AC 2011-794: AN ANALYSIS OF FEMALE STEM FACULTY AT PUBLIC TWO-YEAR INSTITUTIONS

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An Analysis of Female STEM Faculty at Public Two-Year Institutions

Abstract

Compared to four-year institutions, limited research exists on the careers of female faculty teaching STEM at public two-year institutions. Unfortunately, the mission and structure of two-year schools differs greatly from their well-studied counterparts. Thus the explanatory power of STEM career success and advancement outcomes of female faculty in the four-year sector cannot explain how female faculties succeed at public, two-year schools. For example, female STEM faculty hold near parity in the percents achieving the ranks of professor or associate professor at public two-year schools, while they are half as likely to rise to those levels at four-year schools.[1]

This paper presents a quantitative analysis on career success and employment outcomes in STEM fields using data from National Study of Postsecondary Faculty (NSOPF), with focus on the most recent survey in 2003-4. The analysis will be based on the hypothesis of the effect of gender on salary, rank, part-time status, highest degree and field of teaching for faculty in two-year institution compare to four-year institution.

Prediction models were built on statistical analysis tools provided by the National Center of Education Statistics (NCES); DAS[2] and Powerstats[3]. The factors associated with advancement and employment outcomes were investigated and preliminary outcomes was confirmed by the qualitative analysis.

Due to differences of STEM definition, this paper will also present a clear definition of STEM, using CIP and NSOPF codes. Major definitions of STEM will be mapped into the major classification codes including CIP, BLS Occupational Codes and NSF. Further research on this study is based on the comparison of the result of this paper and the actual data collected.

Introduction

The definition of academic success in 2-year institutions has noteworthy differences over academic success at 4-year institutions. This paper looks into a specific group in higher education, female faculty teaching STEM topics at two-year schools. This paper is a follow up paper on career success for female STEM faculty at public two-year institutions paper[4], which is also part of a larger NSF ADVANCE grant looking for overall success factor in female faculty in 2 year institutions.

There is no standard definition of STEM. To be able to define the academic success of female faculty in STEM related field, the first step is to establish a standardized definition of STEM. After a STEM definition has been established, the variables used for the model can be identified. This paper will focus on building prediction models based on principal field of teaching related to the defined STEM and will present the analysis based on the statistical result of DAS and

Powerstats. Prediction models will be built based on the hypothesis regarding the success measurement and will be confirmed through the NSOPF data[1].

There will be 4 hypotheses tested in this work. The first hypothesis tests to see if gender affects the full-time status of STEM faculty at two-year public schools. The second tests if gender has any influence on the earnings of two-year institution faculty. The third hypothesis is whether gender is affects ascension to professorship of STEM faculty in two-year institutions. The forth hypothesis looks at gender and the highest degree obtained.

Background

STEM definition

There is no standard definition of STEM. Scholars define STEM from different perspectives, for different purposes and by using different (or no) coding schemes. Broadly, STEM is classified by either education or occupational definitions. Through meta-analysis, we created a standardized definition of STEM that combines education and occupational definitions with NSOPF codes[5].

Educational Definitions
Most scholars focus on STEM as an academic discipline. Some use the broad categories of Science, Technology, Engineering and Math, while others define specific CIP codes. Despite the granularity of the definition, some disciplines are consistently defined as STEM. Using simple frequency of occurrence for disciplines in 44 most common public definitions, including educational institutions, the following disciplines are defined as High-STEM: mathematics, chemistry, computer science, biological sciences, physics, geometric analysis, and engineering disciplines related to computer science, electrical, chemical and mechanical.

Occupational Definitions
Another area of frequent STEM definition is occupation. Again, definitions of which fields are “STEM” varied; the most detailed used SOC codes. Occupations showing a high frequency of occurrence include: biological scientists, physicists, mathematicians, chemists, astronomy related scientists, food related technicians, chemical engineer, civil engineer, materials engineers, and electrical engineers. Occupations in natural sciences related disciplines also have a high frequency of being defined as STEM fields.

Table 1 lists STEM definition used for this work based on the high frequency of occurrence in educational and occupational definitions.

Variables Identification

Most of the literature regarding success measurement provides qualitative analysis. Palmer (2003) wrote a report that examined the differences between the subgroups of faculty and staff within the public 2-year sector.

