Data Analysis 3 : Assignment 1

Ghazal

1.Introduction

The purpose of this assignment is to build four predictive models using linear regression. The source of data for this purpose is CPS-earning data set which can be found here. The chosen occupation for this project is *Human Resource worker* with the census occupation code of *630* which has 701 observations. GitHub link can be found here.

2. Data Munging and Transformation

Predicting the weekly earning is a quantitative prediction exercise. For the process of data munging and transformation, hourly wage_**(w)**_ is calculated by dividing the weekly earnings (earnwke) by the number of hours (uhours) and the log of the mentioned variable ***(lnw)*** is also created. To model other variables are created and transformed which are as following: education level, marital status, if an individual owns a child, working sector dummies are created. Other character variables such as Gender and education levels are created. To model non-linearity in age for the regression with earning per week as a dependent variable, quadratic age predictor is created. The sample is varied with high number of females (521) compared to men (180). For further data filtering process, education is included from high school to PhD. The education levels below college are added into *Non-degree* category, and both associate certificates of vocational and academic are added to *associate*. The data contains observation who are 18 years old or above and less than 64 years. Moreover, the selected data set is transformed to observations who earns more than one USD per week.

3. Variables, Interations, and Regressions

Variables : Education is likely a strong predictor of earning per hour. Table 4, in the Appendix indicates that the mean difference between of a human resource worker with no degree to a human resource worker who holds a PhD degree is 27 USD. Moreover, other variables such as age and age square are added to the predication models. Gender plays an important role, Table 7 shows that female human resource workers earn 4 USD less than their male counterparts. Moreover, a binary variable capturing if human resource worker is married or otherwise, indicates interesting summary in the Appendix Table 10. It shows that married human resource workers earn more than the otherwise. **Interactions :** To further capture the interplay of independent variables, interactions are used. Interactions such as gender and education, marital status and gender, gender times owning a child and education are used to understand the interplay of variables. **Regressions :** Four linear regression models are built to prediction analysis. As Table 1, in the appendix shows, Model 1 is the simplest containing education dummies, as following Model 2 has the Model 1 explanatory variables along with age and age squared. Moreover, in the Model 3, more explanatory variables such as gender, working sector, marital status, and own-child are added. Model 4, is the most complex among all model. This mentioned model contains all the mentioned independent variables and the respective interactions.

4. Model Performance

BIC is the measure of the fit of a model using all the original data and it penalizes the model complexity and helps to avoid over-fitting. Models with lower BIC are generally preferred. Among the models Model 2 has the lowest BIC, however it has minimal difference with Model 3. The second measurement to evaluate model performance is RMSE, which is the average squared loss across several target observations. RMSE is the lowest for the models 3 and 4. By looking to the Table 2 for the result of cross validation of the models, it suggests that Model 2 and Model 3 have the best properties. Model 3 has the lowest for BIC and cross validation RMSE average. Thus, Model 3 is selected for the purpose of the project which contains 14 variables.

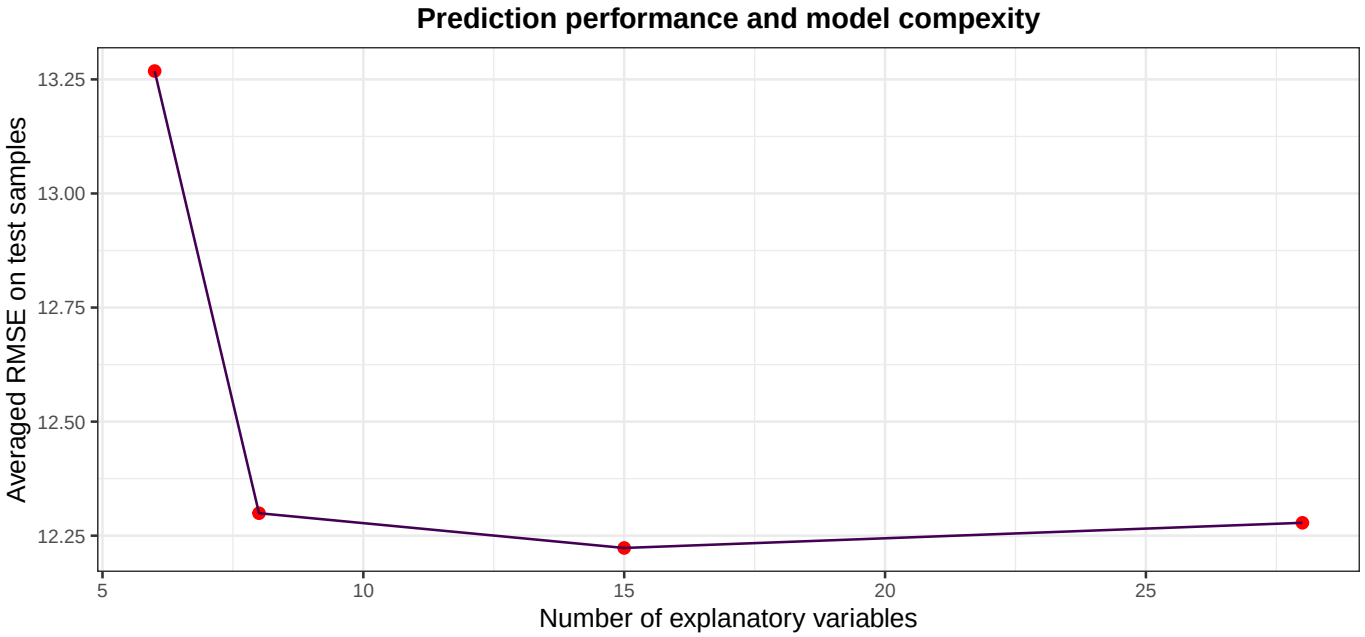
Table 1: Regression Models for Earning per hour

