

# Risk and Returns to Education

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- A thorough understanding of the relationship between education and future earnings helps students to make informed decisions about their education and has other important implications such as on fiscal policy
- Education by degree and field of study is a risky investment and individuals are not risk-neutral
- Therefore, it is important to take into account this risk component in modelling returns to education
- We are the first to examine returns to education for different types of degrees and majors (fields of study) where we incorporate all four moments of the distribution (mean, variance, skewness, kurtosis)
- There is some emerging work on capturing higher moments in returns to education in other contexts, although this does not incorporate fields of study [Harmon et al., 2003, Henderson et al., 2020]

- The Household, Income and Labour Dynamics in Australia (HILDA) Survey is a longitudinal, nationally representative study of Australian households conducted annually since 2001
- We focus on wave 16 (year 2016) which is the most recent data before the pandemic with information on fields of study
- We use “Financial year gross wages & salary” in Australian dollars as our main measure of income

# Data: 45 Education Categories

- 1 We have 45 education categories which are interactions between three degree categories and 15 fields of study
- 2 Lower education is our base case, i.e., individuals with no post-school qualification
- 3 Our three degrees categories are Postgraduate degrees, Bachelor degrees, and Sub-Bachelor degrees (e.g., Diploma, Associate Degree, Certificate)
- 4 The 15 fields of study include (1) Natural / Physical Sciences; (2) IT; (3) Engineering; (4) Architecture / Building; (5) Agriculture / Environment; (6) Medicine; (7) Nursing; (8) Other Health; (9) Education; (10) Management / Commerce; (11) Law; (12) Social Sciences; (13) Creative Arts; (14) Personal Services / Hospitality; (15) Other Majors

# Methods: Ordinary Least Squares (OLS)

- As our baseline, we run Mincerian wage regressions via OLS to estimate average returns to education on earnings, including the 45 education variables and a rich set of control variables
- We also include proxies for ability which are based on cognitive ability tests and are conducted as part of the HILDA Survey, such as the Symbol Digits Modalities Test, the Backwards Digit Span Test and the National Adult Reading Test
- Education as a “treatment” so we do not condition on variables like occupation which are caused by the treatment (i.e., over control bias)

# Methods: Modelling Higher Moments

- We use the Generalized Additive Models for Location, Scale and Shape (GAMLSS) framework to model the higher moments of returns to education
- GAMLSS is a flexible framework for regression models and allows the outcome variable to follow any distribution
- A GAMLSS framework can deal with non-constant variance (heteroskedasticity), skewness and heavy or light tails
- All the the four parameters of the distribution can be modelled as functions of explanatory variables

# Methods: GAMLSS Equations

$$\mathbf{Y} \sim D(\mu, \sigma, \nu, \tau) \quad (1)$$

$$\eta_1 = g_1(\mu) = \beta_{\mu,0} + \sum_{k=1}^{45} \beta_{\mu,k}(\text{Major}_i \times \text{Degree}_i) + X_i' \gamma_{\mu} \quad (2)$$

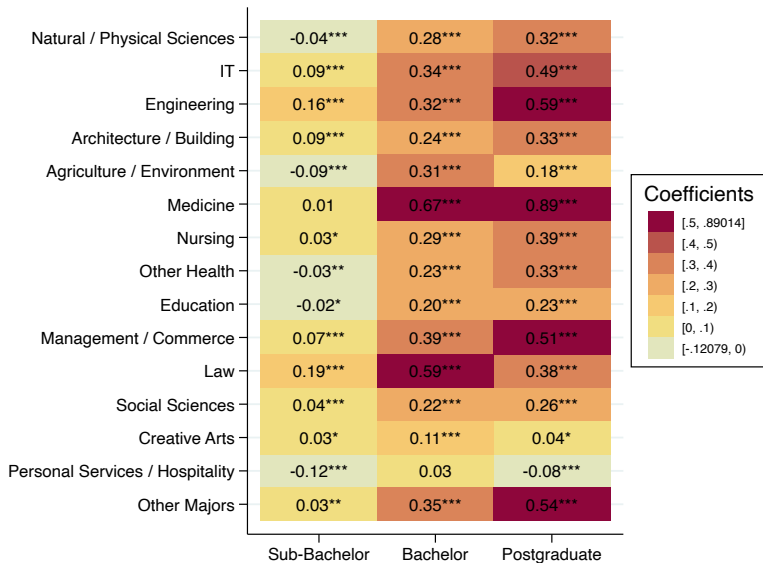
$$\eta_2 = g_2(\sigma) = \beta_{\sigma,0} + \sum_{k=1}^{45} \beta_{\sigma,k}(\text{Major}_i \times \text{Degree}_i) + X_i' \gamma_{\sigma} \quad (3)$$

