Influence of Education on Wages – an Empirical Analysis

1. Introduction & Motivation

While most German universities demand low tuition fees, students in the US often have to take on loans to afford university tuition: On average, these amount to 30,000 dollars for a public university's Bachelor's degree[1]. Debt is taken on in the expectation of higher future returns on education, namely salary. Whether this assumption holds true is a question many students are puzzled by. This paper will therefore try to estimate the effect of education on salary income, providing students with a more informed perspective on the economic value of education. Education being subject to diminishing marginal returns this investigation will consider bachelor and master separately[4]. Moreover, this poster will try to reach some understanding of the impact of degree subject area on salary.

2. Theoretical Background

Four hypotheses were formulated to draw conclusions about the relationship between education and real wage.

Hypothesis 1: There is a wage gap between academics and non-academic, indicating that people with a bachelor's degree earn significantly more than those with a high school degree.

- Underlying research question (1/2)
- $\ln(\text{wage})i = \beta 0 + \beta 1 \cdot \text{Highschool} + \sum_{i=1}^{k}(\gamma_k * CVariable_k) + ui$

Hypothesis 2: Master degrees increase salary. However, the salary increment stemming from a master's degree is much lower than from a bachelor's degree due to diminishing marginal returns.

- Underlying research question (2/2)
- $\ln(\text{wage})i = \beta 0 + \beta 1 \cdot \text{Master} + \sum_{i=1}^{k}(\gamma_k * CVariable_k) + ui$

Educational returns are not simply a matter of degree or no degree but similarly of subject area. As our data does not provide any direct indication of degree choice we factor in this effect drawing from proxies. We do this based on two ideas: As graph 2 & 3 illustrate wage distribution between males and females deviates substantially and so do the effects of education. We believe this to be due to a common division in subject areas, where women tend to study social sciences and men are more prone towards natural sciences[2]. Likewise the company size can be considered as such a proxy. Whereas social scientists are broadly employed across all industries and firm sizes, natural scientists are not. If working in their original profession they are mainly employed by large firms, as only they can provide the monetary means for research and development.

Hypothesis 3: Due to differences in subject areas (social science vs. natural science) women tend to earn less than men with the same formal qualification (bachelor or master).

Hypothesis 4: There is a wage gap between academics in small and large firms due to the higher specialisation of jobs in large firms.

3. Experimental Design

3.1. Data Sample

For the analysis, we use the Current Population Survey Dataset (CPS)

Key characteristics:

- The Current Population Survey (CPS) is administered monthly by the U.S. Bureau of the Census to over 65,000 households.
- Initiated in the 1940s in the wake of the Great Depression, the survey was designed to measure unemployment.
- These surveys gather information on education, labor force status, demographics, and other aspects of the U.S. population.

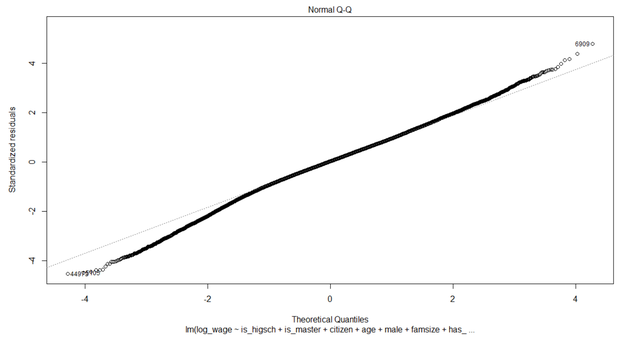
The data of our analysis is Cross-Sectional Data as we consider the same phenomena across different entities at the same point in time (2011). This comes with the disadvantage of being unable to account for individual effects such as intelligence or ability on wage income. However, given the large number of observations we are able to derive a fair and generalised conclusion. While the initial data set contains 204.983 observations, the following selection criteria were applied in order to obtain a sub sample of 52.446 observations suitable to our hypotheses:

- People who are not in the labour force: indicated by LABFORCE
- All people under the age of 20 to exclude people that are still in education.
- People that do not work full time
- We excluded all people that have no salary/ wage income, thus business owners or people with a different pay structure are not considered.

3.2. Methodology

Income is subject to diminishing marginal returns, meaning that a nominal change in income does not have the same effect on living circumstances across all income levels. To account for this effect, we took the natural logarithm of income. This changes the interpretation from nominal to percentage terms and furthermore normalizes the data.

