Analysis on Hiring process and Promotion in Black Saber Software

Testing existence of gender effect in the model

Report prepared for Black Saber Software by Onyu Data

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Executive summary

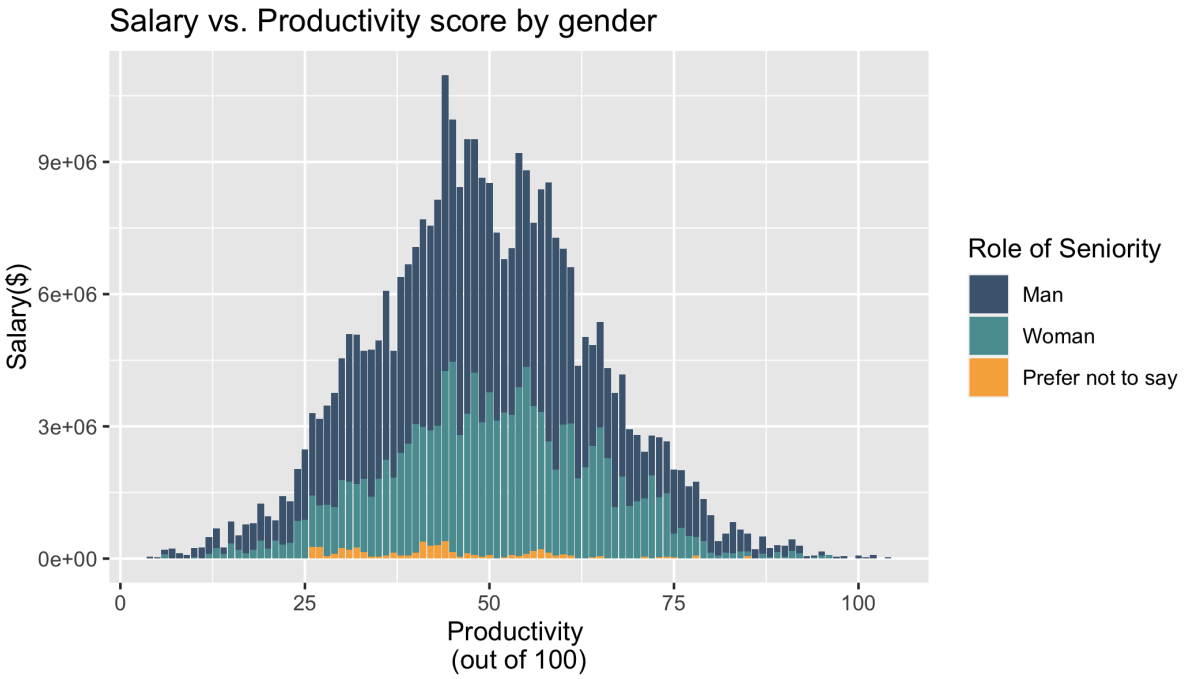
Introduction

The gender equality is still a big issue that most company needs pay attention to. The Black Saber Software company requested analysis on their hiring process and promotion to see if they have equal chance for each gender. They have provided three data sets for each of their hiring phases and one data set of current employee for promotion analysis. The aim of the study is to check for existence of gender effect in both hiring process and promotion.

Methods

To check for gender effect in hiring process and promotion, we used likelihood ratio and drop-in deviance test. For each data, we fitted the baseline model using exploratory analysis. The generalized linear model was used for three phases of hiring process. The response variable for each phase was the result of each phase indicated as 0 (did not pass) and 1 (passed). The drop-in deviance was used to compare fixed effects of models in all three phases.

The linear mixed model was used for the promotion data with salary as our response variable. The employee ID and team were chosen as our random effect. The role of seniority and leadership for level was added to our baseline model. From the data, men tend to have higher salary than than other gender wih same productivity.



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Another model was fitted with interaction of gender and productivity to see this effect is significant.

Results

In all three phases, including gender as fixed effect to the model were not significant than the baseline model. The p-values of gender and its interaction effect was not significant ($p > 0.05$) and the model when the models were compared with baseline model, we had no evidence that the model with gender effect is more significant than the baseline model.