$$\eta_3 = g_3(\nu) = \beta_{\nu,0} + \sum_{k=1}^{45} \beta_{\nu,k}(\text{Major}_i \times \text{Degree}_i) + X_i' \gamma_{\nu} \quad (4)$$

$$\eta_4 = g_4(\tau) = \beta_{\tau,0} + \sum_{k=1}^{45} \beta_{\tau,k}(\text{Major}_i \times \text{Degree}_i) + X_i' \gamma_{\tau} \quad (5)$$

$\mathbf{Y}$  is log annual income,  $\mu$ ,  $\sigma$ ,  $\nu$ ,  $\tau$  are the location, scale and shape parameters,  $\eta$  is the linear predictor,  $g_1(\mu)$  to  $g_4(\tau)$  are link functions.

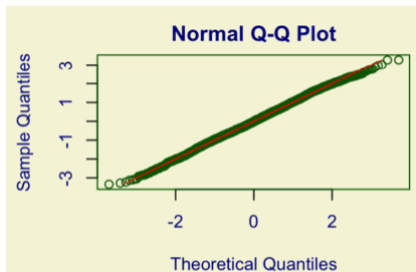
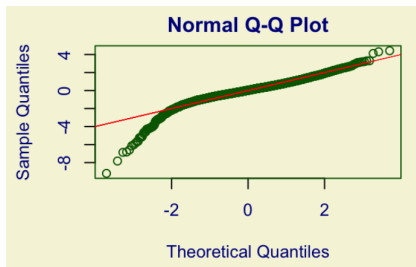
# OLS Results: Heatplot for Education Categories



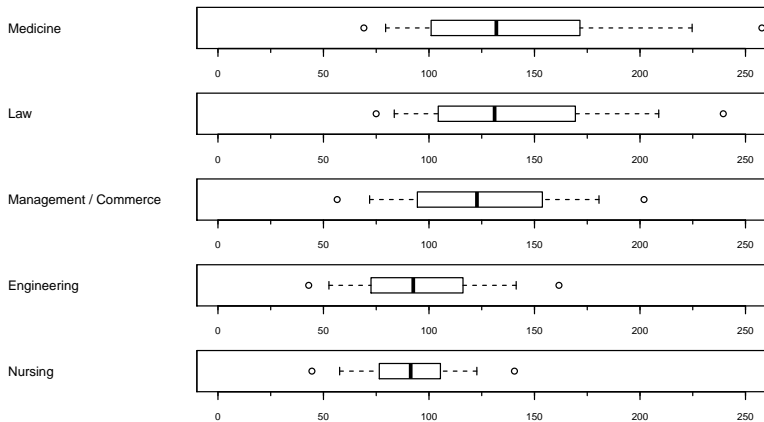
# GAMLSS Results: Model Selection and Fit

- 1 We consider all continuous distributions on  $(0, \infty)$  and we select the Box-Cox t distribution with four moment parameters
- 2 We select identity, log, identity, log as the link function for our four distribution parameters  $\mu, \sigma, \nu, \tau$
- 3 We select the set of explanatory variables for each of our four distribution parameters
- 4 Using several diagnostic tools we show that GAMLSS estimated via a Box-Cox t distribution provides a superior fit to an OLS model and to other GAMLSS distributions
- 5 We derive the earnings distribution for each of our education categories based on the estimated coefficients for each moment equation from GAMLSS

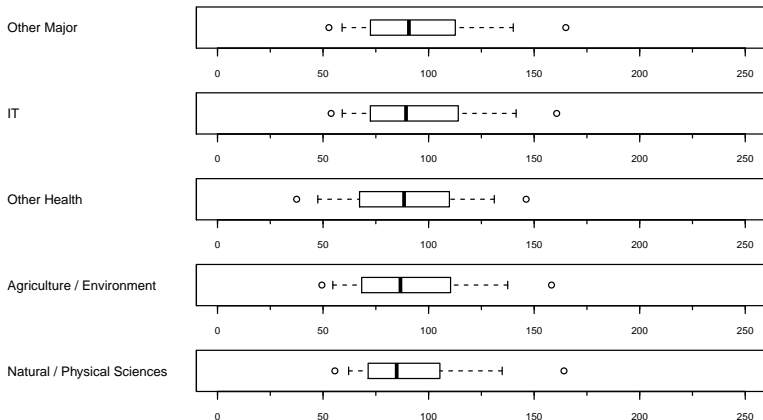
# GAMLSS Results: Q-Q plots for Normal and Box-Cox t Distributions