Palmer[6] described the differences in the age reflecting the concern of the impending turnover for the gradually aging faculty. In NSOPF 1993, the total of faculty in 2-year institutions was 255,300, which increased to 370,700 faculty in fall 2003. Compared to NSOPF 1993, the percentage of faculty employed part-time increased to 64% from 62% in fall 2003. Hence, looking at part-time status in this study is considered significant as one of the factors in the predicting model.

Table1 STEM definition in NSOPF 2003[1]

NSOPF	Field of Teaching
101	Agriculture and related sciences
102	Natural resources and conservation
501	Biochem/biophysics/molecular biology
502	Botany/plant biology
503	Genetics
504	Microbiological sciences & immunology
506	Zoology/animal biology
507	Biological & biomedical sciences, other
803	Computer science
809	Information science/studies
810	Computer/info sci/support svcs, other
1101	Biomedical/medical engineering
1102	Chemical engineering
1103	Civil engineering

NSOPF	Field of Teaching
1104	Computer engineering
1105	Electrical & Comm. Engineering
1106	Engineering technologies/technicians
1107	Environmental / Env Health Eng.
1108	Mechanical engineering
1109	Engineering, other
1801	Mathematics
1802	Statistics
2501	Astronomy & astrophysics
2502	Atmospheric sciences and meteorology
2503	Chemistry
2504	Geological & Earth sciences/geosciences
2505	Physics
2506	Physical sciences, other

There are in total 370,700 faculty and staff employed in 2-year institutions both male and female. Table 2 shows the NSOPF projections for faculty in 2-year schools. Figure 1 illustrates the projected distribution of male and female faculty based on their employment status in STEM and Non-STEM related fields. It is shown that in fall 2003, there are only 13.7% or 25,100 female faculty teaching in STEM related field out of 182,500 female faculty teaching in 2-year institution. The proportion of part time has been unequal as part time are having bigger distribution either in STEM related field or in Non-STEM related field.

Table 2 Estimated Number of Faculty (1,000's) of instructional faculty and staff by employment status in public 2-year colleges Fall 2003[1]

	All Disciplines		STEM	
	Full-Time	**Part-Time**	**Full-Time**	**Part-Time**
Male	63.6	124.5	18.4	31.4
Female	61.9	120.7	9.2	15.9
Total	125.5	245.2	27.6	47.3

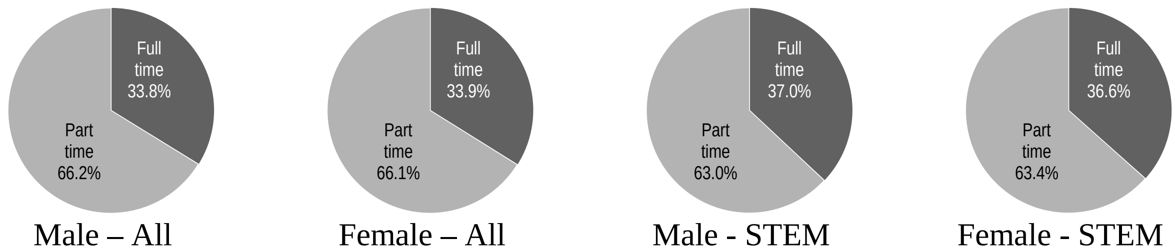

Figure 1 Percentage distribution of instructional faculty and staff by employment status in public 2-year colleges Fall 2003[1]

Salary is considered a measure of success in the academic world, and gender is often cited as affecting the compensation of faculty. Figure 2 shows the estimated proportion of faculty at the default NSOPF 2003 basic institutional salary levels. The dotted lines show all STEM faculty at public 2-year schools and the solid shows full-time faculty.