In the analysis of promotion, the ineraction of gender and productivity was significant. From the drop-in deviance test, there was significant evidence that the complex model is better fitted mode.

Conclusion

We conclude that the hiring process is fair - the result is not dependent on gender. However, the promotion is dependent on the gender by interaction with productivity. This means that the effect of productivity on the salary is dependent the gender of the employee. Thus, we cannot say that the promotion in Black Saber Software is fair.

Technical report

Introduction

The purpose of this analysis is to address if there is any discrimination in hiring and promotion process. Specifically, we are looking for if difference in gender affects the hiring and promotion in Black Saber Software. The data is prepared from Black Saber Software by Daubry Byagogo. The hiring process of Black Saber Software have three phases. We will be analyzing each phases and see if the gender has significant effect on result of each phases. The promotion of each employee will be measured by the salary. We will be testing if including the gender provides better estimation of the salary.

Research questions

- Was the result of hiring processes (Phase 1, phase2 and phase 3) dependent on the gender?
- Are the effect of gpa, extracurriculars and work experience differ by gender of the applicant?
- Is the salary fair among all current employees, accounting to their values (productivity and leadership for level)?
- Is the model with gender provide more significant model?

The effect of gender in Hiring process

Phase1

Table 1: A snapshot of phase1 data

applicant_id	team_applied_for	cover_letter	cv	gpa	gender	extracurriculars	work_experience	result
1010	Software	0	1	1.3	Man	1	1	0
1020	Software	0	1	3.4	Woman	2	1	0
1030	Data	1	1	2.4	Woman	2	0	1
1040	Software	0	1	2.7	Man	1	1	0
1050	Data	1	0	2.1	Prefer not to say	0	1	0
1060	Software	0	1	2.6	Prefer not to say	1	1	0

For the data manipulation, we included the result of phase 1 from the list of phase2 data. For the `0` indicates applicants who did not pass phase 1 and `1` indicates applicants who passed phase 1.

Table 2: Mean values of GPA, Work experience, and extracurriculars by sex and result of phase 1

Gender	Result of Phase1	Team applied for	GPA	Work experience	Extracurriculars	n
Man	Did not pass Phase 1	Data	2.4	0.8	1.1	58
Man	Did not pass Phase 1	Software	2.3	0.8	1.0	88
Man	Passed Phase 1	Data	3.1	1.2	1.4	67
Man	Passed Phase 1	Software	3.1	1.1	1.4	78
Prefer not to say	Did not pass Phase 1	Data	2.6	0.6	0.8	5
Prefer not to say	Did not pass Phase 1	Software	2.1	1.0	1.0	3
Prefer not to say	Passed Phase 1	Data	2.8	1.0	1.0	2
Prefer not to say	Passed Phase 1	Software	2.4	1.0	2.0	1
Woman	Did not pass Phase 1	Data	2.4	0.7	1.0	61
Woman	Did not pass Phase 1	Software	2.3	0.8	1.1	98
Woman	Passed Phase 1	Data	3.2	1.1	1.3	63
Woman	Passed Phase 1	Software	3.1	1.2	1.5	89

From the table, we can see that the applicants who passed the phase 1 has higher values in all categories regardless of the sex. If we consider all the variables - gpa, work experience and extracurricular, the logit should be linearly related to these covariates. To check whether gender also accounts for the result, we can compare a model with and without a gender.