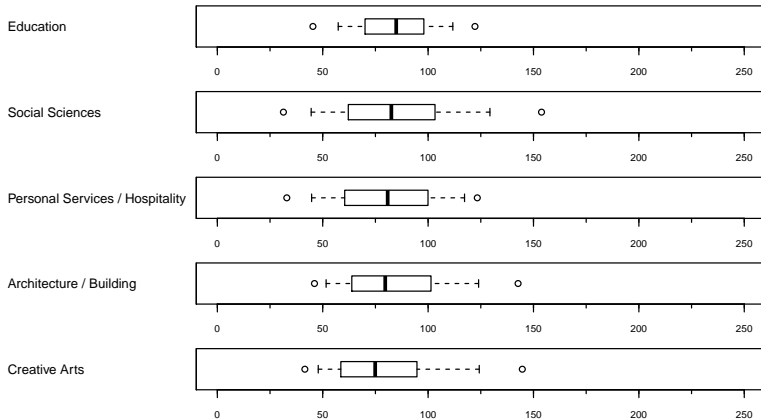
# GAMLSS Results: Boxplots with Bachelor Majors (Top 5)



# GAMLSS Results: Boxplots with Bachelor Majors (Mid 5)



# GAMLSS Results: Boxplots with Bachelor Majors (Bottom 5)



# GAMLSS Results: Probabilities Sorted from the Top

	Top 1	Top 5	Top 25	Top 50	Top 75	Top 95	Top 99
Postgraduate Medicine	0.067	0.424	0.881	0.976	0.993	1.000	1.000
Bachelor Medicine	0.043	0.244	0.761	0.924	0.973	0.998	1.000
Bachelor Management / Commerce	0.032	0.110	0.431	0.694	0.899	0.976	0.995
Postgraduate Management / Commerce	0.022	0.163	0.556	0.798	0.882	0.960	0.984
Postgraduate Engineering	0.021	0.186	0.658	0.893	0.970	0.998	1.000
Postgraduate Law	0.021	0.079	0.445	0.844	0.919	0.975	0.994
Sub-Bachelor Creative Arts	0.015	0.034	0.119	0.330	0.768	0.999	1.000
Postgraduate Agriculture / Environment	0.013	0.034	0.315	0.646	0.897	0.989	0.999
Bachelor Law	0.012	0.230	0.749	0.951	0.996	1.000	1.000
Postgraduate Natural / Physical Sciences	0.010	0.064	0.382	0.718	0.915	0.993	1.000
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Sub-Bachelor Other Major	0.000	0.006	0.101	0.351	0.729	0.972	1.000
Sub-Bachelor Nursing	0.000	0.004	0.105	0.342	0.703	0.928	0.997
Postgraduate Architecture / Building	0.000	0.002	0.441	0.757	0.907	0.983	1.000
Bachelor Education	0.000	0.002	0.201	0.660	0.904	0.978	0.993
Sub-Bachelor Natural / Physical Sciences	0.000	0.002	0.149	0.407	0.640	0.871	0.974
Postgraduate Education	0.000	0.000	0.297	0.711	0.910	0.975	0.997
Bachelor Personal Services / Hospitality	0.000	0.000	0.232	0.594	0.819	0.954	0.991
Sub-Bachelor Personal Services / Hospitality	0.000	0.000	0.049	0.269	0.687	0.970	0.999
Postgraduate Personal Services / Hospitality	0.000	0.000	0.028	0.343	0.742	0.933	0.994
Sub-Bachelor Medicine	0.000	0.000	0.001	0.028	1.000	1.000	1.000