	M1	M2	M3	M4
Dependent Var.:	Hourly wage	Hourly wage	Hourly wage	Hourly wage
Intercept	23.10*** (0.8037)	-22.81*** (5.378)	-20.52** (6.539)	-13.63* (6.572)
Associate	0.8083 (1.451)	0.1552 (1.345)	-0.2556 (1.306)	-3.622 (4.754)
BA Degree	5.600*** (1.141)	7.851*** (1.142)	7.588*** (1.137)	3.540 (3.069)
MA Degree	7.823*** (1.742)	8.596*** (1.678)	8.142*** (1.653)	-4.287 (4.167)
Professional Degree	7.016. (4.140)	7.325. (3.946)	6.013 (4.052)	-2.634 (6.896)
PhD	27.20*** (6.873)	24.81*** (6.406)	23.16*** (6.629)	15.16*** (2.980)
Age		1.908*** (0.2840)	1.762*** (0.3245)	1.850*** (0.3298)
Age Squared		-0.0182*** (0.0035)	-0.0166*** (0.0040)	-0.0175*** (0.0040)
genderMale			3.902** (1.198)	
classGovernment-Local			-3.165 (2.657)	-3.549 (2.742)
classGovernment-State			-6.105* (2.573)	-7.255** (2.675)
classPrivate,ForProfit			-0.6463 (2.225)	-1.622 (2.311)
classPrivate,Nonprofit			-1.131 (2.551)	-2.011 (2.603)
Has Child			0.8024 (1.111)	5.244 (5.690)
Married			1.513 (1.022)	1.080 (1.066)
Female				5.972 (9.845)
Associate x Female				-10.21 (10.73)
BA Degree x Female				-9.481 (10.09)
MA Degree x Female				-0.3416 (10.60)
Female x Has Child				-5.955 (6.029)
Female x educNoDegree				-14.29 (10.07)
Female x educPhD				-2.911 (13.29)
Has Child x educBachelors				-5.111 (6.622)
Has Child x educMasters				3.798 (7.628)
Has Child x educNoDegree				-8.396 (6.780)
Has Child x educProfessional				2.046 (9.128)
Female x Has Child x educBachelors				6.810 (7.124)
Female x Has Child x educMasters				0.8014 (8.659)
Female x Has Child x educNoDegree				8.834 (7.268)
S.E. type	Heteroskeda.-rob.	Heteroskedast.-rob.	Heteroskedast.-rob.	Heteroskedast.-rob.
AIC	5,614.2	5,508.0	5,491.3	5,498.8
BIC	5,641.6	5,544.4	5,559.6	5,626.3
RMSE	13.157	12.162	11.898	11.743
R2	0.06554	0.20151	0.23578	0.25562
Observations	701	701	701	701
No. Variables	5	7	14	27

Table 2: 4-Fold Cross Validation and RMSE

Resample	Model1	Model2	Model3	Model4
Fold1	13.56982	12.33827	12.53872	12.59866
Fold2	12.44817	11.49459	11.30927	11.40808
Fold3	12.54938	12.22487	11.92689	11.96471
Fold4	14.40869	13.08738	13.04787	13.07657
Average	13.26833	12.29924	12.22310	12.27824

Appendix



Cross−Validation RMSE in the graphs shows lowest result for the Model 3. This Model contains 14 Variables