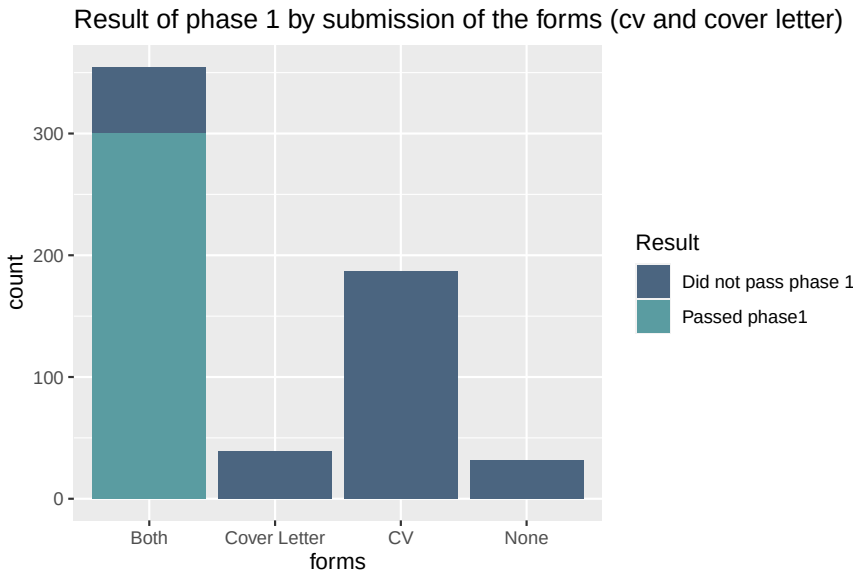


Figure 1: Result of phase 1 by submission of the forms (curriculum vitae and cover letter)

We notice that everyone who passed phase 1 submitted both cover letter and cv. Since the

response variable that we are interested in is binary (0 or 1) with random intercept, we used generalized linear model (GLM) to fit the data.

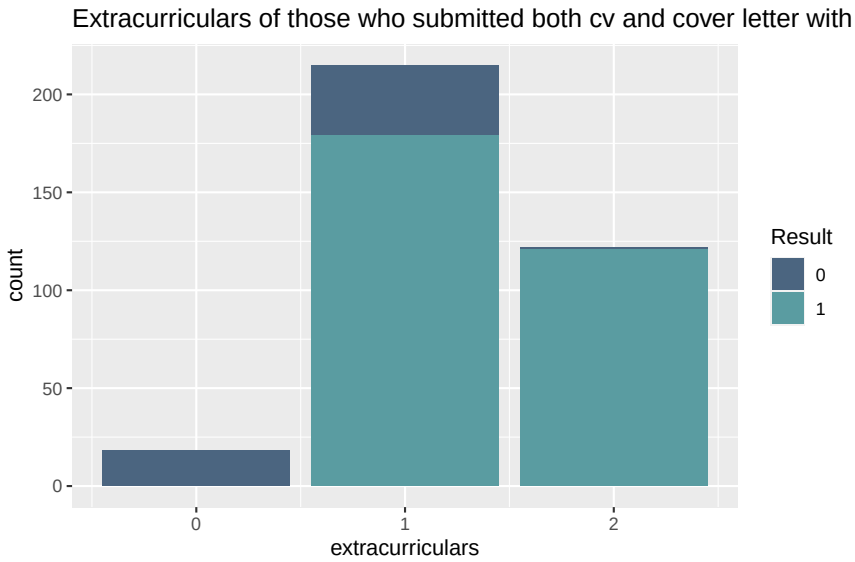


Figure 2: Phase 1 result and extracurricular of applicants who submitted both forms

We can see that those who submitted both cv and cover letter with zero extracurricular did not pass phase 1. Applicants with 3 extracurricular passed the phase 1. We can suspect that there is an interaction between forms (cv and cover letter) and extracurricular

The baseline model included GPA, work experience and effect of extracurricular when applicants submitted both Curriculum Vitae and Cover Letter to predict the result of phase 1. We also fitted two models with the gender as fixed effect and as an interaction term with GPA and work experience. The three models we used are:

- Model 1: Baseline model
- Model 2: Adding gender as fixed effect to the baseline model
- Model 3: Adding gender as interaction with GPA and work experience to the baseline model

For Model 1, all of our coefficient estimates were significant with p-value less than 0.05 where the coefficient estimate for gender in Model 2 was not significant. In Model 3, the interaction of woman and GPA and the interaction of woman and work experience was significant. To check if the addition of gender effect was significant, we used drop-in-deviance test.

Table 3: Result of likelihood ratio test

Models.compared	P.value
Model 1 vs. Model 2	0.97
Model 1 vs. Model 2	0.91

From the comparison between model 1 and 2, we do not have evidence that gender has an effect on the odds of passing phase 1. From the comparison between model 1 and model 3, we do not have a statistically significant evidence that (Wald test: $p < 0.05$) the effect of the GPA and work experience on the odds of passing phase 1 depends on the gender of the applicant. In conclusion, the gender does not have an effect on phase 1 result.