# GAMLSS Results: Probabilities Sorted from Below

	Top 1	Top 5	Top 25	Top 50	Top 75	Top 95	Top 99
Postgraduate Nursing	0.002	0.026	0.319	0.911	1.000	1.000	1.000
Sub-Bachelor Medicine	0.000	0.000	0.001	0.028	1.000	1.000	1.000
Bachelor Law	0.012	0.230	0.749	0.951	0.996	1.000	1.000
Postgraduate Medicine	0.067	0.424	0.881	0.976	0.993	1.000	1.000
Bachelor Natural / Physical Sciences	0.008	0.036	0.264	0.647	0.976	1.000	1.000
Bachelor IT	0.000	0.048	0.373	0.699	0.939	1.000	1.000
Bachelor Other Major	0.000	0.032	0.362	0.720	0.935	0.999	1.000
Bachelor Agriculture / Environment	0.000	0.024	0.329	0.665	0.927	0.999	1.000
Sub-Bachelor Creative Arts	0.015	0.034	0.119	0.330	0.768	0.999	1.000
Bachelor Medicine	0.043	0.244	0.761	0.924	0.973	0.998	1.000
...							
Postgraduate Law	0.021	0.079	0.445	0.844	0.919	0.975	0.994
Postgraduate Personal Services / Hospitality	0.000	0.000	0.028	0.343	0.742	0.933	0.994
Bachelor Education	0.000	0.002	0.201	0.660	0.904	0.978	0.993
Bachelor Other Health	0.000	0.020	0.335	0.663	0.848	0.970	0.993
Postgraduate Social Sciences	0.000	0.024	0.354	0.692	0.872	0.961	0.993
Bachelor Personal Services / Hospitality	0.000	0.000	0.232	0.594	0.819	0.954	0.991
Bachelor Social Sciences	0.007	0.043	0.293	0.625	0.830	0.942	0.986
Postgraduate Management / Commerce	0.022	0.163	0.556	0.798	0.882	0.960	0.984
Postgraduate Creative Arts	0.000	0.021	0.171	0.372	0.665	0.901	0.981
Sub-Bachelor Natural / Physical Sciences	0.000	0.002	0.149	0.407	0.640	0.871	0.974

# Conclusion

- We mostly find positive returns to education for our fields of study, especially among Bachelor degrees and Postgraduate degrees (after controlling for socio-demographic characteristics and ability)
- Higher moments matter and we find differences in income distributions (higher moments) across our education categories
- In terms of probabilities of being in the top or bottom of the income distribution there is no single ranking (like on the mean with OLS), hence risk preferences will matter in choosing field of study
- We conclude that in addition to average returns to education for different degrees and majors, it is important to consider the full distributional impact and include the risk component

# Summary Statistics: Number of Observations

Major	Post-graduate	Bachelor	Sub-Bachelor	Lower Education	Total
Natural / Physical Sciences	52	42	13	0	107
IT	58	54	86	0	198
Engineering	106	51	476	0	633
Architecture / Building	27	20	177	0	224
Agriculture / Environment	18	16	82	0	116
Medicine	25	13	5	0	43
Nursing	40	46	64	0	150
Other Health	49	44	92	0	185
Education	143	160	89	0	392
Management / Commerce	254	219	450	0	923
Law	57	26	23	0	106
Social Sciences	123	92	76	0	291
Creative Arts	31	41	54	0	126
Personal Services / Hospitality	9	5	175	0	189
Other Major	18	14	93	0	125
No post school qualification	0	0	0	877	877
Total	1010	843	1955	877	4685

# Descriptive Statistics: Annual Income Distribution by Degree

Table 5.3: Annual Income Distribution by Degree

	Mean	SD	Skewness	Kurtosis	Min	Max
Postgraduate	110,011.69	69,197.85	2.76	14.61	2,000.00	625,000.00
Bachelor	94,954.35	55,905.10	2.53	13.29	2,000.00	500,000.00
Sub-Bachelor	74,430.15	38,217.42	2.29	16.03	2,055.00	500,000.00
Lower Education	71,141.70	38,488.54	3.20	24.21	2,000.00	450,000.00