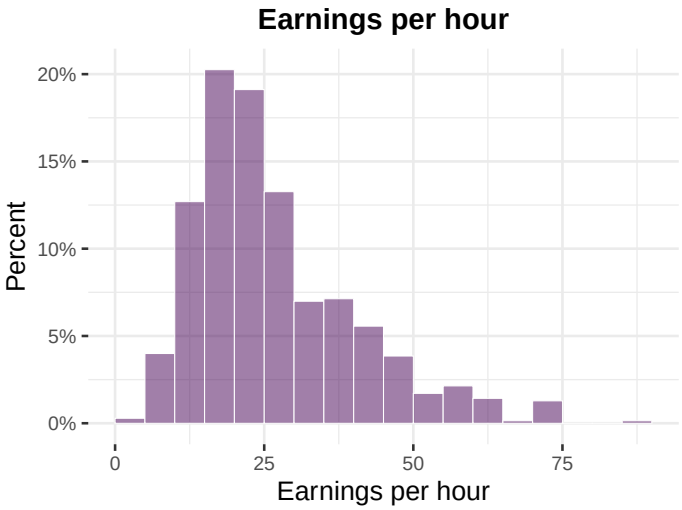
Descriptive Data Summary

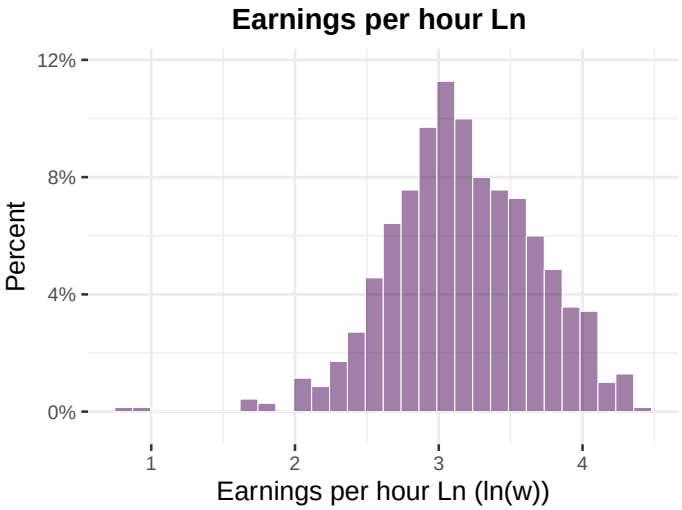
Table 3: Descriptive Summary Statistics

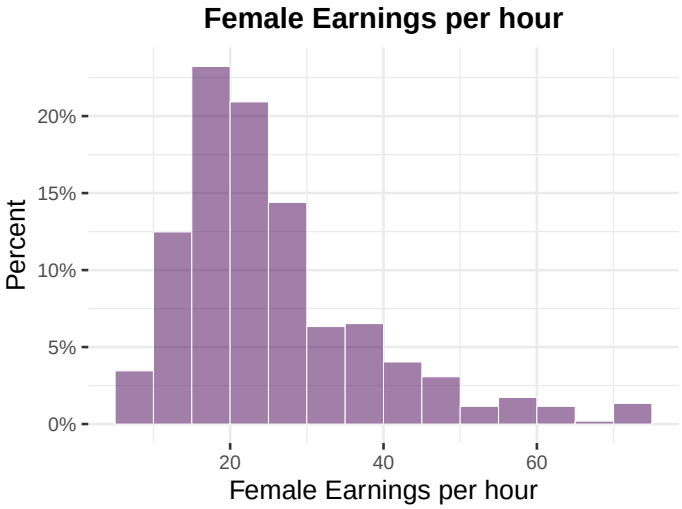
	Median	Mean	SD	Min	Max	P05	P95	N
Weekly earnings	961.53	1111.08	605.24	75.00	2884.61	400.00	2394.00	701
Weekly hours worked	40.00	40.88	7.44	6.00	65.00	28.00	55.00	701
Earning per hour	23.50	26.92	13.62	2.31	85.26	11.00	55.88	701
Female	1.00	0.74	0.44	0.00	1.00	0.00	1.00	701
No degree	0.00	0.30	0.46	0.00	1.00	0.00	1.00	701
Associate	0.00	0.11	0.31	0.00	1.00	0.00	1.00	701
BA Degree	0.00	0.44	0.50	0.00	1.00	0.00	1.00	701
MA Degree	0.00	0.13	0.34	0.00	1.00	0.00	1.00	701
Professional Degree	0.00	0.01	0.10	0.00	1.00	0.00	0.00	701
PhD	0.00	0.01	0.08	0.00	1.00	0.00	0.00	701
Age	40.00	40.83	11.91	19.00	64.00	23.00	61.00	701
Work in Private Sector	1.00	0.79	0.41	0.00	1.00	0.00	1.00	701
Has child	0.00	0.37	0.48	0.00	1.00	0.00	1.00	701
Marital Status	1.00	0.57	0.49	0.00	1.00	0.00	1.00	701

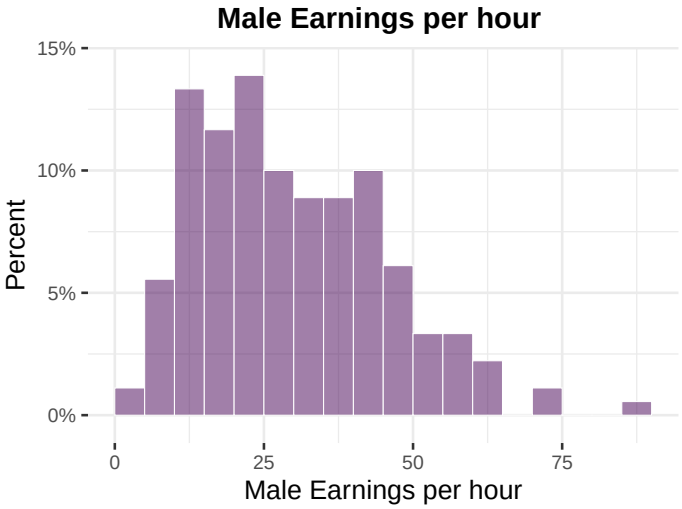
Descriptive summary of the main variables in the data set can be in the above table. From the table it can be inferred that because of the presence of high hourly wage values like USD 2884, mean tends to be to the right of the median thus making the sample distribution rightly skewed. Similarly, we see that there are certain people who work more than 40 hours (maximum value of 65 hours a week) which is also the cause for skewness. Moreover, there is also the presence of extreme values. For example, the minimum wage value is computed out to be USD 2.31