Outliers: As most outlier selection methods assume normality we conducted outlier selection post-log-transformation. In our sample all income values exceeding a 1.5 times inter quartile range bound around the median were considered outliers and consequently excluded. All other values were either Boolean or categorical, thus not subject to outlier selection.
IDD: In order to comply with the assumption of independent distribution we checked correlations across all variables. The majority of the data set being dummy encoded correlations were generally quite low and no features had to be excluded.
Errors: The third least squared assumption is normally distributed error terms (*ui*) with a mean of zero. As can be taken from graph 1 this is approximately the case for model (6).



Graph 1

Then eight different models were estimated, with the wage's natural logarithm being the dependent variable. In model (1), only the variables of interest are included. The aim is to examine the effect of the influencing variables without taking into account omitted variable bias (OVB). Model (2) includes the main sociodemographic control variables. The effect of a bachelor's or master's degree consequently declines as other possible influences are included in the model. In model (3), the control variables related to the workplace are added. Model (4) then includes only the workplace variables and excludes immigration variables. Model (5) comprises the same control variables as model (4), but as well as the information whether a respondent is paid by hour or not. Due to large number of missing values in that variable this model relies on much fewer observations. Model (6) is the final model for Hypothesis I and II, only containing significant variables (p-value < 0.01). In model (7), the interaction effect between gender and education level is included, analysing hypothesis III. The interaction effect between firm size and education level is incorporated in model (8) thus testing hypothesis IV.

The majority of included variables is self-explanatory, while the remainder is explained below:

- Single Parent Dummy – indicates whether the participant is raising kids alone (is divorced, separated or widowed) or not
- Firm size – consists of five dummies for different firm sizes. A large firm is a company with more then 500 employees.
- Race – comprises 4 dummies: Hispanic, POC, Asian, Native American

4. Results

Hypothesis 1 – confirmed ✓

Model (6) is considering Bachelor as the baseline. Therefore the negative impact of high school indicates the invers effect of a bachelor's degree, suggesting that a bachelor increases income by 38.4%. This effect is significant at 0,1% level (p<0,001). The result supports hypothesis I in suggesting that people with a bachelor's degree earn significantly more than people with a high school degree (ceteris paribus).

Hypothesis 2 – confirmed ✓

The dummy variable Master is significant in all models (p-value < 0.001), suggesting that a master's degree has an incremental wage effect of 14.7%. Thus our second hypothesis is also confirmed. A master's not only increases salary compared to a bachelor's degree, but also is this effect much smaller than for a bachelor's. (Model (6)). A master's increases income (ceteris paribus).

Hypothesis 3 – not confirmed ✗

We reject Hypothesis 3 as the interaction effect between gender and education is not significant across bachelor's and master's. Nonetheless, as graph 2 and 3 illustrate there is a significant difference in the effects of education on salary between men and women. However, this effect is not driven by an interaction between the two. This does not imply that degree subject has no impact on salary, but rather that gender cannot be used as a proxy to model differences in degree choice. We thus cannot rely on gender to account for the omitted variable degree subject in our data set.

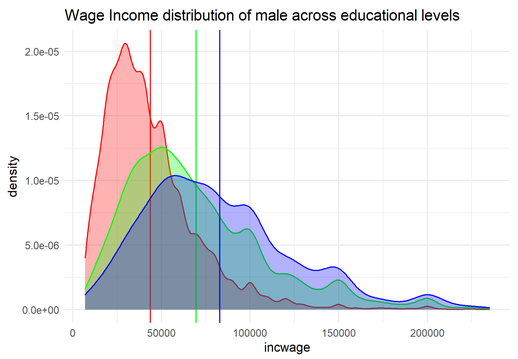
Hypothesis 4 – not confirmed ✗

The fundamental idea of Hypothesis 4 was the assumption that individuals who work in larger companies (with more than 500 employees) perform more complex and specialized tasks[3]. These tasks usually fall in the area of research and development, thus primarily require a natural science background. Based on that assumption firm size also can be used as a proxy for degree subject area. Model (8) depicts the interaction between a bachelor's degree and large firms as a significant one (p-value < 0.01). Having a bachelor's degree and working in a large company increases salary by 2.9%. However, a similar interaction effect cannot be found for a master's and working in a large company. This result is surprising given the assumption that a master's degree qualifies one for even more specialized jobs, which can be found in larger firms. Therefore, despite the findings for a bachelor's degree we reject Hypothesis 4. Nevertheless, an effect is discernible, but our approach to the effect of degree subject choice is presumably not the correct one.