# Descriptive Statistics: Annual Income Distribution by Major

Table 5.4: Annual Income Distribution by Major

	Mean	SD	Skewness	Kurtosis	Min	Max
Medicine	152,382.86	98,336.34	1.38	4.61	26,243.00	468,000.00
Law	109,587.13	61,583.87	1.71	6.82	2,880.00	370,000.00
Engineering	97,996.56	57,894.22	2.66	15.18	4,000.00	520,000.00
Management / Commerce	97,899.76	70,539.23	2.93	15.50	2,000.00	625,000.00
IT	96,536.87	53,168.34	1.65	7.51	6,000.00	360,000.00
Natural / Physical Sciences	94,443.22	43,408.02	2.00	10.59	8,604.00	325,000.00
Social Sciences	83,744.58	43,693.54	1.53	6.56	6,000.00	300,000.00
Architecture / Building	80,251.90	35,177.89	1.03	4.70	2,055.00	220,000.00
Education	80,193.52	29,238.25	0.43	4.52	6,003.00	230,000.00
Other Major	76,965.92	37,845.04	1.21	4.58	9,361.00	210,000.00
Other Health	76,223.08	40,737.14	2.15	10.56	2,800.00	287,000.00
Agriculture / Environment	75,039.16	37,057.53	1.29	5.51	12,000.00	215,000.00
Nursing	74,550.53	31,247.72	2.19	16.62	9,740.00	290,000.00
No Post School Qualification	71,141.70	38,488.54	3.20	24.21	2,000.00	450,000.00
Creative Arts	69,248.25	33,394.34	1.16	4.40	8,000.00	195,000.00
Personal Services / Hospitality	56,990.34	22,376.61	0.55	4.33	2,500.00	143,000.00

# GAMLSS Results: Postgraduate Major Variables

	(1)	(2)	(3)	(4)
	$\mu$	$\sigma$	$\nu$	$\tau$
Postgraduate Natural / Physical Sciences	0.338*** (0.053)	0.014 (0.113)	2.462 (3.411)	0.815 (1.377)
Postgraduate IT	0.476*** (0.058)	0.143 (0.107)	4.694* (2.761)	0.917 (1.432)
Postgraduate Engineering	0.573*** (0.043)	0.092 (0.080)	1.485 (2.204)	1.182 (1.382)
Postgraduate Architecture / Building	-0.451*** (0.045)	2.870*** (0.141)	33.441*** (0.948)	19.383*** (0.152)
Postgraduate Agriculture / Environment	0.251*** (0.074)	-0.118 (0.170)	8.153 (5.979)	11.546 (9.318)
Postgraduate Medicine	0.887*** (0.072)	0.036 (0.147)	3.838 (5.033)	11.249 (10.110)
Postgraduate Nursing	0.359*** (0.028)	-0.326*** (0.117)	-41.820*** (5.524)	20.159*** (0.152)
Postgraduate Other Health	0.338*** (0.048)	-0.216 (0.139)	2.232 (4.528)	-0.678 (0.452)
Postgraduate Education	0.280*** (0.026)	-0.320*** (0.084)	21.904*** (2.972)	-0.446 (0.314)
Postgraduate Management / Commerce	0.495*** (0.034)	0.132* (0.069)	5.623*** (1.503)	-0.738*** (0.233)
Postgraduate Law	0.403*** (0.040)	-0.488*** (0.154)	-1.304 (5.266)	-1.425*** (0.304)
Postgraduate Social Sciences	0.306*** (0.037)	0.023 (0.085)	8.046*** (2.364)	-0.129 (0.416)
Postgraduate Creative Arts	0.025 (0.081)	0.276* (0.149)	5.616* (3.223)	0.350 (1.106)
Postgraduate Personal Services / Hospitality	-0.002 (0.081)	0.016 (0.238)	23.666*** (7.542)	144.679*** (0.152)
Postgraduate Other Major	0.615*** (0.098)	0.261 (0.171)	8.819** (4.458)	51.012*** (0.152)

