May 7, 2015

Report to the Academic Council on Faculty Salary Equity

The Academic Council's Faculty Compensation Committee delivered its biannual report on faculty salaries at the April 16 meeting of the Council. At that meeting and through private communications afterwards, Council members requested additional information, and ECAC requested that the committee provide a written report speaking to the concerns raised. The attached documents include the original report delivered at the April meeting and a supplementary document with the additional results and explanations.

Joshua Socolar
Chair, Academic Council

Report of Salary Equity Study
Fiscal Year 2014

April 16, 2015

Background

- Every two years the Faculty Compensation Committee (FCC) conducts the salary equity study.
- **Goal**: to look for evidence that average salaries of Duke faculty members differ systematically by gender or race.
- All results are descriptive in nature. One CANNOT attach causal interpretations to the results.
- FCC members:
  - Merlise Clyde, Jon Fjeld, Sunny Ladd, Jerome Reiter (chair), Pat Wolfe
  - Ad hoc member: Fan Li
  - Ex-officio: Kim Harris

Data Used in Study

- Analysis based on 969 individuals in tenure track positions.
- Exclude faculty who were in primarily administrative roles or who left the university during the year.
- Data provided by David Jamieson-Drake and Kendrick Tatum.
- FCC back and forth with David and Kendrick for (small amount of) data cleaning.

Positions by Gender and Race

	Assistant	Associate	Professor	Distinguished
Female	72	83	74	56
Male	109	144	237	195

	Assistant	Associate	Professor	Distinguished
Caucasian	137	175	261	215
Asian	32	30	34	27
Black	8	13	11	6
Hispanic	3	9	4	3
Native American	0	0	1	0
2 or More	1	0	0	0

Because of small sample sizes, in the analysis we combine all faculty who self-identified as black, Hispanic/Latino, Native American, and multi-racial in a group labelled "Underrepresented."

Gender by Division

	Female	Male	% Female
Basic Sciences	26	85	23%
Clinical Sciences	3	10	23%
Divinity	10	18	36%
Fuqua	15	70	18%
Humanities	61	76	45%
Law	15	31	33%
Natural Sciences	34	128	21%
NSoE	11	40	22%
Pratt	15	82	15%
Sanford	11	21	34%
School of Nursing	30	6	83%
Social Sciences	54	117	32%
Total	285	684	29%

Race by Division

	Caucasian	Asian	Underrepresented
Basic Sciences	84 (76%)	22 (19%)	5 (5%)
Clinical Sciences	11 (85%)	2 (15%)	0 (0%)
Divinity	23 (82%)	1 (4%)	4 (14%)
Fuqua	64 (75%)	18 (21%)	3 (4%)
Humanities	111 (81%)	11 (8%)	15 (11%)
Law	41 (89%)	3 (6%)	2 (5%)
Natural Sciences	128 (79%)	30 (18%)	4 (3%)
NSoE	45 (88%)	4 (8%)	2 (4%)
Pratt	75 (77%)	15 (15%)	7 (8%)
Sanford	27 (84%)	2 (6%)	3 (10%)
School of Nursing	32 (88%)	3 (8%)	1 (4%)
Social Sciences	146 (85%)	12 (7%)	13 (8%)
Total	787 (81%)	123 (13%)	59 (6%)

Overall Analysis Plan

- Question of interest: Is there evidence that average salaries differ systematically by gender or race?
- Salary = 9 month base pay (or equivalent for Basic Science or other Division/Departments with 12 month appointments or part-time faculty)
- Exclude supplementary pay (Department chairs, etc.)
- Separate analyses for
  - Assistant Professors
  - Associate Professors
  - Full Professors

Rationale for Regression Analysis

- Inaccurate to compare group averages without adjusting for other factors (available to us) that might influence salary.
- Illustration of problems with unadjusted comparisons
  - Suppose more men than women in large departments where faculty earn high salaries due to market conditions.
  - Comparing average salaries of men and women confounds department differences with potential gender differences.
- Use regression modeling to ask questions like:
  - Among faculty members with the same background characteristics, do women tend to make more/less than men?
  - Among faculty members with the same background characteristics, do Underrepresented faculty tend to make more/less than Caucasian faculty?

Statistical Methodology

Independent variables used in model to predict salary:

- Gender (285 female, 684 male)
- Race Indicators - Caucasian (787), Asian (123), and Underrepresented (59). Use Caucasian as the reference group, so we only include indicators for Asian and Underrepresented.
- Department.
- Time in Rank
- Rank at Hire
- Department Chair Indicator (Full)
- Distinguished Professor Indicator (Full)

Statistical Models: Random effects model using log transformation of salary (use robust regression techniques to minimize the influence of outliers)

Assistant Professors (n = 181)

- Independent variables: Gender, Race, Department, Rank at Hire
- Model explains 97% of the variation in log(salaries)