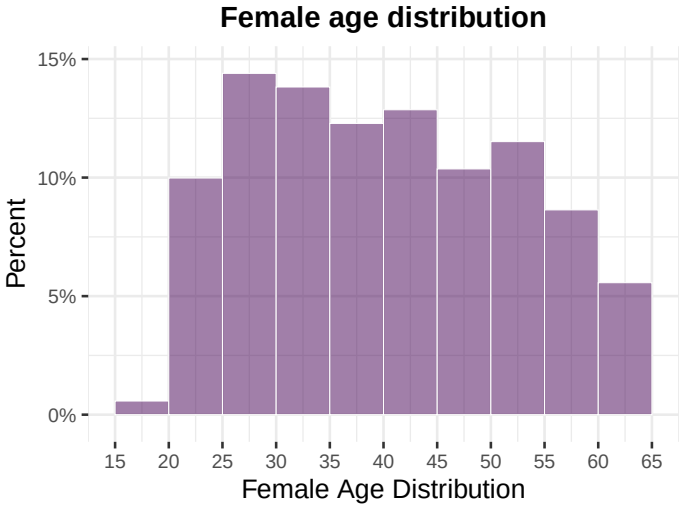
Histograms

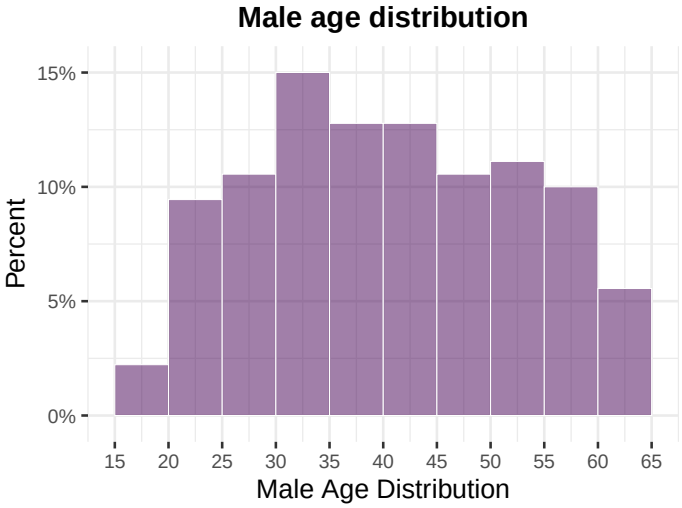

Earnings per hour
Percent
20%
15%
10%
5%
0%
0
25
50
75
Earnings per hour


Earnings per hour Ln
Percent
12%
8%
4%
0%
1
2
3
4
Earnings per hour Ln (ln(w))

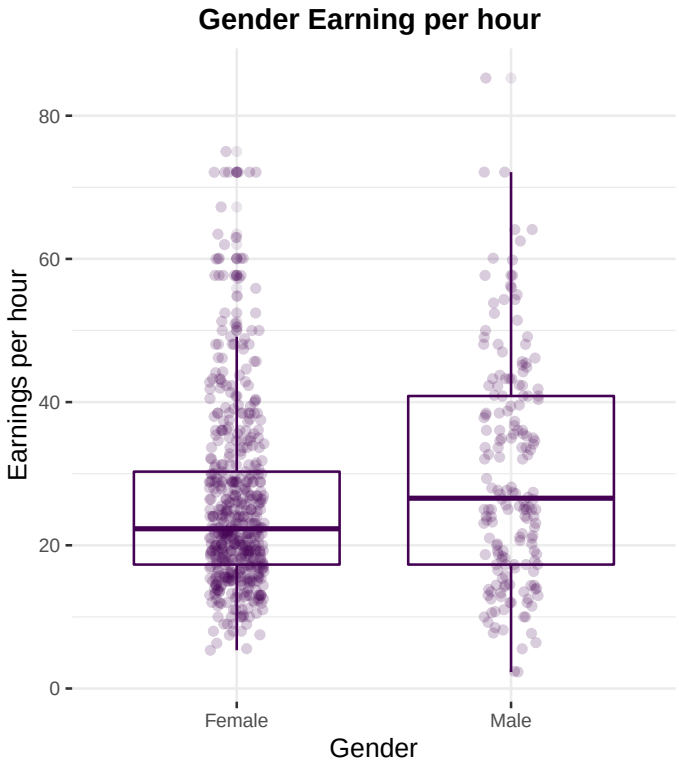

Female Earnings per hour
Percent
20%
15%
10%
5%
0%
20
40
60
Female Earnings per hour