Phase 2

Table 4: Mean values of GPA, Work experience, and extracurriculars and average score of skills tested in phase 2 by sex with result of phase 2

gender	result of phase2	gpa	work experience	extracurriculars	technical skills(%)	writing skills(%)	leadership presence(%)	speaking skills(%)
Man	Did not pass Phase 2	3.1	1.1	1.4	44.3	40.1	46.8	49.2
Man	Passed Phase 2	3.3	1.1	1.5	64.8	56.1	70.0	64.0
Woman	Did not pass Phase 2	3.1	1.2	1.4	47.2	45.6	39.4	31.8
Woman	Passed Phase 2	3.5	1.4	1.9	64.9	57.9	65.7	60.0
Prefer not to say	Did not pass Phase 2	2.7	1.0	1.3	66.0	42.3	43.3	66.7

From the original data `phase2-new-grad-applicants-2020.csv`, we added phase 1 data. The cover letter and curriculum vitae were excluded since all of the applicants in phase 2 submitted both cover letter and curriculum vitae. The scores of the skills were graded by the AI. The score for speaking skills and leadership presence were converted to percentage so that all four scores have same unit. From the Table 4, applicants with higher skills score tend to pass phase 2. We asume the linear relationship between result and the skills score.

Figure 3: Score for technical, writing, speaking skills and leadership presence

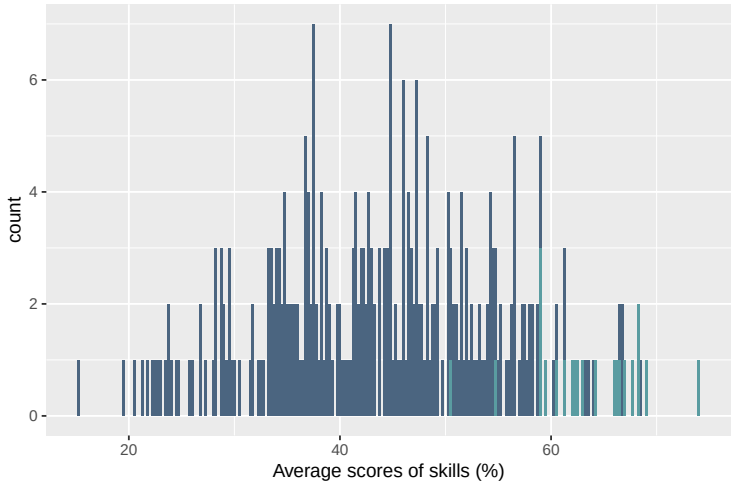
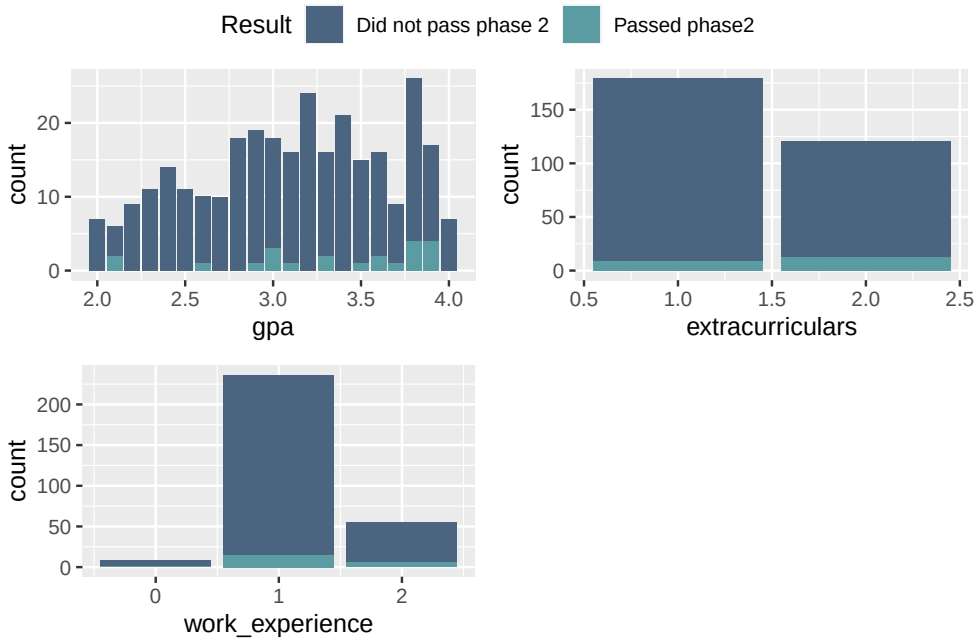


