a STEM major and the earnings during the quarter before first enrolled in college, and the student's earning during the quarter before first term of college enrollment. Standard errors are clustered at college*course portfolio level. Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1