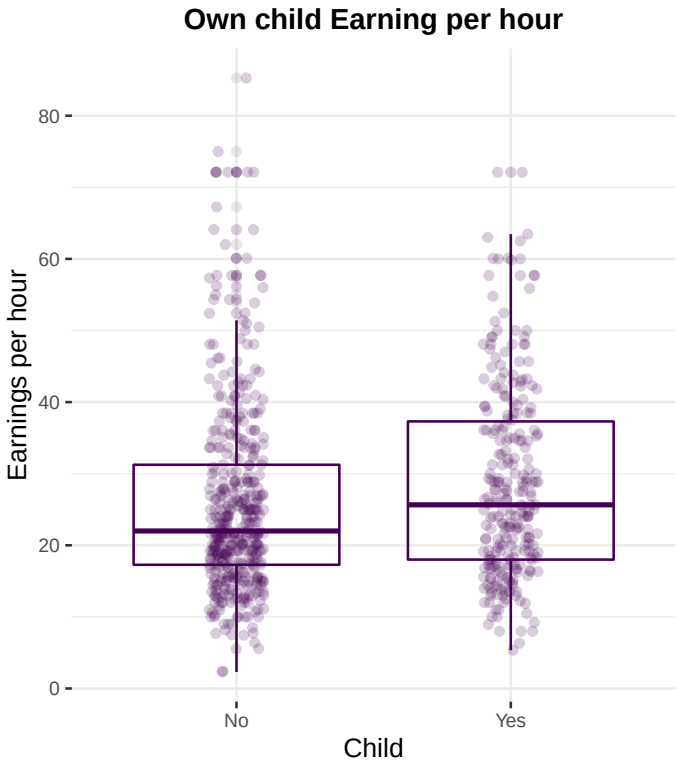

Male Earnings per hour
Percent
15%
10%
5%
0%
0
25
50
75
Male Earnings per hour

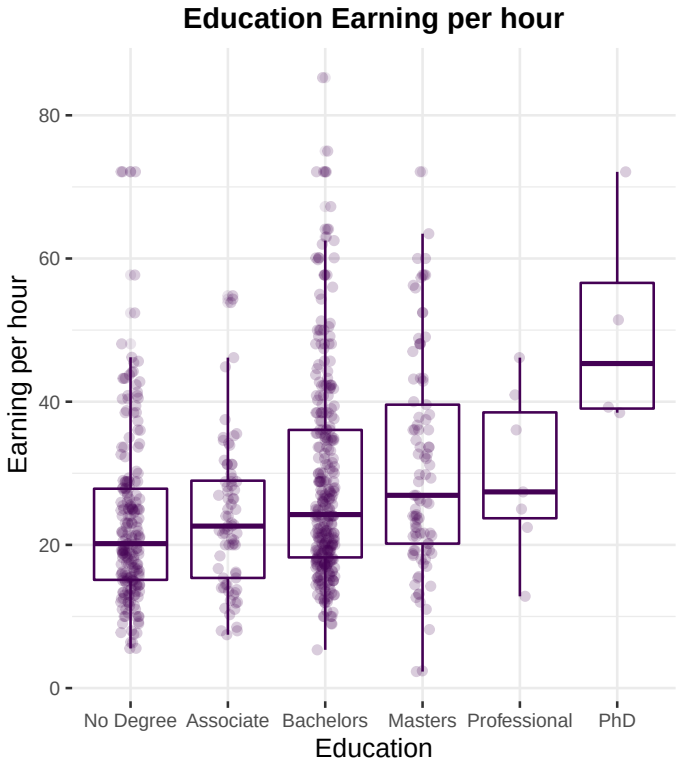

Female age distribution
Percent
15%
10%
5%
0%
15
20
25
30
35
40
45
50
55
60
65
Female Age Distribution

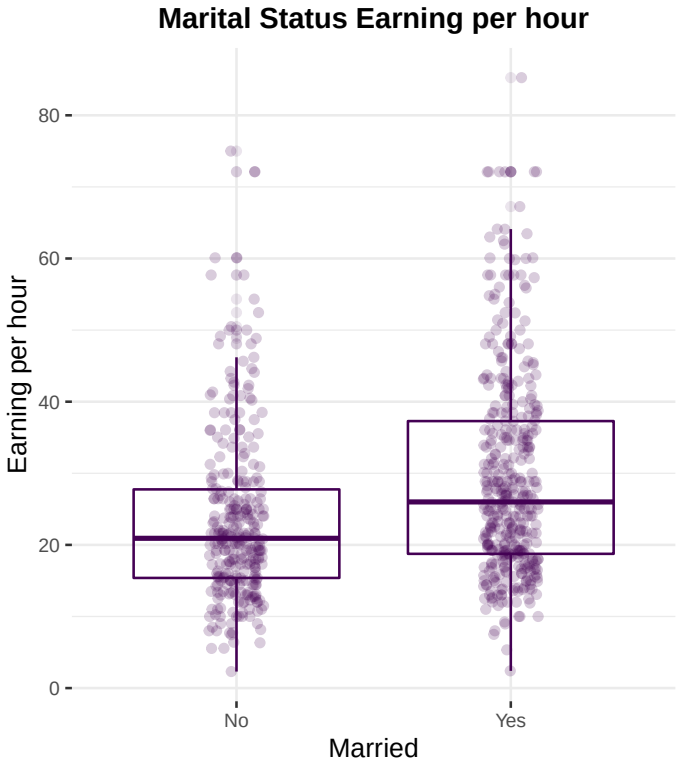

Male age distribution
Percent
15%
10%
5%
0%
15
20
25
30
35
40
45
50
55
60
65
Male Age Distribution