Figure 4: Sum of all four scores

However, as shown in Figure 3 and 4, we see that not every applicant who has high scores passed phase 2. t Some applicants did not pass where others passed with lower score. We would want to know if those variability was due to the gender difference or other covariates.



We do not see any particular patterns on the data from phase 1 too. We wanted to know whether these variability in patterns come from difference in gender.To test whether the gender has an effect on phase 2, we fitted four models. The baseline model includes the technical skills, writing skills, speaking skills and leadership presence to predict the result of phase 2. We also fitted three models with gender.

- Model 1: Baseline model (no gender effect)
- Model 2: Addition of gender to the baseline model as a fixed effect
- Model 3: Addition of gender to the baseline model as interaction with skills
- Model 4: Addition of gender to the baseline model as interaction with data from phase 1 (GPA, extracurricular and work experience)

To compare fixed effects between models, we used drop-in deviance test.

Table 5: Drop-in deviance test

Models.compared	p.value
Model 1 vs, Model 2	0.410
Model 1 vs. Model 3	0.439
Model 1 vs. Model 4	0.740

From model 2, model 3 and model 4, the coefficient estimates for gender or its interaction term with other covariates were not significant ($p > 0.05$). When the models were compared with

drop-in deviance test, there was no significant evidence that including gender to the model improves the model as shown above. Our baseline model was most significant in this test with coefficient estimates being all significant ($p > 0.05$).

Phase 3

Table 6: Sample of the data for phase 3

gender	hired	n	Interviewer Rating #1	Interviewer Rating #2	GPA	Work experience	Extracurriculars	technical skills	writing skills	leadership presence	speaking skills
Man	Did not get hired	7	70.7	67.9	2.9	1.1	1.1	52.3	55.7	70	61.4
Man	Hired	8	79.8	81.9	3.6	1.1	1.8	75.8	56.4	70	66.2
Woman	Did not get hired	5	73.2	71.8	3.5	1.4	1.8	63.6	59.0	60	62.0
Woman	Hired	2	77.5	83.0	3.5	1.5	2.0	68.0	55.0	80	55.0

We created `hired` from the `final-hires-newgrad_2020.csv` where 0 indicates those who did not get an offer letter and 1 indicates those who got the offer letter. Other information(gender, gpa, work_experience, technical skills, and etc) are added to the data from previous data sets that we used. The overall numbers of each columns are higher in `hired` applicant so we used these to predict our binary response variable.

For phase 3, it is hard to define a model since the data itself is too small (n=22). So we tried to fit a model with various interaction with the interviewer rating and see if the adding gender gives us better model

From the drop-in analysis test, the p-value was bigger than 0.05 for the model with gender. Therefore we have no evidence that the result of phase 3 is dependent on gender. For phase 3, we were unable to test to gender interaction with other fixed effects due to the singularity issue.

The effect of gender in promotion

To measure whether the promotion is fair, we used salary as our response variable since higher the salary, more promoted the employee is. There was not much of data manipulation from the original data. We fixed the salary into the a numeric variable.

Table 7: Average productivity and average salary by gender and leadership for level

gender	leadership_for_level	Average Productivity	Average Salary	n
Man	Appropriate for level	47.25	48820.21	3796
Man	Exceeds expectations	73.51	43826.87	268
Woman	Needs improvement	29.98	42469.72	142
Woman	Appropriate for level	51.57	45994.15	2583
Prefer not to say	Needs improvement	34.17	51350.00	6
Prefer not to say	Appropriate for level	45.97	46069.37	111

The employees who have `Needs improvement` have lowest productivity and salary where `Exceeds expectation` have the highest productivity and salary. We can assume linear relationship with those variables. We can try to estimate salary with the productivity score and leadership for level.