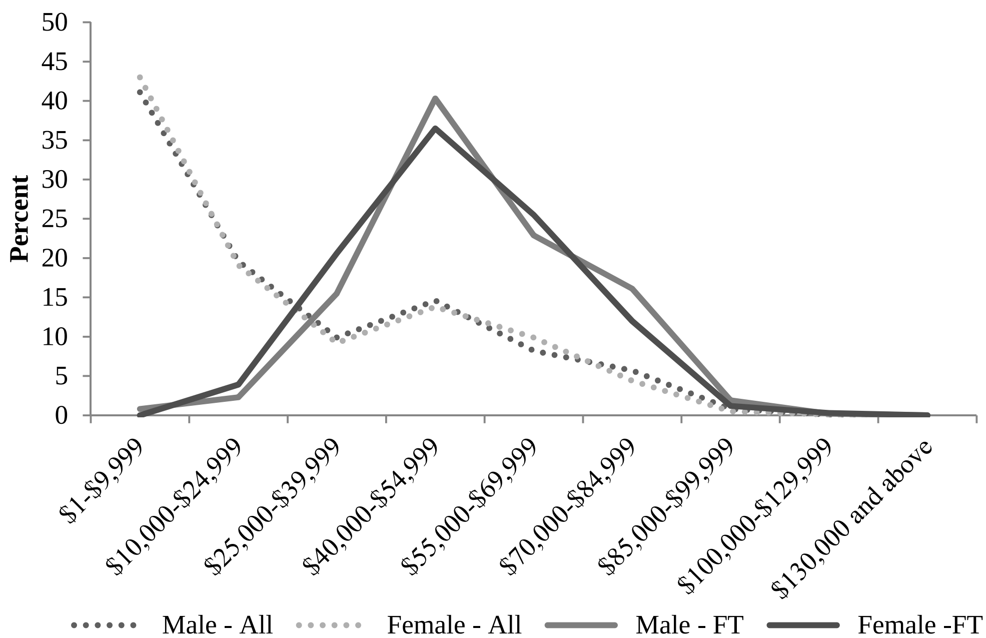

Figure 2 Percentage of STEM faculty at default salary ranges in public 2-year colleges Fall 2003[1]

Another success factor investigated in this work is rank. A graphical analysis regarding the difference of rank due gender and the result is shown in the Figure 3.

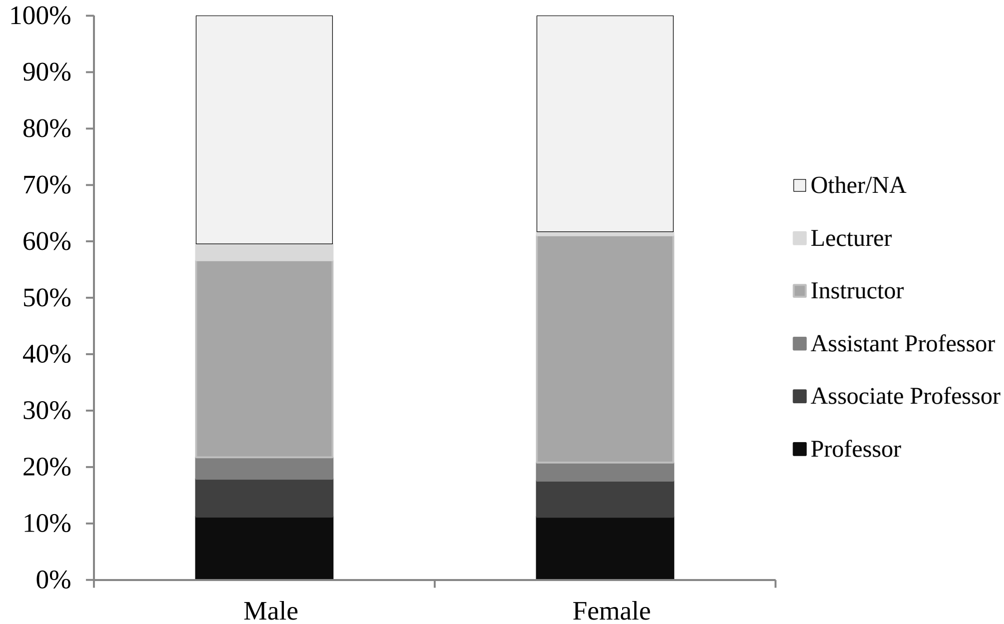

Figure 3 Percentage distribution of STEM faculty based on rank Fall 2003[1]

Highest degree is also investigated as a measure of success. A graphical analysis is shown in Figure 4. It can be seen that while males are projected to have a higher proportion with doctorates, females show a higher proportion with graduate degrees.