One variable plots

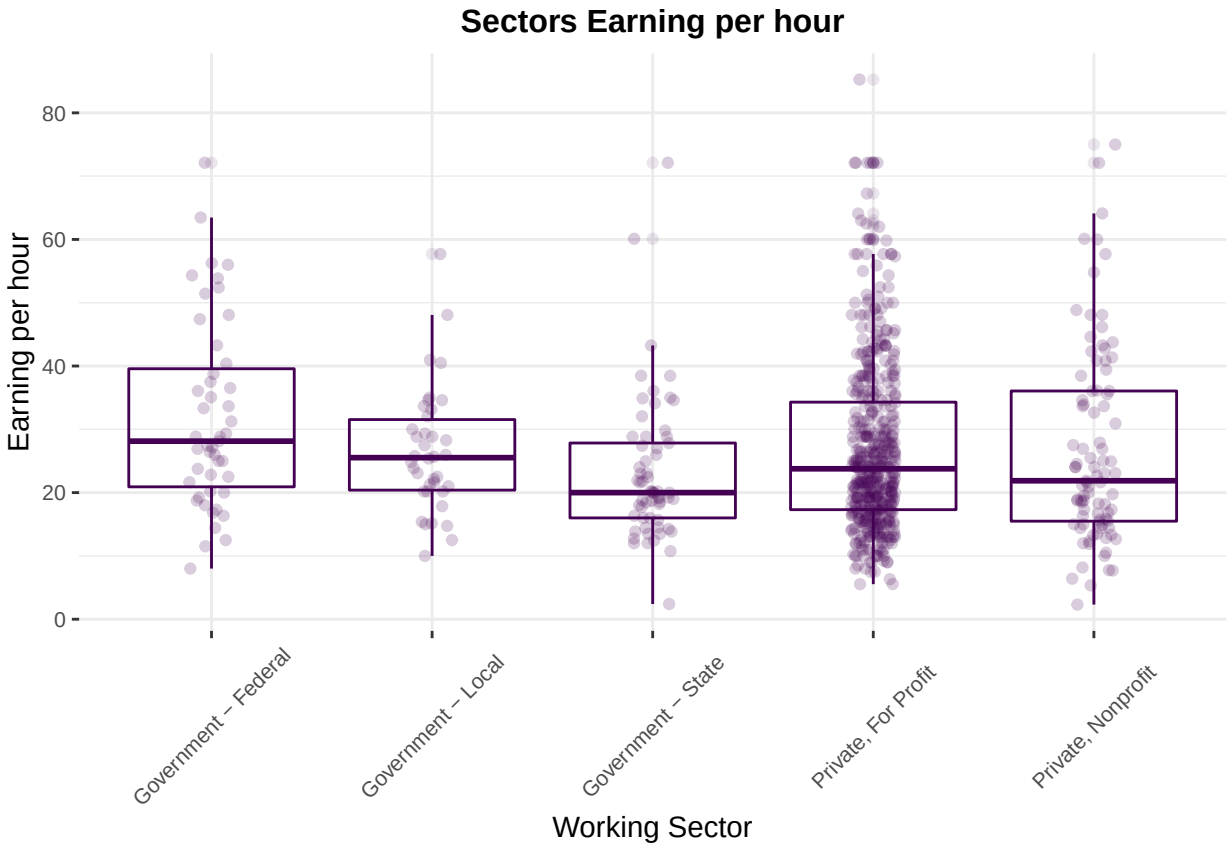




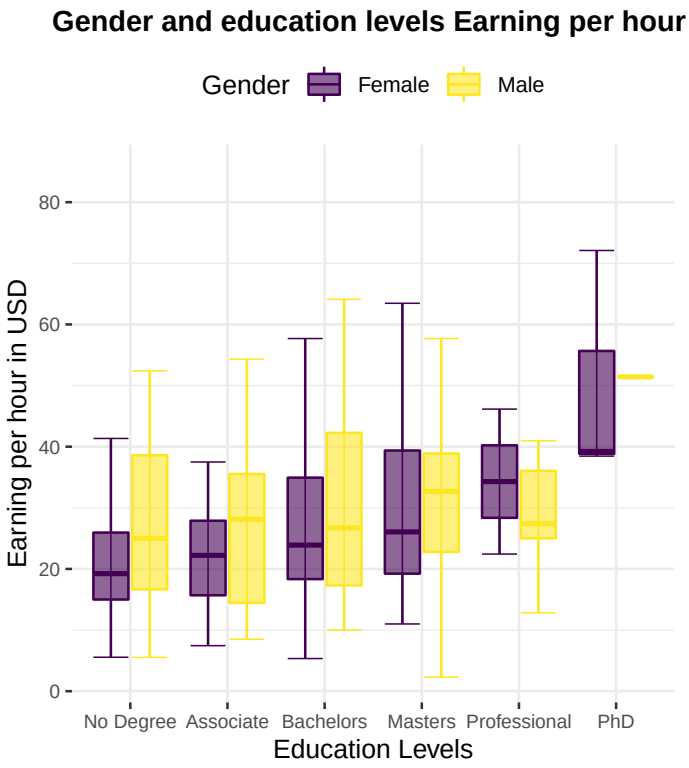


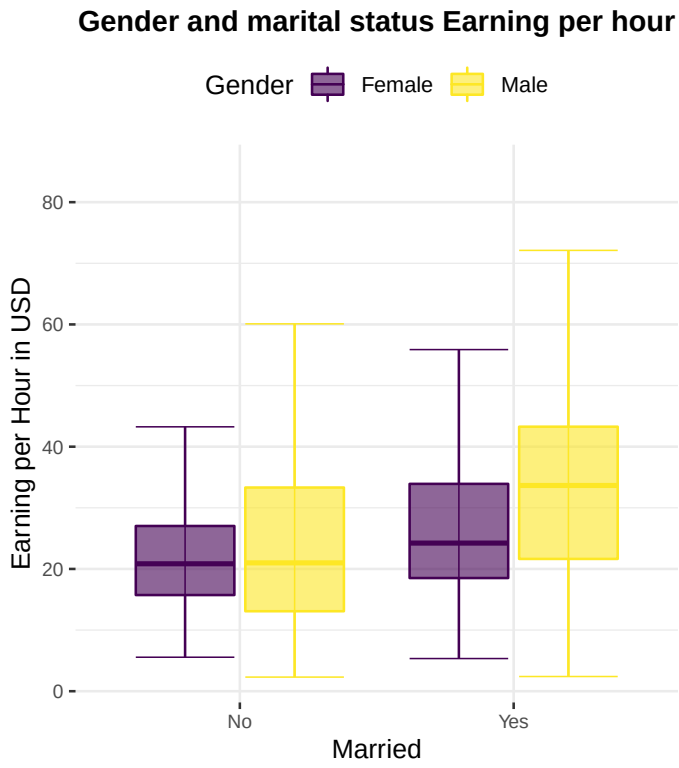


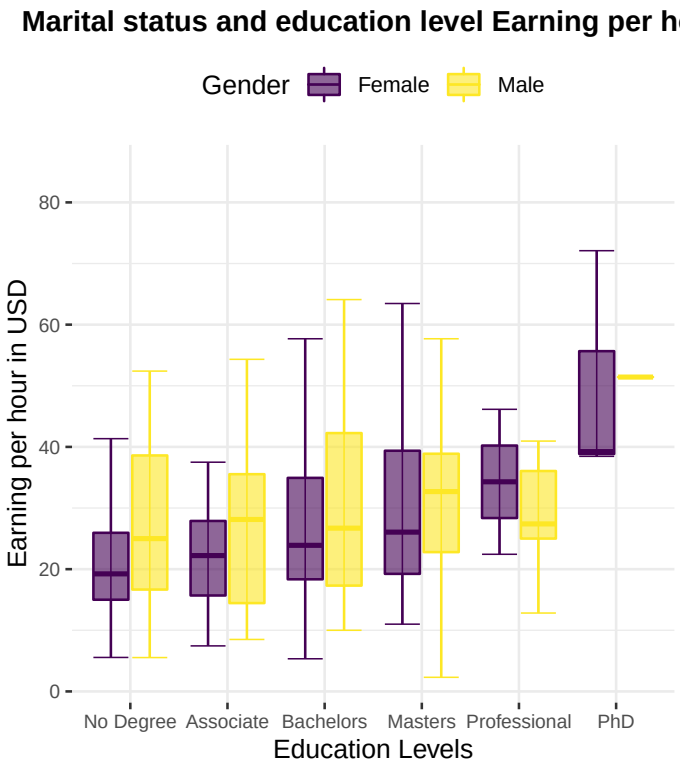
One variable plot

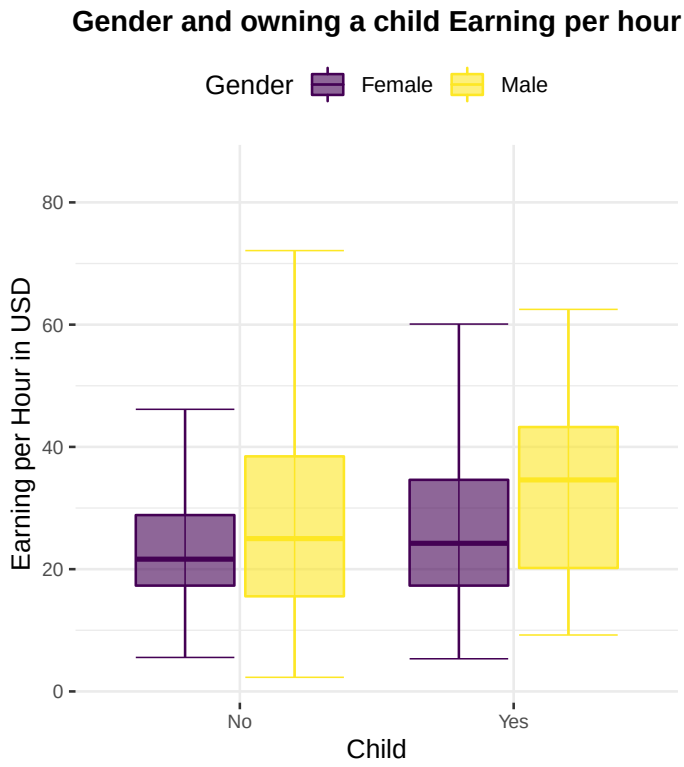


Two Variable plots

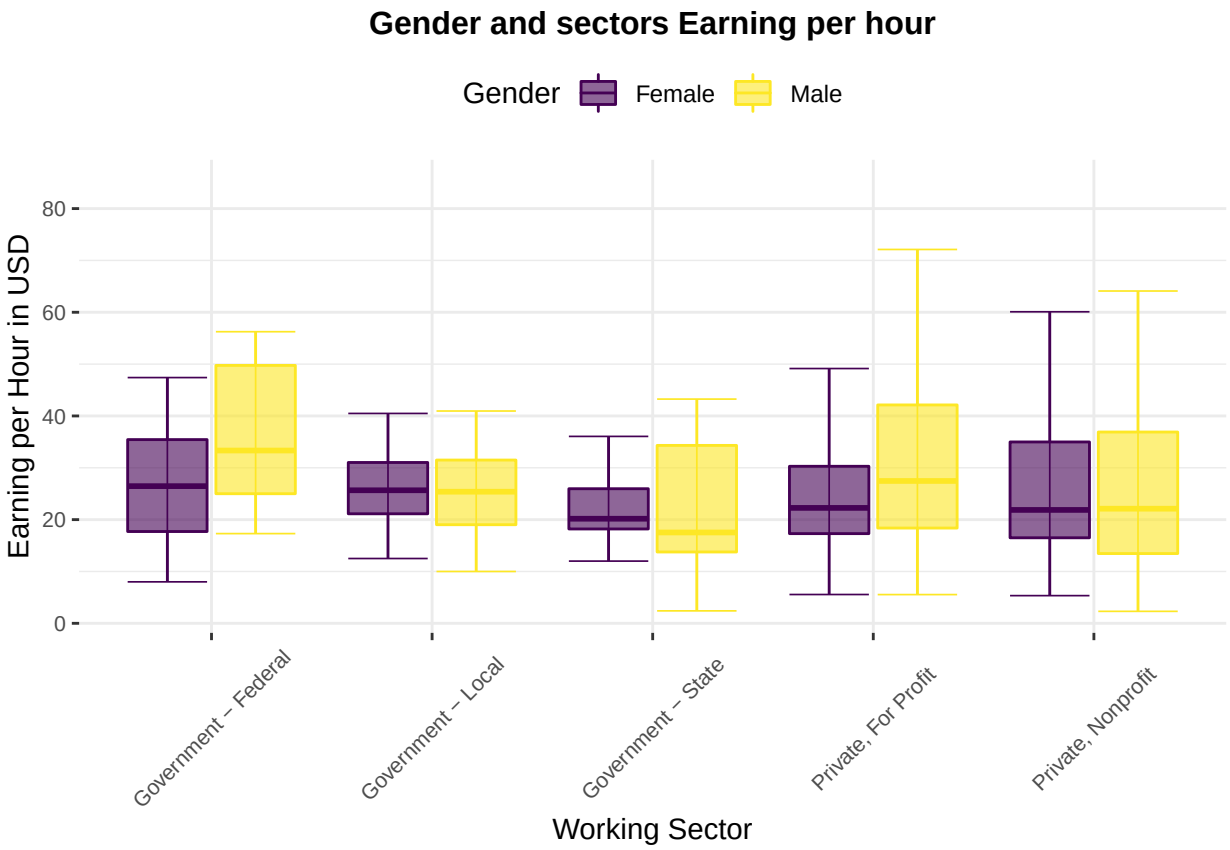








Two Variable plot



Loess

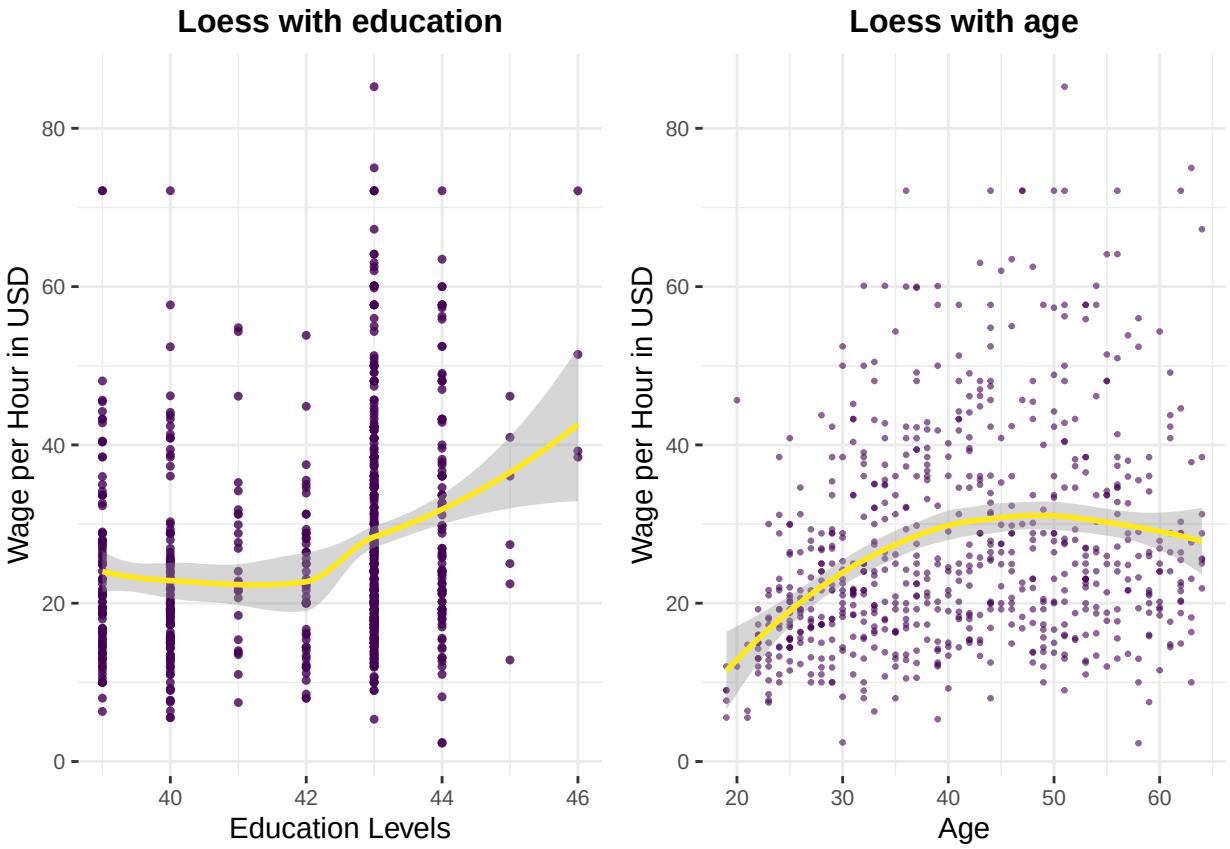

Loess with education
Wage per Hour in USD
0
20
40
60
80
40
42
44
46
Education Levels
Loess with age
Wage per Hour in USD
0
20
40
60
80
20
30
40
50
60
Age

Table 4: Wage and education summary

	Education	N	Percent	mean
w	Associate	76	10.84	23.91
	Bachelors	309	44.08	28.70
	Masters	93	13.27	30.92
	No Degree	212	30.24	23.10
	PhD	4	0.57	50.30
	Professional	7	1.00	30.12

Table 5: Wage and class summary