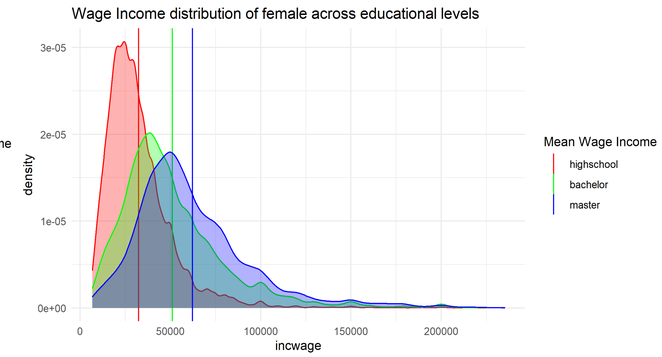
The table below shows the results of the different regression models:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Highschool degree only	-0.440***	-0.429***	-0.384***	-0.400***	-0.304***	-0.384***	-0.390***	-0.365***
	(0.006)	(0.006)	(0.005)	(0.005)	(0.011)	(0.005)	(0.008)	(0.010)
Masters degree	0.196***	0.175***	0.146***	0.149***	0.096***	0.147***	0.152***	0.124***
	(0.009)	(0.008)	(0.008)	(0.008)	(0.015)	(0.008)	(0.011)	(0.018)
US Citizen	No	Yes***	Yes***	Yes***	Yes***	-Yes***	Yes***	Yes***
Age	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Gender (male)	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
No. of direct family members	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
No. of children	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Single parent	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
First generation immigrant	No	Yes***	Yes***	No	Yes**	Yes***	Yes***	Yes***
Second generation immigrant	No	Yes***	Yes***	No	Yes*	Yes***	Yes***	Yes***
Included in pension scheme	No	No	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Member of a workers union	No	No	Yes	Yes	Yes*	No	No	No
Poor health condition	No	No	No	No	Yes***	Yes***	Yes***	Yes***
Paid by hour	No	No	No	No	Yes***	No	No	No
Disabled	No	No	No	No	Yes	No	No	No
Firm with 500+ employees	No	No	Yes***	No	No	No	No	Yes***
Interaction high school & male	No	No	No	No	No	No	0.012	No
							(0.011)	
Interaction master & male	No	No	No	No	No	No	-0.013	No
							(0.016)	
Interaction high school & large firm	No	No	No	No	No	No	No	-0.029**
								(0.012)
Interaction master & large	No	No	No	No	No	No	No	0.028
								(0.020)
Constant	10.844***	10.414***	10.205***	10.146***	10.295***	10.195***	10.205***	10.192***
	(0.005)	(0.014)	(0.016)	(0.014)	(0.033)	(0.016)	(0.016)	(0.017)
Race (Hispanic, POC, Asian, Native American)	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Firm size effect	No	No	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	52446	52446	52446	52446	12252	52446	52446	52446
R^2	0.1570	0.2660	0.3160	0.3088	0.3677	0.3159	0.3168	0.3163
Adjusted R^2	0.1569	0.2658	0.3157	0.3086	0.3663	0.3156	0.3165	0.3160

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001



Graph 2



Graph 3

5. Conclusion

In our study we examine the effect that study degrees have on the wage in the US in the year 2011 using data from the CPS Dataset. Different OLS regression models with different control variables were used with the conclusion that in general pursuing higher studies has a significantly positive effect on one's wages: In the case of the bachelor's degree, this brings a salary increase of 38.6% compared to graduates with only a high school degree. Master graduates also earn more than graduates with only a bachelor's degree (by 14,8%). No significant interaction effect between gender and educational level for either bachelor's or master's degree could be proven in this context. With regard to the next interaction effect, a significant positive correlation between company firm size and salary could only be demonstrated at Bachelor's level; this was not the case for Master's graduates.

Following these results, one can conclude that education generally has a positive impact on salary. This, in turn, can justify taking out any loans necessary for studying, although this must be considered on a case-by-case basis.

6. Sources

[1]Hanson, M. (2021, 17. November). *Student Loan Debt Statistics*. Education Data Initiative. https://educationdata.org/student-loan-debt-statistics
[2]Kugler, A. D., Tinsley, C. H. & Ukhaneva, O. (2021). Choice of majors: are women really different from men? *Economics of Education Review*, *81*, 1. https://doi.org/10.1016/j.econedurev.2021.102079
[3]Oi, W. Y. & Idson, T. L. (1999). Chapter 33 Firm size and wages. *Handbook of Labor Economics*, 2165–2214. https://doi.org/10.1016/s1573-4463(99)30019-5
[4]Carneiro, P., Heckman, J. J., & Vytlacil, E. J. (2011). Estimating marginal returns to education. American Economic Review, 101(6), 2754-81.