Gender and Race Results for 2014

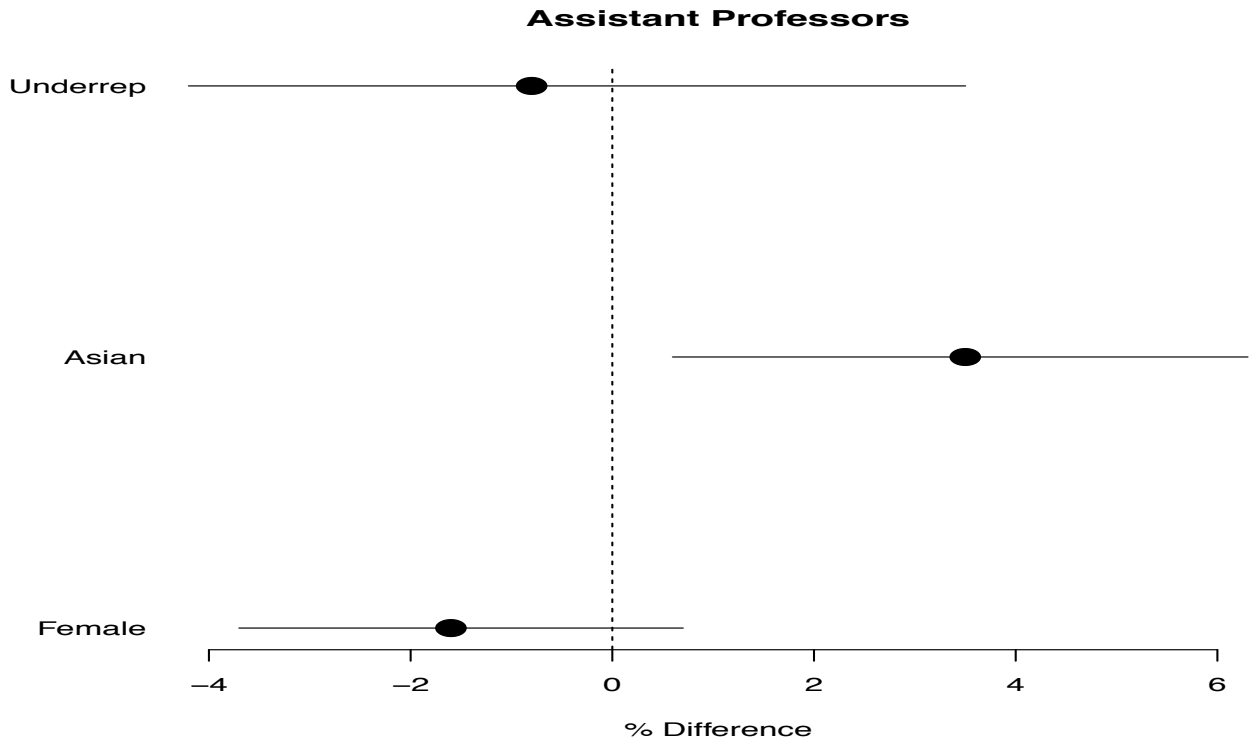
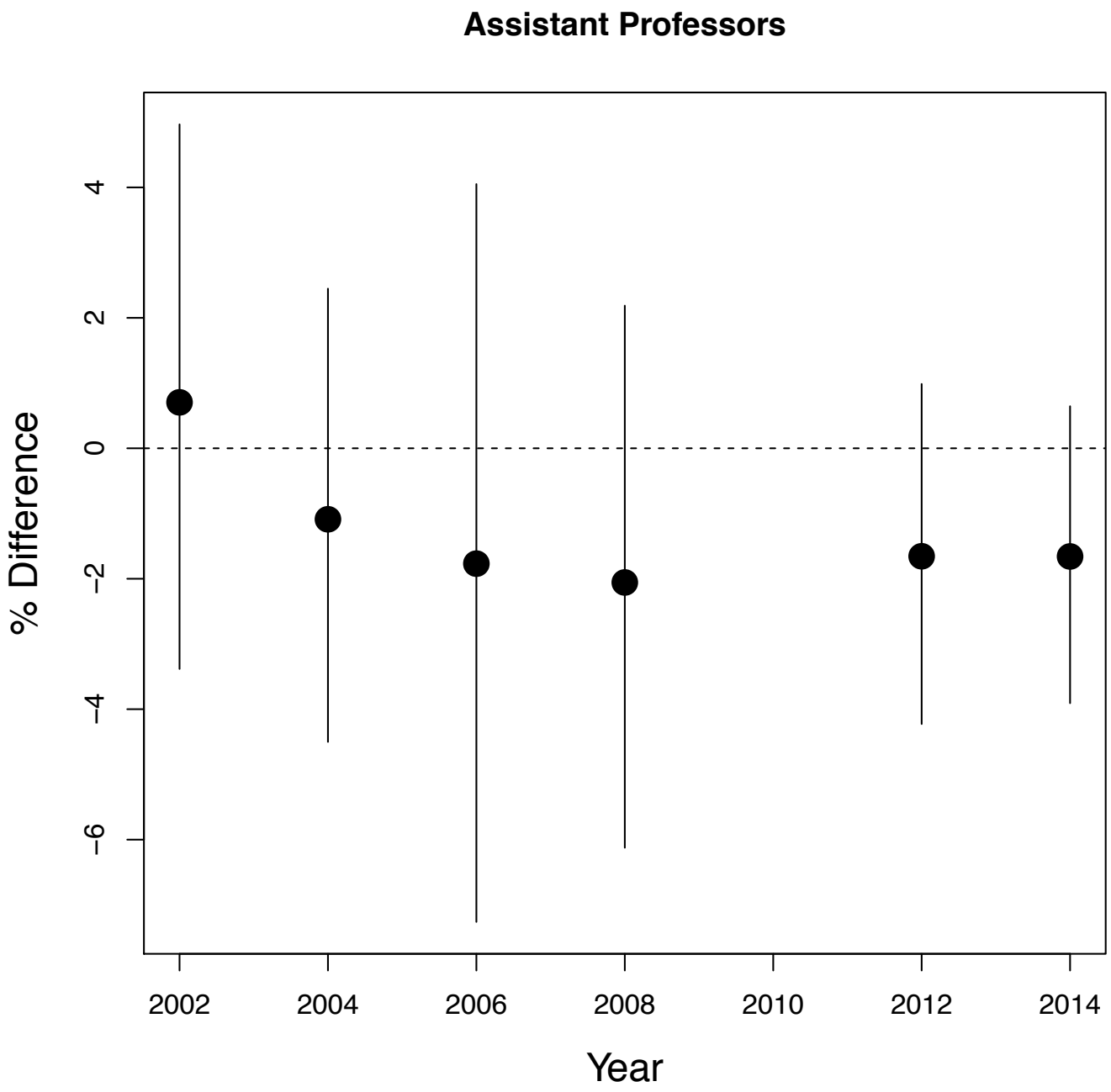


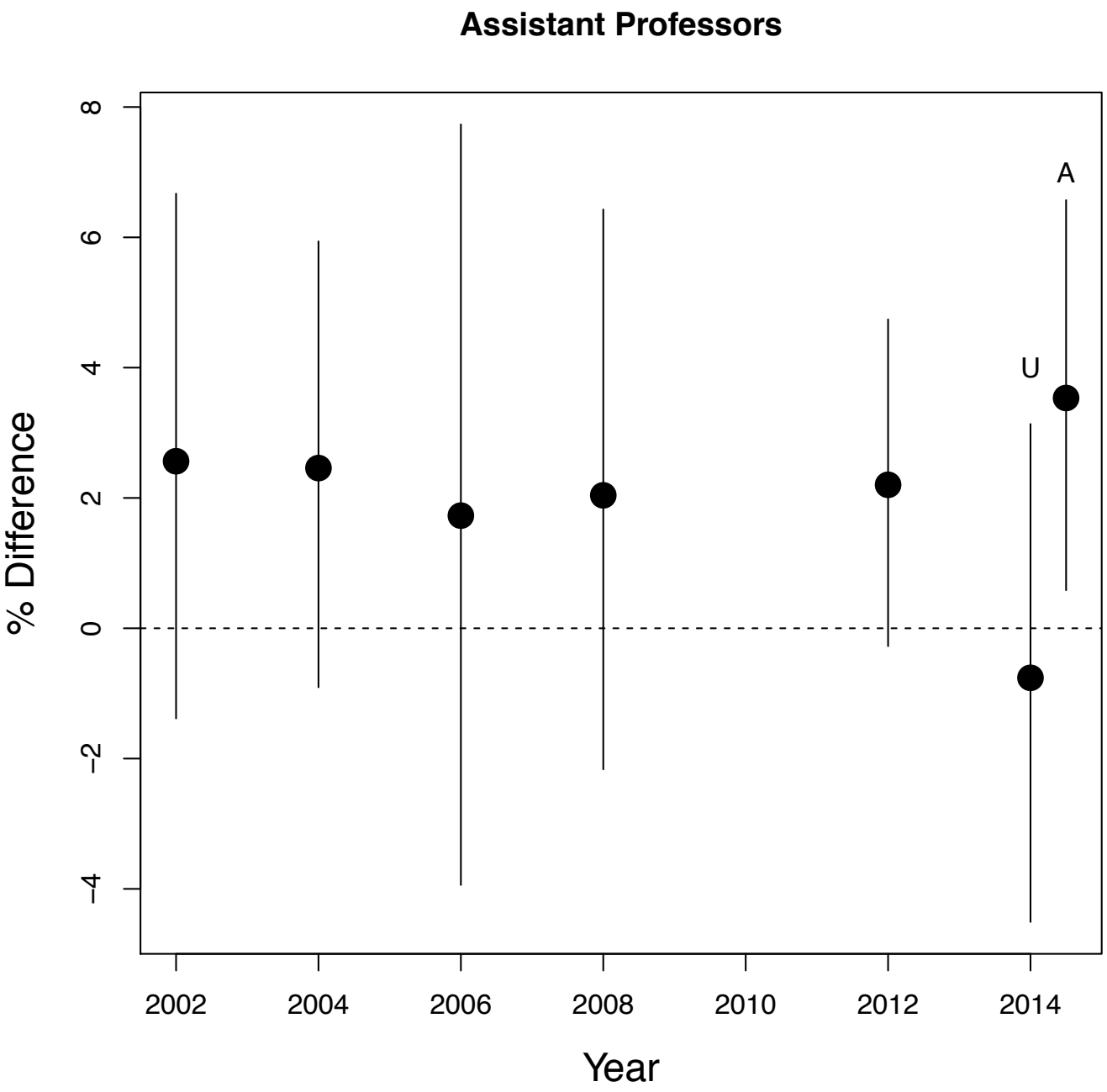
Table: Percentage difference in median salary

	n	Estimate	95% CI
Female	72	-1.6	(-3.7,0.7)
Asian	32	3.5	(0.6, 6.3)
Underrepresented	12	-0.8	(-4.2, 3.5)

