Gender inequality in faculty and instructor salaries at Carleton

Root Gorelick
28 February 2018 [abstract added 9 May 2018]

Abstract

Oaxaca-Blinder decomposition demonstrates gender inequality in salaries of faculty and instructors at Carleton University. After accounting for confounding variables, my analysis revealed significant discrimination in wages for female employees at Carleton, depending on their faculty (arts: $2,837; engineering: $6,720; public affairs: $3,854; science: $5,828; instructors: $5,580). Women in business earn $3,258 less than men, but this difference was not statistical significance, likely because of small sample size. I strongly recommend that Carleton increase base pay for all female faculty members by the above amounts. These amounts will and should vary between faculties because of past unequal treatment, especially due to negotiated salaries at hiring. I also recommend increasing base pay and increasing previous pension contributions for all female faculty members, back-dated from year of hire, using percentage differences calculated from Oaxaca-Blinder decomposition. Oaxaca-Blinder decomposition is the gold-standard amongst labour economists and was the methodology used by McMaster, Simon Fraser, and University of British Columbia when they corrected similar gender inequalities.

Introduction

This is a major update of the gender-salary differential study that Jennifer Stewart published for CUASA in January 2015. Not only am I using newer data (2018 versus 2014), but this analysis contains three major methodological changes: exclusion of multicolinearity, inclusion of interaction terms when appropriate, and, most prominently, adoption of Oaxaca's (1973) and Blinder's (1973) decomposition of gender differences in wages. Stewart (2015) found no statistically significant differences between female and male salaries at Carleton. By contrast, regardless of methodology that I used – all of which were different from Jennifer's – I found statistically significant salary differences between females and males in all faculties except for business.

The 2015 study used *departments/schools* as an independent variable, which was problematic in two regards. First and foremost, salaries are determined by the deans of faculties, not by department chairs or directors of schools. Therefore the natural unit for aggregating salary data at Carleton is the faculty. Second, using department/school as an independent variable precluded inclusion of interaction terms from the linear model. This was because several departments lacked either female or male faculty members, such as women's & gender studies, African studies, and (until 2015) computer science. By changing the independent variable to *faculty*, interaction terms can be included in the model. Lack of inclusion of interaction terms could have resulted in an incorrect assignment of variance to remaining terms in the model.

The 2015 study contained three variables that were highly collinear: rank, years at Carleton, and years since highest degree. Colinearity confounds analysis of variance and regression, violating many model assumptions and often resulting in improperly ascribing variance. Here, I replaced those three variables with the single variable of year since first degree. I choose to use year since first degree for four reasons: First and foremost, years since first degree is explicitly used by management at Carleton as an input in determining base pay at initial hiring. Second, unlike year of highest degree and rank, years since first degree is generally uncorrelated with sex. Third, years since first degree can also influence salary when employees hit the CDI breakpoint or ceiling, thereby also affecting salary. Fourth, salaries at Carleton are not based on merit and do not change upon promotion. Given all these reasons, years since first degree should affect pay for the entire career of faculty at Carleton. And factors that strongly affect/predict pay at other universities, such as rank, will have a much smaller effect at Carleton.

While CUASA knows that years since first degree affects initial salary at hiring, we don't know what else goes into the recommended initial salary range that the Office of Institutional Research and Planning (OIRP) provides deans before they engage in salary negotiations with candidates. Their formula might include mean salary in the faculty or mean salary department/school, but CUASA simply does not know. This formula might be worth a Freedom of Information Act request given that OIRP clearly has an automated formula for the recommended initial salary range.

Finally, and maybe most crucially, I utilized the most widely accepted measure for quantifying disparity in wages (Blinder 1973, Oaxaca 1973) to compute the unexplained, aka discriminatory, portion of the difference between female and male CUASA faculty/instructor wages at Carleton. According to google scholar, Oaxaca (1973) has been cited over 8,000 times, while Blinder (1973) has been cited over 5,900 times.

Data

Data are from the file "CUASA SALRAT-January 2018.xls" that Sue Gilmour of OIRP sent to CUASA on 10 January 2018. As with the 2015 study, I excluded librarians. I excluded all duplicate entries, often due to cross-appointments, so that each individual only is listed once and in the faculty with which they hold their majority appointment. I excluded the one instructor in TSES (Technology Society & Environment Studies) because they are assigned across four of the five faculties.

I separated out Instructors (I, II, III) from Professors (Assistant, Associate, Full) for four reasons. First, there is usually no progression from instructor ranks to professor ranks. Second, in the past, instructors were hired without PhDs, whereas professors had PhDs. Third, and this is related to the previous reason, instructors have a different CDI (career development increment) formula than professors. Fourth, women outnumber men 2:1 in the instructor ranks, whereas men outnumber women 2:1 in the professor ranks.

I conducted analyses across all professors, separated out by what faculty they belong to, but could not do the same for instructors because of the small number of instructors in some faculties (e.g. only three in engineering). Most instructors are in a single faculty, Arts & Social Sciences, also providing cause of aggregating instructor data across all five faculties.