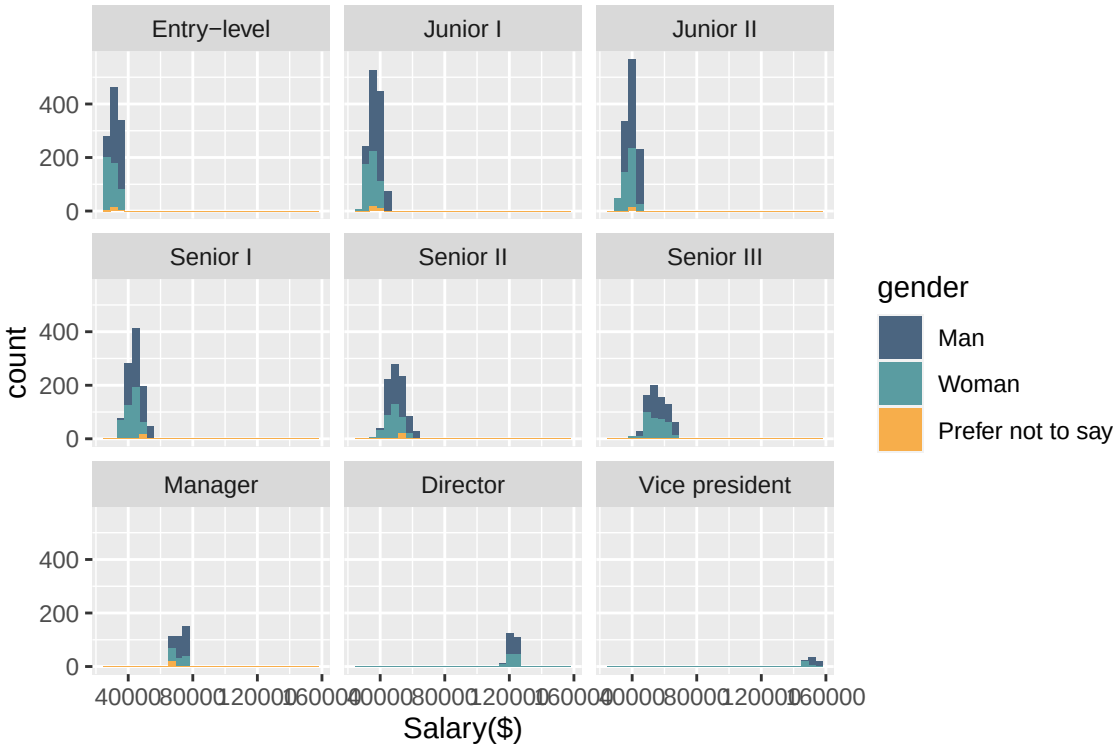


Figure 5: Salary of current employees organized by role_seniority

From Figure 5, when the data is organized in to different role_seniority, we see that each histogram has normal curves. From this evidence, we used linear mixed model for the data and

include role_seniority as our covariate too.