# GAMLSS Results: Bachelor Major Variables

	(1)	(2)	(3)	(4)
	$\mu$	$\sigma$	$\nu$	$\tau$
Bachelor Natural / Physical Sciences	0.253*** (0.043)	-0.234* (0.122)	-9.026** (4.519)	0.991 (1.664)
Bachelor IT	0.313*** (0.056)	0.105 (0.102)	3.390 (2.936)	15.530*** (0.176)
Bachelor Engineering	0.349*** (0.061)	0.100 (0.127)	6.972** (3.135)	-0.271 (0.569)
Bachelor Architecture / Building	0.205*** (0.077)	-0.056 (0.162)	-0.364 (5.442)	13.762*** (0.944)
Bachelor Agriculture / Environment	0.274*** (0.087)	0.008 (0.180)	-1.722 (6.045)	50.500*** (0.152)
Bachelor Medicine	0.683*** (0.082)	-0.374 (0.275)	2.608 (9.076)	-0.822 (0.724)
Bachelor Nursing	0.329*** (0.039)	-0.520*** (0.168)	15.161** (6.232)	-1.248*** (0.334)
Bachelor Other Health	0.276*** (0.055)	-0.008 (0.141)	9.831** (3.836)	-0.443 (0.548)
Bachelor Education	0.249*** (0.023)	-0.395*** (0.075)	14.711*** (3.074)	-0.005 (0.399)
Bachelor Management / Commerce	0.348*** (0.031)	-0.036 (0.075)	2.955 (1.802)	-0.898*** (0.228)
Bachelor Law	0.680*** (0.086)	0.221 (0.145)	2.263 (3.914)	15.865*** (0.180)
Bachelor Social Sciences	0.200*** (0.045)	0.097 (0.119)	15.852*** (2.280)	-1.258*** (0.264)
Bachelor Creative Arts	0.133* (0.059)	0.103 (0.116)	-0.476 (3.506)	11.096 (10.010)
Bachelor Personal Services / Hospitality	0.010 (0.132)	0.817** (0.319)	27.202*** (4.947)	14.839*** (0.743)
Bachelor Other Major	0.315*** (0.070)	-0.295 (0.192)	-0.998 (8.727)	23.922*** (0.152)

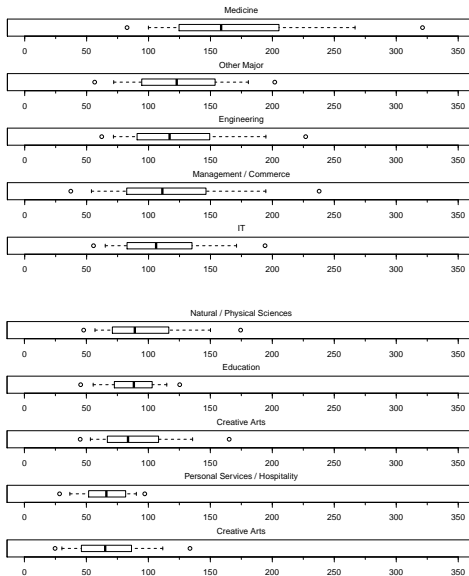
# GAMLSS Results: Sub-Bachelor Major Variables

	(1)	(2)	(3)	(4)
	$\mu$	$\sigma$	$\nu$	$\tau$
Sub-Bachelor Natural / Physical Sciences	0.092 (0.122)	0.391** (0.199)	9.600** (4.506)	27.205*** (0.152)
Sub-Bachelor IT	0.098** (0.045)	0.138* (0.082)	-1.820 (2.269)	27.600*** (0.152)
Sub-Bachelor Engineering	0.162*** (0.023)	0.070 (0.046)	-0.402 (1.204)	1.032* (0.530)
Sub-Bachelor Architecture / Building	0.126*** (0.032)	-0.073 (0.072)	3.506* (1.896)	-0.095 (0.351)
Sub-Bachelor Agriculture / Environment	-0.055 (0.042)	-0.060 (0.094)	3.937 (2.715)	0.359 (0.692)
Sub-Bachelor Medicine	-0.002 (0.026)	-0.980*** (0.319)	-177.017*** (30.760)	11.697 (13.590)
Sub-Bachelor Nursing	0.034 (0.038)	-0.116 (0.095)	6.357** (3.240)	4.671 (39.700)
Sub-Bachelor Other Health	-0.003 (0.036)	-0.248** (0.109)	-2.081 (3.148)	-0.774** (0.305)
Sub-Bachelor Education	0.010 (0.041)	0.098 (0.084)	1.554 (2.446)	1.994 (2.728)
Sub-Bachelor Management / Commerce	0.073*** (0.022)	-0.054 (0.052)	3.037** (1.392)	-0.327 (0.225)
Sub-Bachelor Law	0.228*** (0.063)	-0.133 (0.151)	0.011 (5.902)	10.056 (35.950)
Sub-Bachelor Social Sciences	0.048 (0.036)	-0.185** (0.093)	4.510 (3.152)	1.023 (1.213)
Sub-Bachelor Creative Arts	-0.038 (0.038)	-0.173* (0.102)	-12.851*** (3.931)	11.220 (7.545)
Sub-Bachelor Personal Services / Hospitality	-0.057** (0.028)	-0.174** (0.075)	4.232* (2.222)	-0.457 (0.290)
Sub-Bachelor Other Major	0.023 (0.040)	0.047 (0.079)	-2.721 (2.347)	25.319*** (0.152)