I used wage ("annual rate of pay") as the dependent variable in all analyses, in lieu of the natural logarithm of salary, because salaries at Carleton are confined to a fairly limited range, with lowest and highest salaries separated by only about a factor of 3 and a factor of only 2.5 when restricting attention to professors.

Methods

To analyze the SALRAT data, I used Oaxaca-Blinder decomposition (Blinder 1973, Oaxaca 1973), which is the gold-standard amongst labour economists. Oaxaca-Blinder decomposition first computes an ordinary least squares regression for only male employees, second computes a regression for only female employees, third the analysis takes the difference between those two regression equations, and finally fourth rearranges terms. The difference between the two regressions additively decomposes into so-called twofold and threefold decompositions: (1) the part of the difference in pay between the sexes that would be explained by females having identical backgrounds as their male counterparts and (2) the part of the difference in pay between the sexes that cannot be explained, and (3) any possible interactions. This second component of the unexplained pay represents how much female employees have been discriminated against.

While these methods are computationally simple (see below), bootstrapping is required to compute standard errors of estimates, for which I used the R software ‘Oaxaca’ decomposition software provided by Hlavak (2018). As a check, I also computed the Oaxaca-Blinder decomposition manually using simple regressions, which yielded identical point estimates.

The equations for the Oaxaca-Blinder decomposition are given as follows, where *w* is wage, *yr* is year since first degree, and greek letters are parameter estimates (α = intercept, β = slope, ε = residual/error):

Male wage: $w_m = \alpha_m + \beta_m yr_m + \varepsilon_m$

Female wage: $w_f = a_f + b_f yr_f + e_f$

Wage difference: $w_m - w_f = \left(\alpha_m - \alpha_f\right) + \left(\beta_m y_m - \beta_f yr_f\right) + \left(\varepsilon_m - \varepsilon_f\right)$

Adding and subtracting $yr_f b_m$ from the right hand side of this equation yields the twofold decomposition of:

$$w_m - w_f = \left[\left(yr_m - yr_f\right) b_m\right] + \left[\left(a_m - a_f\right) + \left(b_m - b_f\right) yr_f\right] + \left(e_m - e_f\right)$$

The first square bracket is the <u>*explained*</u> *wage difference*, which is due to gender disparity in years since first degree. The second square bracket is the <u>*unexplained*</u> *wage difference*, which are the numbers provided in Table 1 and Figure 1. I ran these equations separately for each faculty for employees at professor rank (assistant, associate, full) and once for all instructors across the five faculties.

I also ran a Oaxaca-Blinder decomposition that simultaneously incorporated all five faculties, which gave similar results. Unfortunately the R software for ‘Oaxaca’ did not seem to work for explicitly including all five faculties to eliminate multicolinearity per Suits (1984) or Gardeazabal & Ugidos (2004). Therefore I had to manually adjust those categorical variables. Without this modification, one has to exclude one value of each categorical variable from the analysis and, even then, Oaxaca-Blinder decomposition is notorious for yielding different estimates depending on which value of the categorical variable was excluded. Here that would mean excluding one of the five faculties from analysis because every employee is considered to be in one and only one faculty. While I can manually adjust point estimates with all five faculties included in order to remove the errors imposed by excluding one of the faculties, I cannot manually adjust their standard errors, which still requires bootstrapping. I therefore will not be reporting those results here.

While Oaxaca-Blinder decomposition is the standard procedure in econometrics, I also ran a simple linear model (multivariate regression), which seems more intuitive to someone in science or engineering, in order to see whether this yielded comparable results. The multivariate regression model has a single dependent variable of annual pay rate, three independent variables – sex, year since first degree (*yr*), and faculty – plus all two-way and three-way interaction terms between these three independent variables:

$$\begin{aligned} w = \alpha_0 + \alpha_1 sex + \alpha_2 yr + \alpha_3 faculty \\ + \alpha_4 sex \cdot yr + \alpha_5 sex \cdot faculty + \alpha_6 yr \cdot faculty \\ + \alpha_7 sex \cdot yr \cdot faculty + \varepsilon \end{aligned}$$

Throughout the above analyses – Oaxaca-Blinder decomposition and mutivariate linear regression – even though year since first degree and wage only took on whole values (no fractions of years and no fractions of pennies), I still considered them continuous variables.

Results

For professors in each faculty and instructors across all faculties, there exists discrimination in wages for female employees; see Table 1 and Figure 1 for the numerical results. The size of this inequality for female professors varied depending on their faculty. In business, which is by far the smallest faculty at Carleton, there is insufficient statistical power to discern if the $3,258 (Oaxaca) or $3,017 (GLM) wage gap is statistically significant, i.e. if the wage gap is statistically different from zero after accounting for years since first degree. This amounts to only 2% less pay for women than men in business. Having only 44 business faculty members in any type of professor rank may have driven this statistical lack of significance. The other four faculties have statistically significant wage disparities for female faculty members of professor rank (assistant, associate, or full), after accounting for years since first degree. For professors in arts and social sciences, women make 2% less than men, i.e. $2,837 (Oaxaca) or $2,631 (GLM) per year. For professors in public affairs, women make 3% less than men, i.e. $3,854 (Oaxaca) or $3,857 (GLM) per year. For professors in science, women make 4½% less than men, i.e. $5,828 (Oaxaca) or $6,363 (GLM) per year. For professors in engineering, women make 5% less than men, i.e. $6,720 (Oaxaca) or $7,072 (GLM) per year. Instructors (I, II, III) across all faculties have statistically significant wage disparities for females after accounting for years since first degree. For instructors across all faculties, women make 5¼% less than men, i.e. $5,580 (Oaxaca) or $5,564 (GLM) per year.