Trend - Gender



Trend - Race


Assistant Professors
% Difference
8
6
4
2
0
−2
−4
A
U
2002
2004
2006
2008
2010
2012
2014
Year

Associate Professors (n = 226)

- Independent variables: Gender, Race, Department, Rank at Hire, Time in Rank
- Model explains 84% of the variation in log(salaries)

Gender and Race Results for 2014

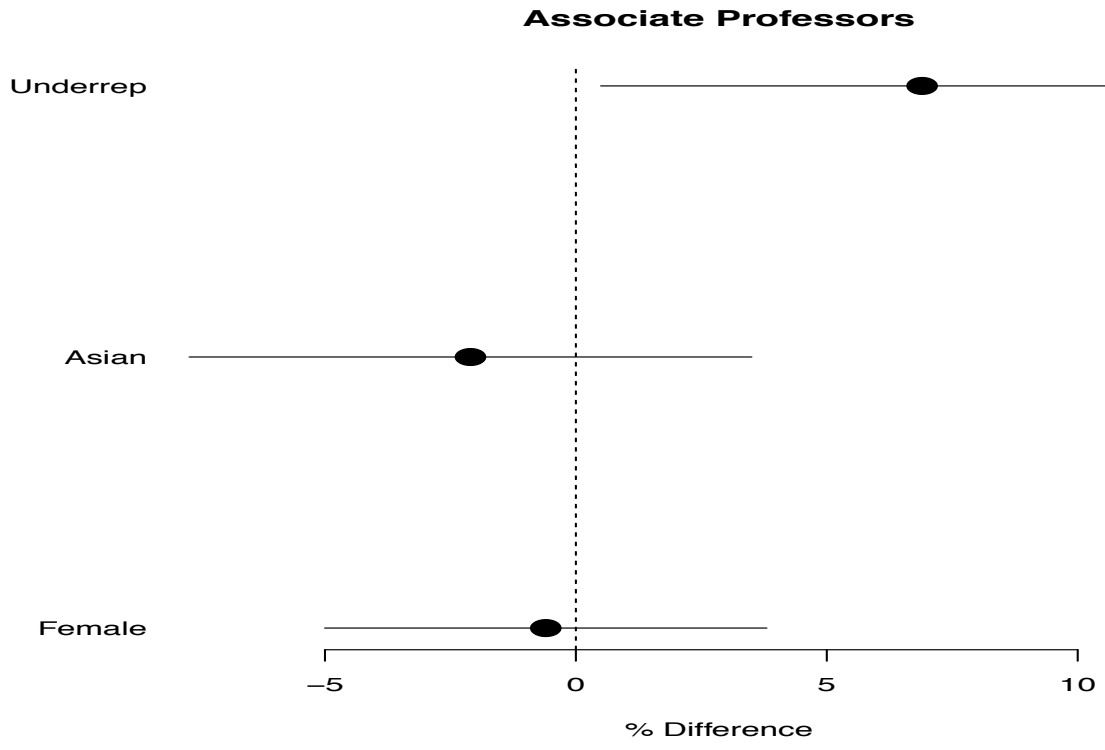
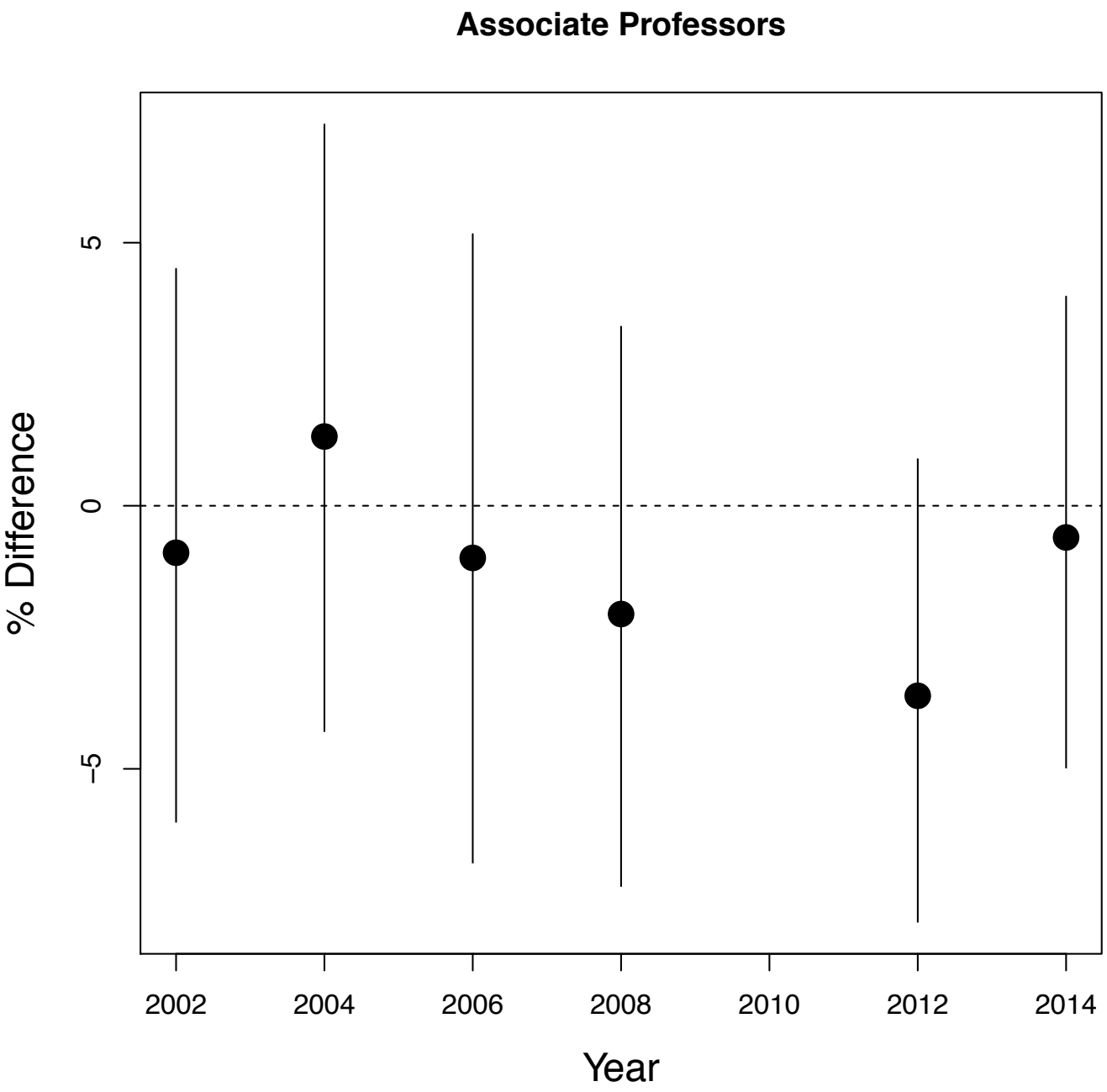