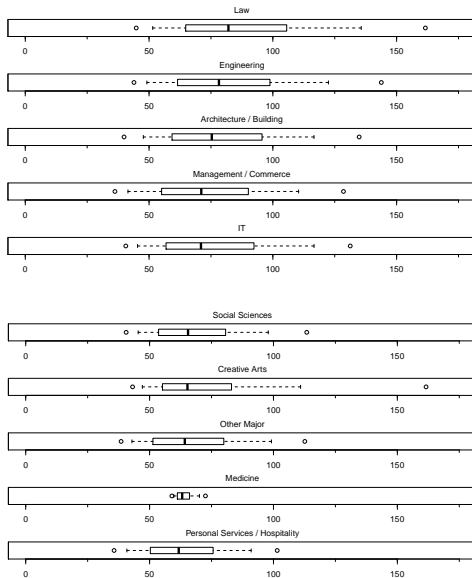
# GAMLSS Results: Interactions Specification - Control Variables

	(1)	(2)	(3)	(4)
	$\mu$	$\sigma$	$\nu$	$\tau$
Tenure (Decades)	0.182*** (0.018)	-0.333*** (0.043)	-6.933*** (0.913)	0.296*** (0.000)
Tenure Squared	-0.034*** (0.005)	0.078*** (0.013)	2.103*** (0.300)	-0.079*** (0.000)
Experience (Decades)	0.250*** (0.029)	0.046 (0.072)	-10.507*** (1.234)	-0.066*** (0.000)
Experience Squared	-0.032*** (0.006)	-0.007 (0.014)	1.546*** (0.267)	0.018*** (0.000)
Age 35 to 44	-0.006 (0.019)	0.058 (0.048)	4.013*** (0.787)	-0.107*** (0.000)
Age 45 to 54	-0.114*** (0.026)	0.075 (0.066)	7.349*** (1.289)	-0.275*** (0.000)
Age 55 to 65	-0.161*** (0.036)	0.100 (0.089)	4.588** (1.83)	-0.365*** (0.000)
Male=1	0.092*** (0.016)	0.166*** (0.043)	-0.224 (0.828)	-0.161*** (0.000)
Married=1	-0.027* (0.016)	0.047 (0.045)	-1.226 (0.944)	-0.317*** (0.000)
Aboriginal and/or Torres Strait Islander	0.097*** (0.032)	0.119 (0.089)	-2.676 (2.417)	0.861*** (0.000)
Non English speaking background	-0.079*** (0.017)	0.023 (0.040)	-3.904*** (0.821)	0.091*** (0.000)
Children=1	-0.011 (0.015)	0.045 (0.045)	2.643*** (0.971)	0.071*** (0.000)
Partner's Income	0.001*** (0.000)	-0.000 (0.000)	-0.014*** (0.005)	0.000*** (0.000)
Word pronunciation score (NART)	0.009*** (0.001)	-0.004 (0.003)	-0.158*** (0.058)	-0.002*** (0.000)
Backwards digits score	0.009** (0.004)	0.015 (0.009)	-0.688*** (0.182)	0.090*** (0.000)
Symbol digit modalities score	0.003*** (0.001)	-0.002 (0.001)	-0.114*** (0.025)	-0.001*** (0.000)
Male=1 × Married=1	0.077*** (0.023)	-0.094* (0.057)	-0.410 (1.162)	0.661*** (0.000)
Male=1 × Children=1	0.086*** (0.022)	-0.009 (0.056)	-1.088 (1.155)	-0.249*** (0.000)
Constant	10.233*** (0.042)	-3.419*** (0.108)	25.881*** (2.175)	1.705*** (0.152)

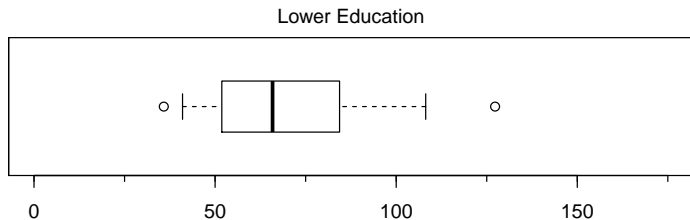
# GAMLSS Results: Boxplots with Postgraduate Majors





# GAMLSS Results: Boxplots with Sub-Bachelor Majors



# GAMLSS Results: Boxplot for Lower Education



# References I

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