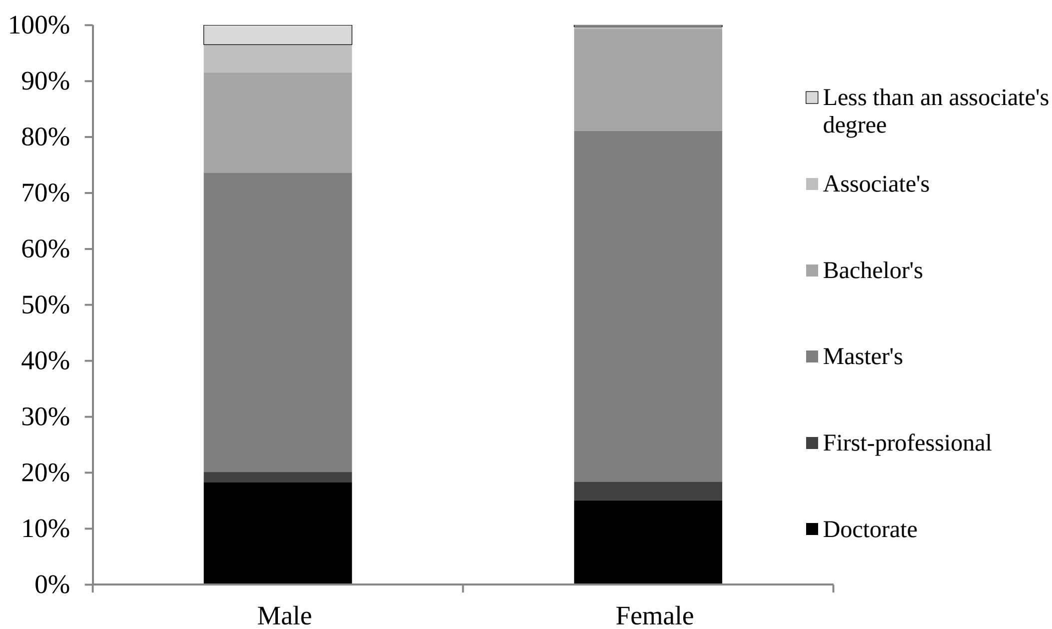

Figure 4 Percentage distribution of STEM faculty based on highest degree Fall 2003[1]

Methodology

In this paper, a statistical model will be created based on the appropriate NSOPF variables. The estimates of the variables were based on a questionnaire to faculty in NSOPF 2003, which was derived from a sample. The National Center of Education Statistics (NCES) provides online statistical tools DAS[2] and Powerstats[3] to analyze the results. The statistical method used for this paper has been implemented by various authors for NCES reports [7].

Since the estimates of this report are based the differences between two estimates, there is a risk of having a Type I error in interpreting the differences due to sampling differences. In order to minimize this risk, the statistical significance of differences between estimates was tested using a t-test. Statistical significance was determined by calculating t values for differences between pairs of means or proportions and comparing these with published values of t for two-tailed hypothesis testing, using a 5 percent probability of a Type I error (a significance level of .05)[8].

The t values may be computed to test the difference between estimates with the following formula:

$$t = \frac{E_1 - E_2}{\sqrt{se_1^2 + se_2^2}} \quad (1)$$

According to Chen, there are hazards in reporting statistical tests for each comparison. First, comparisons based on large t statistics may appear to merit special attention. This can be misleading since the magnitude of the t statistic is related not only to the observed differences in means or percentages but also to the number of sample members in the specific categories used for comparison. Hence, a small difference compared across a large number of sample members would produce a large t statistic[8].

A second hazard in reporting statistical tests for each comparison occurs when making multiple comparisons between categories of an independent variable. For example, when making paired comparisons between different levels of income, the probability of a Type I error for these comparisons taken as a group is larger than the probability for a single comparison. When more than one difference between groups of related characteristics or "families" are tested for statistical significance, one must apply a standard that assures a level of significance for all of those comparisons taken together[8].

Hypothesis 1: Gender Affects Full Time Employment

The data in table 1 shows that very little gender difference exists between the full-time employment status in STEM for faculty at two-year public institutions. To test this, a simple hypothesis test for equality is performed with a t test. The projections from NSOPF 2003 are 37% and 36.6% full-time male and female, respectively, with standard errors (using BRR) of 1.72 and 2.85. Using the t formula in equation 1 the t statistic is 0.12016 and the total comparisons of 1 the 5% critical value for a two-tailed test is 1.96.

Hypothesis 2: Gender Affects Institutional Salary

The perception is that salary is affected by gender. To test this hypothesis, the NSOPF 2003 continuous variable Q66A (basic salary from the institution) was chosen as the dependent variable in a least squares regression. The sample was restricted to STEM (using variable X09Q16, specific teaching categories, and the STEM definition given previously) and public 2-year schools (X113Q0). The independent variables were gender (Q71 – male as control), employment status (Q5 – full time as control), years since first faculty or instructional staff job (X02Q23 – continuous variable) and union (X01Q14 – with all but: “Union not available” lumped into Union). The model had an R^2 value of 0.774, and the ANOVA results are given in Table 3.