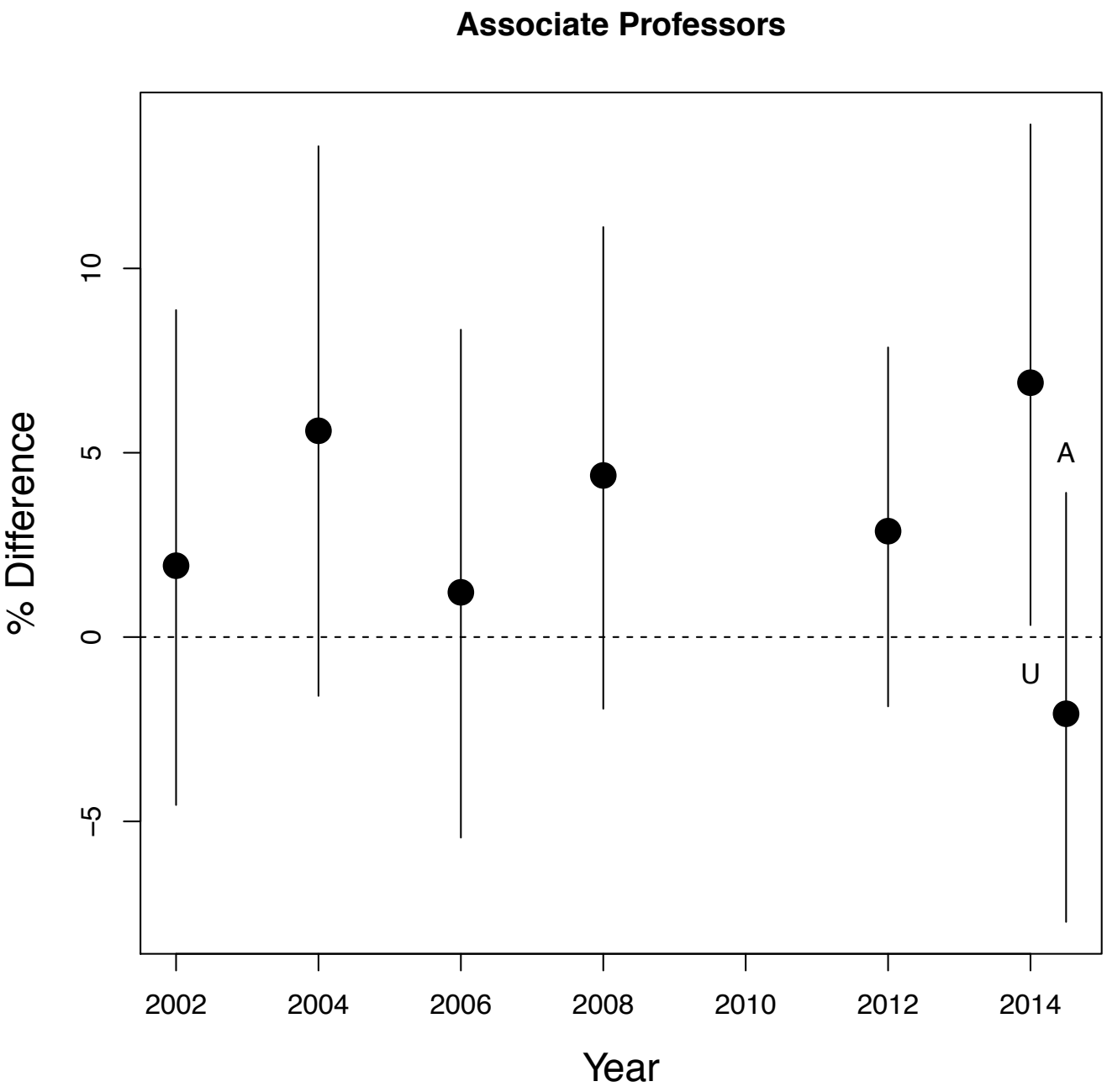
Table: Percentage difference in median salary

	n	Estimate	95% CI
Female	83	-0.6	(-5.0,3.8)
Asian	30	-2.1	(-7.7, 3.5)
Underrepresented	22	6.9	(0.5, 13.4)

Trend - Gender



Trend - Race


Associate Professors
% Difference
10
5
0
−5
A
U
2002
2004
2006
2008
2010
2012
2014
Year

Full Professors (n = 562)

- Independent variables: Gender, Race, Department, Time in Rank, Rank at Hire, Department Chair, and Distinguished Professor
- Model explains 76% of the variation in log(salaries)

Gender and Race Results for 2014

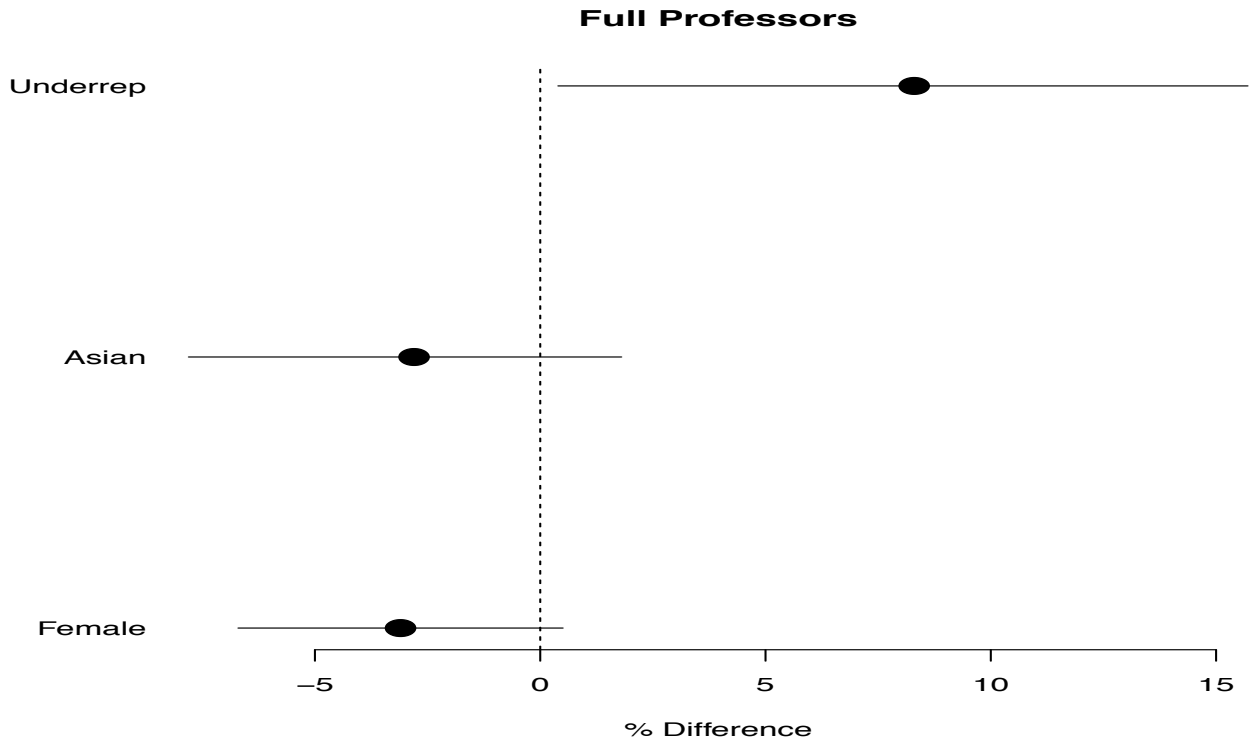
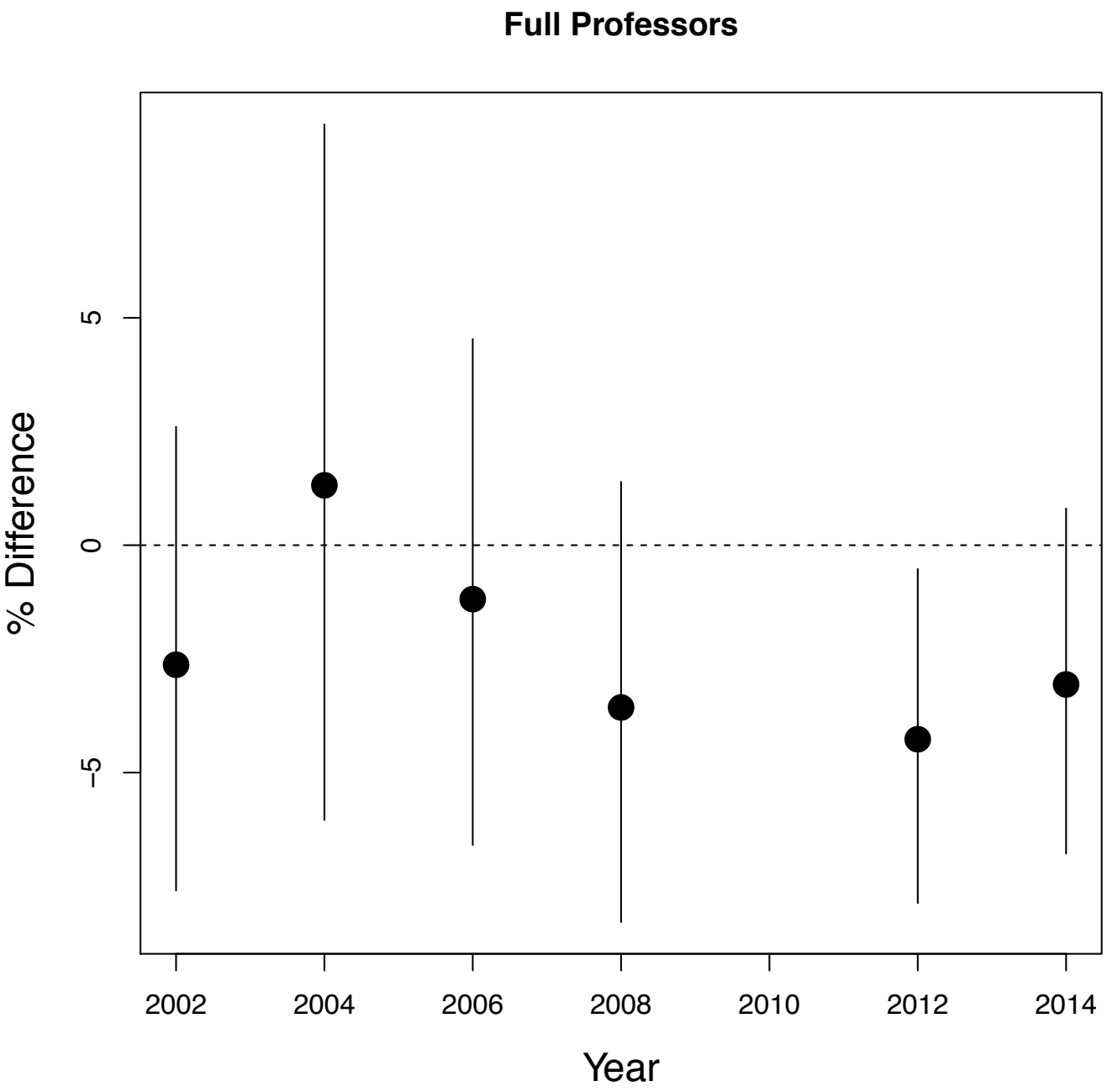