For the GLM model with professors (i.e. excluding instructors), the overall F-test was highly significant ($p < 0.0031$; F-ratio = 1.3372), explaining 79% of variation ($R^2_{adj} = 0.7926$) in annual rate of pay. All three independent variables were highly significant ($p < 0.0001$), but none of the interactions terms were significant except *yr***faculty* with $p < 0.0001$. This sole significant interaction term reflects that in some fields (science and engineering) professors spend significantly more time in post-docs than in some other fields (arts and business).

For this dataset, years since first degree is not explained by sex within any of the five faculties nor for the instructors, which provides a test of one of the assumptions behind our choice of years since first degree as an independent variable.

Recommendation

Increase base pay for all female faculty members by the amounts listed in the pay disparity column via Oaxaca-Blinder decomposition highlighted in Table 1. These amounts will and should vary between faculties because of past unequal treatment, especially of negotiated salaries at hiring. However, this recommendation would only restore gender equity going forwards; it would not provide reparations for gender-bias in previous years nor adjustments to pension contributions. I therefore also recommend increasing base pay (as was done at UBC; Bradshaw (2013)) and increasing previous pension contributions for all female faculty members, backdated from the year they were hired, using the percentage differences calculated by the Oaxaca-Blinder decomposition. While both analyses, Oaxaca-Blinder decomposition and GLM, provide similar numbers, we recommend using the Oaxaca-Blinder decomposition simply because that is the gold standard for labour economists working with gender-pay inequities.

Acknowledgments

Sue Bertram of Carleton University and Tricia Johnson of Rush University provided many of the methodological ideas underlying this work. Their assistance here may even rise to the level of co-author status for which I owe them many thanks. Thanks also to Jennifer Stewart of Carleton University and Surrey Walton of University of Chicago at Illinois for helpful discussions on methodology.

References

Blinder AS (1973) Wage discrimination: reduced form and structural estimates. *Journal of Human Resources* 8: 436-455.

Bradshaw J (2013) UBC gives all female tenure-stream faculty a 2 per cent raise. *Globe & Mail*. 2 February 2013. https://www.theglobeandmail.com/news/national/education/ubc-gives-all-female-tenure-stream-faculty-a-2-per-cent-raise/article8150659/.

Gardeazabal J, Ugidos A (2004) More on identification in detailed wage decompositions. *Review of Economics and Statistics* 86: 1034=1036.

Hlavac M (2018) oaxaca: Blinder-Oaxaca decomposition in R. https://CRAN.R-project.org/package=oaxaca.

Oaxaca R (1973) Male-female wage differentials in urban labor markets. *International Economic Review* 14: 693-709.

Stewart J (2015) Analysis of gender differential in faculty salaries at Carleton University. http://cuasa.ca/wp-content/uploads/2016/09/payequitystudy.pdf.

Suits DB (1984) Dummy variables: Mechanics V. Interpretation. *Review of Economics and Statistics* 66: 177-180.

Table 1. Differences between male and female wages, accounting for years since first degree

Faculty	Oaxaca (SE)	GLM (SE)	Oaxaca minus GLM	Oaxaca ratio F/M	GLM ratio F/M
Arts	2,837 (1,185)	2,631 (1,425)	+205	0.978	0.979
Business	3,258 (3,063)	3,017 (3,622)	+241	0.979	0.980
Engineering	6,720 (2,255)	7,072 (2,794)	-352	0.953	0.951
Public Affairs	3,854 (1,730)	3,857 (1,719)	-2	0.972	0.971
Science	5,828 (2,611)	6,363 (2,267)	-534	0.958	0.954
Instructors (across faculties)	5,580 (2,841)	5,564 (2,419)	+16	0.947	0.947

Oaxaca = unexplained difference between male and female salaries from Oaxaca-Blinder decomposition (dollars)
GLM = difference in pay due to being female from general linear model (dollars)
SE = standard error (dollars).

All differences are statistically different from zero, except in the faculty of business, in which neither the Oaxaca nor GLM difference is statistically different from zero. However, sample size is sufficiently small in business (44 people of professor rank) resulting in a lack of statistical power, for which we should not penalize female business professors.

Highlighted amounts are what female base salaries should be increased by to achieve gender-pay equity going forwards.

$$\text{Oaxaca ratio} = \frac{\bar{w}_m - unexplained}{\bar{w}_m} = \frac{\bar{w}_m - \left[\left(a_m - a_f\right) + \left(b_m - b_f\right) y_f\right]}{\bar{w}_m}$$

$$\text{GLM ratio} = \frac{\text{GLM}_m - \,difference}{\text{GLM}_m}$$

Figure 1. Differences between male and female wages, accounting for years since first degree