Table 3 Effect of gender, employment status, years and union on salary of STEM faculty in public 2-year colleges: Fall 2003[1]

Parameter	b	std. error	t	Probability t
Intercept	2957.39	850.886	3.476	0.001
Male	973.96	888.373	1.096	0.277
Full time	41242.96	1079.567	38.203	0.000
Years since began first faculty or instructional staff job	266.55	51.938	5.132	0.000
Union	4241.01	719.535	5.894	0.000

Hypothesis 3: Gender Affects Rank

To test gender’s effect on rank attained, the proportion of faculty at each rank was projected, by gender, for STEM faculty at two-year, public institutions using the NSOPF 2003 data, using DAS[2]. Table 4 shows the test data for each rank. With six simultaneous comparisons, the Bonferroni 5% significant value is 2.635.

Table 4 Effect of gender on rank of STEM faculty in public 2-year colleges: Fall 2003[1]

Rank	Male Proportion	Female Proportion	S.E. Male	S.E. Female	t Stat.
Professor	11.20	11.20	1.33	2.91	0.00000
Associate Professor	6.70	6.40	1.10	1.67	0.15002
Assistant Professor	3.80	3.20	0.72	0.92	0.51359
Instructor	34.90	40.30	2.17	3.48	1.31671
Lecturer	2.90	0.60	0.85	0.40	2.44833
Other/NA	40.40	38.30	2.01	3.95	0.47383

Hypothesis 4: Gender Affects Highest Degree

To test gender’s effect on highest degree attained, the proportion of faculty at each degree was projected, by gender, for STEM faculty at two-year, public institutions using the NSOPF 2003 data, using DAS[2]. Table 5 shows the test data for each degree level. With six simultaneous comparisons, the Bonferroni 5% significant value is 2.635.

Table 5 Effect of gender on highest degree of STEM faculty in public 2-year colleges: Fall 2003[1]

Rank	Male Proportion	Female Proportion	S.E. Male	S.E. Female	t Stat.
Doctorate	18.3	15.1	1.52	2.09	1.23826
First-professional	1.8	3.3	0.65	1.27	1.0514
Master's	53.4	62.7	2.21	3.28	2.35142
Bachelor's	18	18.2	1.89	3.42	0.05118
Associate's	4.9	0.4	1.11	0.26	3.94722
Less than an associate's degree	3.5	0.3	1.05	0.36	2.88288

As a secondary test, a hypothesis test was run to see if gender was determining of any graduate degree. The proportion of males projected to have graduate degrees was 73.5% and females was 81.1%, with standard errors of 2.01 and 3.44 respectively. The t statistic is 1.9075, with 5% significance again at 1.96.

Result and Analysis

Hypothesis 1 confirmed the visual observation that no significant difference exists in the proportion of public 2-year, STEM faculty who work part time, with respect to STEM. If any difference exists in full-time employment, it would appear to be between faculty in STEM and outside of STEM.

With respect to compensation, the regression model in table 2 shows that while the effect of male is positive in base salary, it is not significant when accounting for employment status, years in education and the unionization of the campus. Figure 2 clearly shows the effects on compensation of full-time status.

Rank was also shown to have no significant differences, with respect to gender. At the professorial levels, males and females have almost identical proportions. Below them, the differences appear in the proportion estimates, but the differences are not significant at the 5% system wide error rate. The largest t statistic is at the lecturer rank. However, less than 3% of males and 1% of females were projected to be at that rank in STEM disciplines.

The only test where significant differences appeared was in the highest degree attained. For individual graduate degrees, no significance was seen. And bachelor’s degrees also showed no significance. However, at the associates and below, significant differences were seen. In both cases, males showed to have more degrees than females, however the total percent of all males with these lower degrees was less than 10%. A second test to see if all graduate degrees was significant, with respect to gender, showed no significance at the 5% level.

Conclusions

Women make up large proportion of faculty at public two-year schools. While still underrepresented in STEM disciplines, success, as measured in this study, was equivalent with their male peers. While STEM faculty teach part-time in different proportions, female faculty are equally likely to obtain full-time employment. Female faculty also show no significant difference in salary across STEM disciplines, when service status and unionization are taken into account. They rise to professorial ranks at the same rates and show similar attainment of highest degrees.

In the second phase of the NSF ADVANCE grant female faculty teaching STEM faculty were interviewed at 9 Community Colleges in Ohio. As interview coding proceeds, other factors of success will emerge. These factors, if possible, will be tested with NSOPF data to see if gender differences do exist.

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