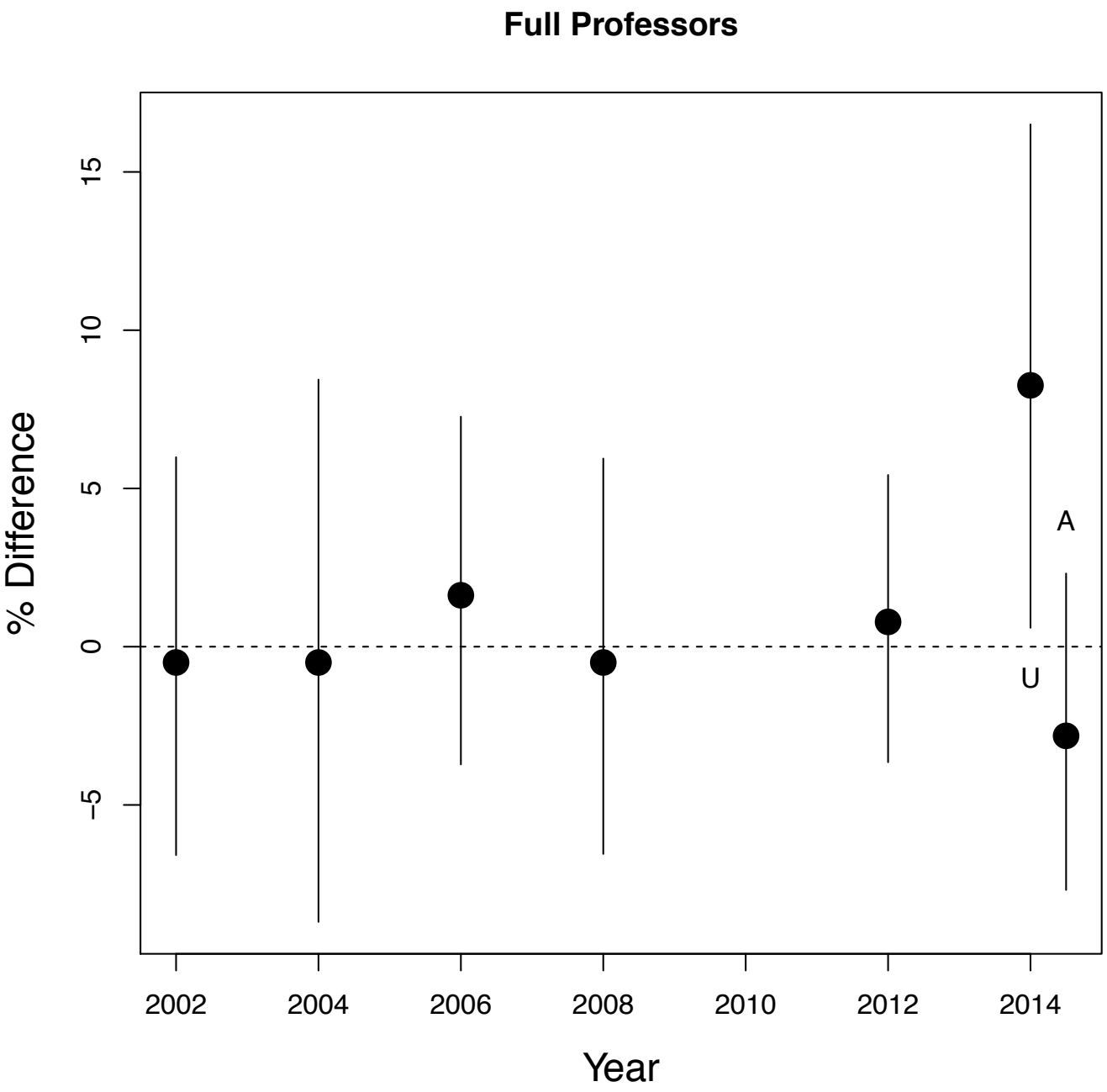
Table: Percentage difference in median salary

	n	Estimate	95% CI
Female	130	-3.1	(-6.7,0.5)
Asian	61	-2.8	(-7.8, 1.8)
Underrepresented	14	8.3	(0.4, 15.7)

Trend - Gender



Trend - Race


Full Professors
% Difference
15
10
5
0
−5
A
U
2002
2004
2006
2008
2010
2012
2014
Year

Distinguished Professors (n = 251)

- Independent variables: Gender, Race, Department, Time in Rank, New Hire, and Department Chair
- Model explains 73% of the variation in log(salaries)