	class	N	Percent	mean
w	Government - Federal	47	6.70	32.00
	Government - Local	38	5.42	26.51
	Government - State	61	8.70	23.21
	Private, For Profit	464	66.19	26.95
	Private, Nonprofit	91	12.98	26.79

Table 6: Wage and Own a child summary

	Own a child	N	Percent	mean
w	0	439	62.62	25.91
	1	262	37.38	28.61

Table 7: Wage and Gender summary

	Gender	N	Percent	mean
w	Female	521	74.32	25.86
	Male	180	25.68	29.98

Table 8: Wage, Gender and own a child summary

	Gender	Own a child	N	Percent	mean
w	Female	0	320	45.65	24.87
		1	201	28.67	27.43
	Male	0	119	16.98	28.70
		1	61	8.70	32.49

Table 9: Wage, education and Gender summary

	Education	Gender	N	Percent	mean
w	Associate	Female	59	8.42	22.39
		Male	17	2.43	29.17
	Bachelors	Female	234	33.38	27.78
		Male	75	10.70	31.59
	Masters	Female	66	9.42	31.00
		Male	27	3.85	30.73
	No Degree	Female	157	22.40	21.58
		Male	55	7.85	27.44
	PhD	Female	3	0.43	49.93
		Male	1	0.14	51.42
	Professional	Female	2	0.29	34.29
		Male	5	0.71	28.45

Table 10: Wage and Marital status summary

	Married	N	Percent	mean
w	0	298	42.51	23.49
	1	403	57.49	29.45

Table 11: Wage, education and marital status summary

	Education	Married	N	Percent	mean
w	Associate	0	30	4.28	19.69
		1	46	6.56	26.66
	Bachelors	0	136	19.40	25.85
		1	173	24.68	30.94
	Masters	0	29	4.14	24.63
		1	64	9.13	33.78
	No Degree	0	100	14.27	21.05
		1	112	15.98	24.93
	PhD	0	0	0.00	
		1	4	0.57	50.30
	Professional	0	3	0.43	25.40
		1	4	0.57	33.65

Table 12: Wage, gender and marital status summary

	Gender	Married	N	Percent	mean
w	Female	0	228	32.52	23.35
		1	293	41.80	27.81
	Male	0	70	9.99	23.95
		1	110	15.69	33.82