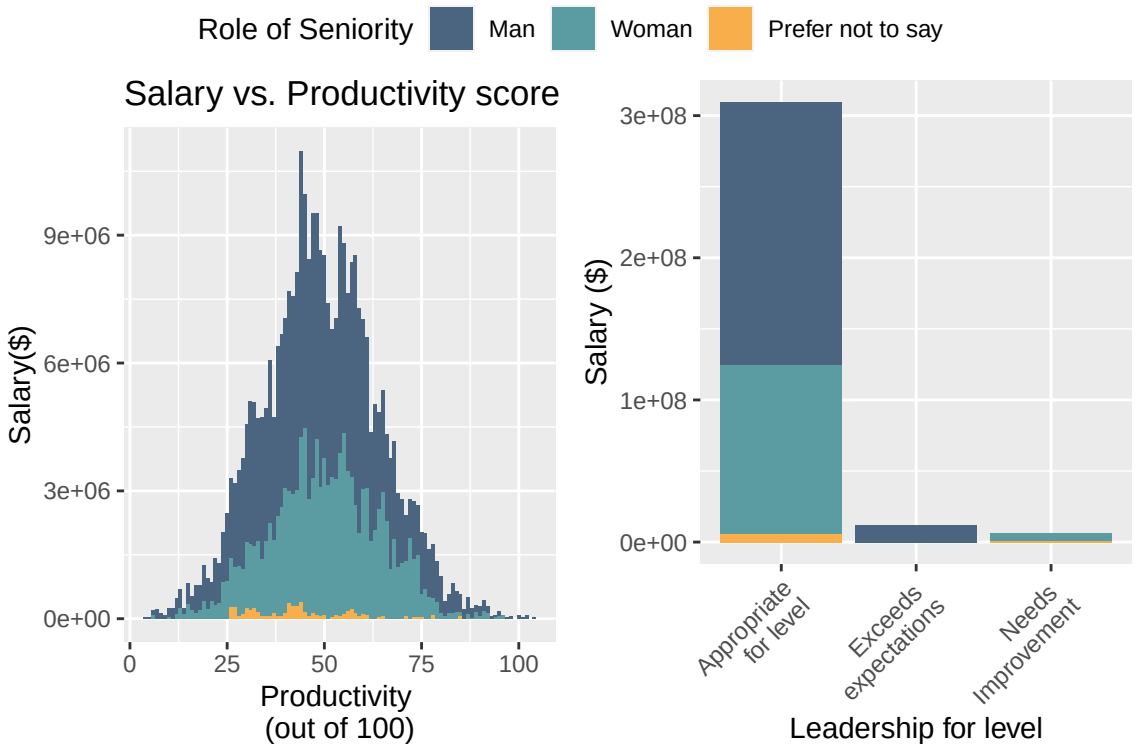


Figure 6: Salary vs. Productivity (left) and Leadership for level (right)

From the plot, we can suspect that the effect of productivity has different effect on the salary depending on the gender. We tested for the interaction between gender and productivity. Since our response have normality with some random effects, we used linear mixed model to measure our promotion.

First, we tested for different random effects for the model - employee ID, financial quarter, and team to construct our baseline model. By using likelihood ratio test, the employee id and team were chosen as our random effect. Then the role of seniority was added as a fixed effect. The proposed baseline model is that for each role of seniority, we have different effect on the salary after accounting for team and employee ID.

The gender was included in the model as an interaction term with productivity. The productivity with each gender will have different effect on the salary.

Table 8: Coefficient estimates from the model

Coefficient	Estimates
productivity:genderMan	5.09
productivity:genderWoman	-13.43
productivity:genderPrefer not to say	11.36

From the table, we can see that man and those who said prefer not to answer, are more likely to have higher salary than woman with same productivity. The fairness of the promotion is violated since woman will tend to get lower salary even if they have high productivity.

Discussion

For hiring process, we did not find evidence that the gender has an effect on the result of each phase. We also did not find any evidence that the gender has an effect on other fixed effects - for example, being a woman does not change the effect of gpa on the result. Therefore, we concluded that the hiring process is fair.

For promotion, we did find the evidence that the gender has an effect on productivity. The effect of productivity on the salary depends on the gender. For example, woman who has same productivity score with a man will tend to get less salary.

Strengths and limitations

The purpose of this study is to find out whether there is any significant gender effect in hiring process and promotion. Keep in mind that the model provided in this study is not the best model for prediction of the result. Also, phase 3 from hiring process is too small to be evaluated. In order to provide more significant model for hiring process, we would recommend analyzing data from previous hiring process together.

Consultant information

Consultant profile

Sehee Kim. Sehee is a senior consultant with Onyu Data. She specializes in data visualization and model building. Sehee earned her Bachelor of Science, Specialist in Statistics Methods and Practice, from the University of Toronto in 2015. She has done internships in various area - Health Canada, TD Canada Trust and Rogers.

Code of ethical conduct

- Our Onyu Data uses appropriate statistical methods and interpretation of the data to help client improve their knowledge of science, economy and society.
- We do not expect specific result from the analysis. Our job is not about fulfilling the expectation of ourselves or the clients.
- Our company respects the rights and interests of the clients. The data provided to Onyu Data is used only for the client and will be discarded after providing full analysis of it. The data and the analysis will be kept only when the client need further analysis on it.