Gender and Race Results for 2014

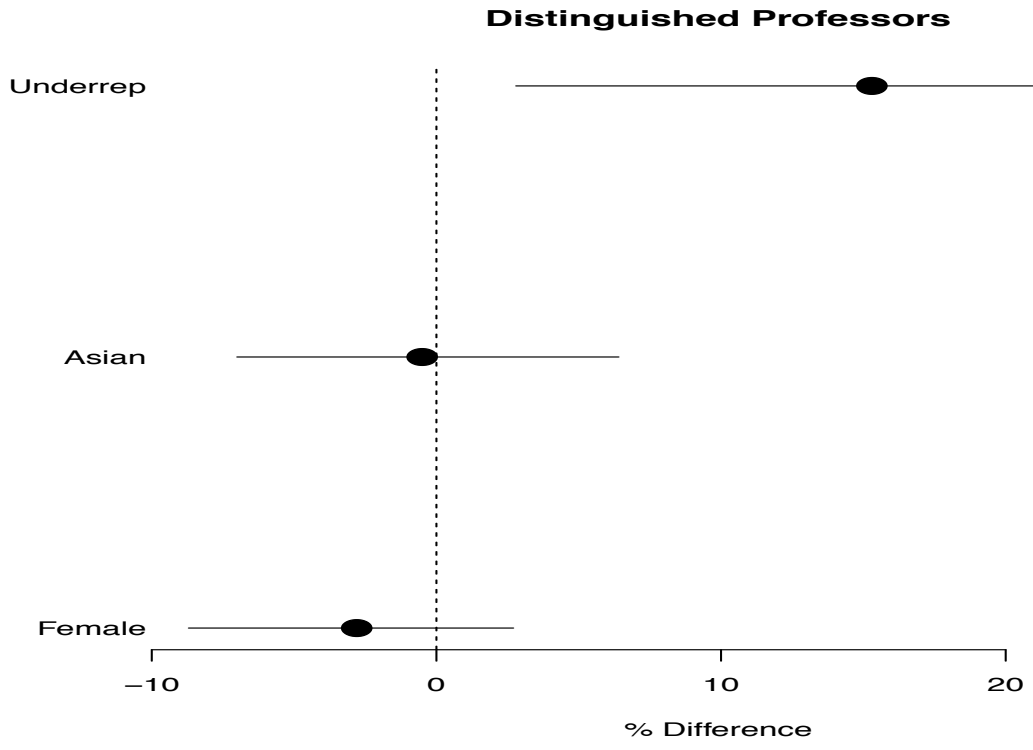


Table: Percentage difference in median salary

	n	Estimate	95% CI
Female	56	-2.8	(-8.7,2.7)
Asian	27	-0.5	(-7.0, 6.4)
Underrepresented	9	15.3	(2.8, 28.5)

Full Professors w/out Distinguished Professors (n = 311)

- Independent variables: Gender, Race, Department, Time in Rank, New Hire, and Department Chair
- Model explains 68% of the variation in Salaries

Gender and Race Results for 2014

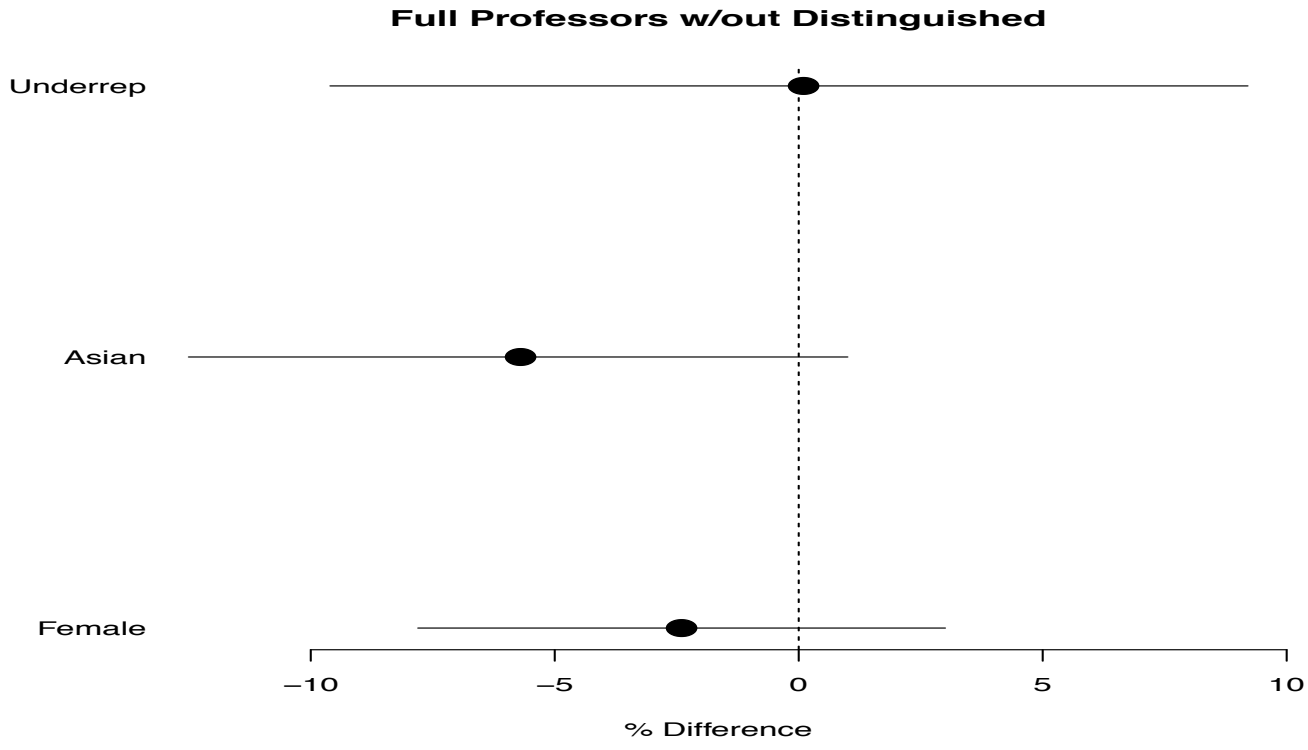


Table: Percentage difference in median salary

	n	Estimate	95% CI
Female	74	-2.4	(-7.8,3.0)
Asian	34	-5.7	(-12.5, 1.0)
Underrepresented	15	0.1	(-9.6,9.2)

Overall Conclusions from Salary Equity Study

- The FCC does not find sufficient evidence at any rank to conclude that average salaries differ systematically for men and women, after adjusting for available background characteristics.
- The FCC finds evidence at the associate and full professor rank that average salaries are higher for Underrepresented faculty members than for Caucasian faculty members, after adjusting for available background characteristics.
- The FCC finds evidence at the assistant professor rank that average salaries are higher for Asian faculty members than for Caucasian faculty members, after adjusting for available background characteristics.

Supplementary Material for 2014 Salary Equity Study

This document includes supplementary material for the 2014 Salary Equity Study report. The study was conducted by the Faculty Compensation Committee (FCC) and presented to Academic Council on April 16, 2015. Section 1 includes coefficient estimates and 95% posterior intervals for the regression models at the assistant, associate, and full professor ranks. The estimates of the coefficients for gender and race were included in the report to Academic Council. Section 2 presents average salaries by rank for the population under study. It includes some speculative explanations for why the ratios of female to male average salaries at Duke reported in an article in the Chronicle of Higher Education (CHE) (`http://chronicle.com/article/2013-14-AAUP-Faculty-Salary/145679/#id=198419`) differ from those for other universities.

Descriptive statistics for the 969 faculty used for the analysis are presented in the report to Academic Council. The Clinical Sciences faculty include faculty on tenure track in Biostatistics and Bioinformatics.

1 Detailed results of regression models

The FCC used regression models that predict log(salary) from several explanatory variables, described in Table 4 at the end of this supplement. The model uses a robust regression (t-distributed rather than normally distributed errors) and random effects for departments. Models are estimated separately by rank.

For each variable j included in a particular model, we estimate its regression coefficient, $\hat{\beta}_j$, and 95% posterior interval using a well-accepted Bayesian model fitting procedure. When reporting results, to aid interpretation we exponentiate the coefficient estimates and 95% posterior interval limits. This allows for the following types of interpretations. We expect Duke

to pay a median salary to female assistant professors that is about 98.4% of the median salary of male assistant professors with the same background. Because we treat the reported faculty salaries as a sample of the salaries that Duke faculty could have hypothetically been paid, each $\hat{\beta}_j$ is an uncertain estimate of a corresponding true, unknown coefficient. Under this interpretation, we believe that there is a 95% chance that Duke pays female assistant professors a median salary that is between 96.1% and 100.6% of the median salary of similar male assistant professors. Note that we use median salaries rather than average salaries when interpreting the results of the regression; this is a consequence of using the log(salary) as the dependent variable.

The report to Academic Council presents results for the female and race coefficients only, and on a slightly different scale. In the report, we subtract one from all exponentiated numbers, so that the results are interpreted as a percentage difference. For example, rather than report the 98.4% from the regression models, we state that female assistant professor salaries are 1.6% lower than male assistant professor salaries. See Table 1 for results for assistant professors, Table 2 for results for associate professors, and Table 3 for results for full professors. All tables are at the end of the document.

2 Average Salary by Gender

At the presentation in Academic Council, several faculty requested more details on salary distributions by gender. These questions were motivated by the article in the CHE, which reported the ratios of average female to male salaries by rank for Duke and other institutions. The ratios at Duke, particularly for assistant professors, were noticeably lower than the ratios for peer institutions.

Using the data provided by David Jamieson Drake's office, we found that the average salary for female assistant professors is about 85% of the average salary for male assistant professors.

The corresponding percentages for associate and full professors are 92.5% and 94.9%. For professors with distinguished chairs the percentage is 93.4%. See Table 5 for details.

These university-wide averages mask differences across units at Duke. For example, as evident in Table 6, in Arts & Sciences we see large disparities in the Social Sciences (ratio of 77%) compared to the Natural Sciences (ratio of 96%) and Humanities (ratio of 100%). Such differences demonstrate the importance of not ignoring department when comparing average salaries for male and female faculty members. Simply comparing average salaries across all of Duke is not appropriate; one should compare averages after accounting for differences across departments (and other characteristics), as done with the regression model.

The substantial gender gap in salaries in the Social Sciences reflects departmental differences in gender distributions. Faculty in the Department of Economics tend to have the largest salaries, more than 1.6 times the typical faculty salary at Duke at the assistant professor level (whereas assistant professors in most social science departments earn close to the typical salary). The Economics department has comparatively small numbers of female tenure track assistant professors — the home page of the Economics department lists 12 tenure track assistant professors of whom one is female. This gender imbalance in a department with comparatively high salaries tilts the overall average among Social Science assistant professors toward higher rates for men.

The FCC did not investigate why Duke has low percentages of female to male average salaries, particularly among assistant professors, in the CHE salary study. Here, we offer two speculative explanations that could be examined in a future study. Should such studies be commissioned, we recommend making resources available (e.g., hours from work-study students) to collect relevant data as needed.

- *Departmental gender balance differences across universities.* The gender imbalances that produced the large disparity in the Social Sciences at Duke could be present in vary-

ing degrees at other universities. For example, based on current (May 2015) departmental home pages, in the Department of Economics at Harvard there are 5 assistant professors of whom one is female; and in the Department of Economics at MIT there are 3 assistant professors of whom one is female. If assistant professors in the Economics departments at these universities are compensated at market premiums present at Duke, the university-wide average salaries at Harvard and MIT may not be as strongly tilted towards males as those for Duke. Checking this explanation would be difficult, as one would need the average salary and faculty count by department at peer universities.

- *Inconsistencies in data and reporting.* The FCC worked closely with David Jamieson-Drake to clean data errors and assure the most appropriate universe for analysis. The FCC computes the university-wide female/male average salary ratio for assistant professors to be 85%, whereas the CHE reports the ratio at 80%. Given the substantial difference in the Duke ratio and CHE ratio, it suggests that the way in which data are reported could differentially impact the ratios provided by CHE for other universities. Checking this possible explanation is almost impossible, as one would need cleaned data from other universities.

[Table 1 about here.]

[Table 2 about here.]

[Table 3 about here.]

Covariate	Estimate	95% Interval
Female	0.984	(0.961, 1.006)
Underrepresented	0.993	(0.956, 1.031)
Asian	1.035	(1.006, 1.064)
First hired in rank other than TT Assistant	0.984	(0.948, 1.019)
African and African American Studies	NA	NA
Art, Art History & Visual Studies	0.901	(0.821, 0.993)
Asian and Middle Eastern Studies	0.785	(0.725, 0.852)
Biochemistry	1.158	(1.067, 1.259)
Biology	0.910	(0.857, 0.968)
Biomedical Engineering	1.104	(1.014, 1.201)
Biostatistics & Bioinformatics	1.382	(1.252, 1.520)
Cell Biology	1.195	(1.122, 1.272)
Chemistry	0.978	(0.920, 1.039)
Civil and Environmental Engineering	NA	NA
Classical Studies	0.804	(0.739, 0.882)
Computer Science	1.126	(1.047, 1.214)
Cultural Anthropology	0.880	(0.811, 0.957)
Divinity School	0.750	(0.702, 0.799)
Earth and Ocean Sciences	0.996	(0.861, 1.157)
Economics	1.641	(1.566, 1.723)
Electrical and Computer Engineering	1.124	(1.032, 1.224)
English	0.769	(0.694, 0.855)
Environmental Sciences and Policy	1.118	(1.036, 1.208)
Evolutionary Anthropology	0.956	(0.865, 1.053)
Fuqua School of Business	1.962	(1.856, 2.068)
Germanic Languages	0.743	(0.681, 0.816)
History	0.839	(0.777, 0.907)
Immunology	1.156	(1.087, 1.233)
Literature	0.781	(0.685, 0.911)
Marine Science and Conservation	1.151	(1.030, 1.287)
Mathematics	1.066	(0.985, 1.151)
Mechanical Engineering and Materials Science	1.041	(0.948, 1.140)
Molecular Genetics and Microbiology	1.157	(1.089, 1.230)
Music	0.740	(0.646, 0.859)
Neurobiology	1.156	(1.086, 1.230)
Pathology	1.132	(0.977, 1.304)
Pharmacology & Cancer Biology	1.128	(1.045, 1.217)
Philosophy	0.898	(0.831, 0.974)
Physics	0.962	(0.871, 1.065)
Political Science	1.002	(0.932, 1.072)
Psychology and Neuroscience	0.932	(0.875, 0.996)
Religious Studies	0.914	(0.797, 1.042)
Romance Studies	0.797	(0.737, 0.862)
Sanford School of Public Policy	1.068	(1.015, 1.124)
School of Law	NA	NA
School of Nursing	1.120	(1.057, 1.184)
Slavic and Eurasian Studies	0.995	(0.869, 1.143)
Sociology	0.991	(0.889, 1.110)
Statistical Science	0.982	(0.906, 1.064)
Theater Studies	0.747	(0.654, 0.876)
Women's Studies	0.908	(0.796, 1.043)

Table 1: Assistant Professors: Exponeniated coefficients with 95% posterior intervals for all covariates in the regression.

Covariate	Estimate	95% Interval
Female	0.993	(0.950, 1.038)
Underrepresented	1.069	(1.006, 1.138)
Asian	0.979	(0.924, 1.038)
First hired as Associate	1.057	(1.013, 1.105)
Hired between 7/1/99 and 6/30/07	0.952	(0.903, 1.005)
Hired between 7/1/91 and 6/30/99	0.904	(0.814, 0.998)
Hired between 7/1/83 and 6/30/91	0.915	(0.819, 1.012)
Hired before 7/1/83	0.904	(0.715, 1.072)
African and African American Studies	1.128	(0.938, 1.342)
Art, Art History & Visual Studies	0.936	(0.747, 1.194)
Asian and Middle Eastern Studies	0.899	(0.750, 1.115)
Biochemistry	1.136	(0.965, 1.336)
Biology	0.836	(0.767, 0.910)
Biomedical Engineering	1.037	(0.917, 1.176)
Biostatistics & Bioinformatics	1.343	(1.194, 1.512)
Cell Biology	0.960	(0.826, 1.124)
Chemistry	0.900	(0.779, 1.041)
Civil and Environmental Engineering	0.960	(0.877, 1.052)
Classical Studies	0.907	(0.759, 1.086)
Computer Science	0.929	(0.814, 1.056)
Cultural Anthropology	0.929	(0.772, 1.109)
Divinity School	0.751	(0.690, 0.814)
Earth and Ocean Sciences	1.024	(0.820, 1.269)
Economics	1.937	(1.751, 2.137)
Electrical and Computer Engineering	1.073	(0.992, 1.163)
English	0.980	(0.848, 1.138)
Environmental Sciences and Policy	1.006	(0.892, 1.140)
Evolutionary Anthropology	0.980	(0.794, 1.220)
Fuqua School of Business	1.664	(1.567, 1.763)
Germanic Languages	NA	NA
History	0.841	(0.774, 0.917)
Immunology	1.128	(0.872, 1.430)
Literature	0.757	(0.640, 0.897)
Marine Science and Conservation	1.099	(0.977, 1.237)
Mathematics	0.869	(0.728, 1.031)
Mechanical Engineering and Materials Science	1.034	(0.940, 1.145)
Molecular Genetics and Microbiology	1.092	(1.000, 1.194)
Music	0.799	(0.685, 0.934)
Neurobiology	1.086	(0.936, 1.263)
Pathology	0.787	(0.631, 1.033)
Pharmacology & Cancer Biology	1.098	(0.968, 1.258)
Philosophy	0.862	(0.683, 1.094)
Physics	0.840	(0.745, 0.957)
Political Science	1.152	(1.051, 1.259)
Psychology and Neuroscience	0.850	(0.735, 0.978)
Religious Studies	0.941	(0.796, 1.112)
Romance Studies	0.886	(0.783, 1.001)
Sanford School of Public Policy	1.050	(0.925, 1.188)
School of Law	1.487	(1.317, 1.663)
School of Nursing	1.093	(1.007, 1.187)
Slavic and Eurasian Studies	0.857	(0.701, 1.060)
Sociology	1.094	(0.921, 1.295)
Statistical Science	1.009	(0.856, 1.188)
Theater Studies	NA	NA
Women's Studies	0.882	(0.761, 1.033)

Table 2: Associate Professors: Exponeniated coefficients with 95% posterior intervals for all covariates in the regression.

Covariate	Estimate	95% Interval
Female	0.970	(0.934, 1.008)
Underrepresented	1.081	(1.006, 1.162)
Asian	0.972	(0.925, 1.022)
Department Chair	1.172	(1.104, 1.248)
First hired as Full	1.154	(1.117, 1.196)
Distinguished Chair	1.278	(1.235, 1.320)
Hired between 7/1/99 and 6/30/07	1.015	(0.979, 1.054)
Hired between 7/1/91 and 6/30/99	1.003	(0.953, 1.053)
Hired between 7/1/83 and 6/30/91	0.942	(0.890, 1.000)
Hired before 7/1/83	0.966	(0.890, 1.047)
African and African American Studies	0.951	(0.779, 1.162)
Art, Art History & Visual Studies	0.910	(0.819, 1.012)
Asian and Middle Eastern Studies	0.857	(0.721, 1.024)
Biochemistry	1.039	(0.920, 1.177)
Biology	0.817	(0.757, 0.884)
Biomedical Engineering	1.007	(0.922, 1.097)
Biostatistics & Bioinformatics	0.976	(0.767, 1.215)
Cell Biology	1.089	(0.970, 1.225)
Chemistry	1.048	(0.938, 1.175)
Civil and Environmental Engineering	1.015	(0.910, 1.141)
Classical Studies	0.802	(0.692, 0.936)
Computer Science	1.024	(0.924, 1.136)
Cultural Anthropology	0.926	(0.818, 1.046)
Divinity School	0.697	(0.637, 0.767)
Earth and Ocean Sciences	0.890	(0.802, 0.986)
Economics	1.556	(1.437, 1.675)
Electrical and Computer Engineering	1.131	(1.037, 1.236)
English	1.008	(0.913, 1.107)
Environmental Sciences and Policy	0.991	(0.903, 1.089)
Evolutionary Anthropology	0.843	(0.739, 0.964)
Fuqua School of Business	1.579	(1.485, 1.680)
Germanic Languages	0.844	(0.689, 1.044)
History	0.890	(0.809, 0.978)
Immunology	1.082	(0.944, 1.243)
Literature	1.233	(1.103, 1.374)
Marine Science and Conservation	0.835	(0.702, 1.008)
Mathematics	0.943	(0.872, 1.021)
Mechanical Engineering and Materials Science	1.037	(0.932, 1.146)
Molecular Genetics and Microbiology	1.275	(1.121, 1.438)
Music	0.820	(0.707, 0.947)
Neurobiology	1.240	(1.039, 1.480)
Pathology	1.055	(0.919, 1.214)
Pharmacology & Cancer Biology	1.136	(1.031, 1.249)
Philosophy	0.836	(0.744, 0.944)
Physics	0.795	(0.737, 0.857)
Political Science	1.207	(1.112, 1.317)
Psychology and Neuroscience	1.048	(0.969, 1.137)
Religious Studies	0.839	(0.742, 0.951)
Romance Studies	0.944	(0.836, 1.061)
Sanford School of Public Policy	1.122	(1.007, 1.248)
School of Law	1.381	(1.301, 1.473)
School of Nursing	1.077	(0.949, 1.234)
Slavic and Eurasian Studies	0.801	(0.654, 0.990)
Sociology	1.142	(1.036, 1.264)
Statistical Science	1.024	(0.901, 1.173)
Theater Studies	0.939	(0.728, 1.214)
Women's Studies	0.966	(0.752, 1.234)

Table 3: Full Professors: Exponeniated coefficients with 95% posterior intervals for all covariates in the regression.

Variable	Description
Gender (self-report)	1 if female, 0 if male
Race (self-report)	Caucasian (reference group), Asian, and Underrepresented
Department	Separate indicator for each department (47 total)
Time in Rank	Number of years served at Duke, grouped in bins of 8 years as follows:
	Hired after 7/1/07 (reference group)
	Hired between 7/1/99 and 6/30/07
	Hired between 7/1/91 and 6/30/99
	Hired between 7/1/83 and 6/30/91
	Hired before 7/1/83
Rank at Hire	Rank hired at Duke, defined as follows:
	assistant professors: 1 if hired in rank other than asst. prof., 0 otherwise
	associate professors: 1 if hired in rank other than assc. prof., 0 otherwise
	full professors: 1 if hired in rank other than full prof., 0 otherwise
Department Chair	1 if Department chair and 0 otherwise
Distinguished Chair	1 if holds a distinguished chair, 0 otherwise.
	Excludes rotating chairs such as Bass professors.

Table 4: Independent variables used in models to predict salary. Note that Distinguished Chair and Chair only relevant for full professor regression.

	Assistant	Associate	Full	Distinguished
Female	95974	121890	157217	219556
Male	112891	131767	164682	235109

Table 5: Average salaries for all Duke faculty in salary equity study, broken out by rank.

	Number faculty	Female Avg. Sal.	Male Avg. Sal.	Ratio
Basic Sciences	31	107025	107676	0.99
Humanities	24	74777	74985	1.00
Natural Sciences	29	89550	93006	0.96
Social Sciences	29	94831	122962	0.77

Table 6: Average salary for assistant professors in selected units at Duke. For purposes of confidentiality, only units with at least 20 assistant professors reported.