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An Economic Analysis of Investment in a College Degree

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***Abstract*— The ever-increasing costs of college tuition make any family or college-bound student question the value and relative cost of higher education. Engineering Economics fundamentally involves evaluating economic outcomes to decide if it is a good idea to invest money in 'something'. This paper investigates the 'worth' of a college education within the areas of salary and tuition trends, using data from the National Center for Education Statistics. Thirty-one years of NCES data for tuition and educational outcomes were analyzed and found a statistically significant higher wage for college graduates, with a payback period for college degree investment of about eight and a half years. However, in constant dollars, the increasing trend for tuition cost over time outpaces the relatively flat trend in college graduate salaries, signaling an unsupported level of surging tuition costs if based solely on a relationship to wages.**

Keywords—Cost, Return on Investment

I. Introduction

The ever-increasing cost of college tuition makes any family or college-bound student question the value and relative worth of higher education. One standard reason used to justify higher education is higher lifetime earnings [1]. The average cost of a college degree has increased significantly relative to overall inflation over the last few decades [2]. Part of this increase could be attributed to decreases in government funding or simply the market demand, as students seek degrees chasing the promise of higher salaries. It makes one ask—are those investments and ongoing tuition increases really justified through high salaries for college graduates?

Engineering Economics fundamentally involves evaluating economic outcomes of alternatives for a given financial situation—is it a good idea to invest money on 'something'. A related question, early on in an engineer's career path, might be 'is it a wise decision to invest in a college degree'? While this analysis might be a little different than a Present Worth (PW) or Future Worth (FW) analysis because of the multitude of variables, it is a very valid question [1]. This paper investigates the 'worth' of a college education, within the areas of salary and tuition, using 31 years of data from the National Center for Education Statistics (https://nces.ed.gov) [4,5].

The analysis uses both "current dollar" and "constant dollar" data to give a perspective of money/cost over time. Current dollars describe actual value in the year that the money was spent or earned while Constant dollars are adjusted for inflation [3]. This study is organized as a traditional statistical investigation, including sections addressing: research question and hypotheses, Statistical techniques, variables and data, test statistics and decision, and interpretations/conclusions.

II. The Study

A. Research Question

The overall questions to be investigated are around the relationships between investment in college (tuition rate) and salary. The 'investment' in this case, is interpreted to be cost of college tuition. From these areas the following research questions were developed.

Q1: Does wage/salary increase with a college degree compared to high school diploma?

Q2: Does wage/salary relate to the cost of a college degree (tuition)?

B. Hypotheses, Type 1 Error, & Technique

Null-hypothesis significance test (NHST) is a method of statistical inference by which an experimental factor is tested against a hypothesis of 'no effect', or no relationship based on a given observation. Using standard statistical analysis terms and methodology the following hypotheses were developed:

Q1: H0: Wage/salary does not change with a college degree. Means are the same.

(H0: $\mu 1 - \mu 2 = 0$ and Halt: $\mu 1 - \mu 2 \neq 0$).

Q2: H0: College Tuition is not correlated with Salary.

Correlation is zero. (H0 : $\rho = 0$; Ha: $\rho \neq 0$).

The Type I error rate used for each analysis is $\alpha = 0.01$. This corresponds to a tested significance value of 0.01 and 99% Confidence Interval. This is a widely used choice of α level for statistical significance test for correlation.

For Q1, an NHST in the form of a paired-sample t-test is an accepted technique for answering a yes/no question about population mean comparison.

For Q2, Pearson's r correlation method and bivariate regression with significance test (NHST) is an accepted technique for answering a yes/no question about correlation and between variables.

C. Assumptions & Limitations

In order for paired-T test. Pearson's r correlation, and bivariate regression to be valid, several assumptions about the data must be met, including: the variables must be quantitative (or no more than 2 levels of categorical), scores should be independent, and the samples are taken randomly from a normally distributed population. Also, there should be no extreme bivariate outliers (X, Y), and (X, Y) relation should be reasonably linear. Ultimately these assumptions support the idea that the sampled data correctly describe the population and that the correlation is not errantly inflated/deflated. For this dataset, tuition and salary are quantitative variables and independent. As a credible supplier of information/statistics, the data available from the National Center for Education Statistics (NCES) is assumed to be random and valid [4,5].

Data from NCES is available dating back to the 1970s, but there are some limitations with the data collected over the period of analysis. As such, only median salary data for 'males' age 25+ with no differentiation by race will be examined, and data are assumed to be equally distributed across age and race. There is also a cultural truth about salary disparity between males and females, but no results generalization will be made between genders in this analysis.

D. Variables, Data Collection, & Data Preparation

For this study, the variables under investigation are tuition and salary. All data used in the analyses were collected from NCES database [4,5]. Archived tables were downloaded in Excel (xlsx) file format and aligned based on year. 31 years of data is used for the analysis. The formatted summary data table is shown in Appendix A. While there is no causal relationship assumed or investigated, where appropriate college tuition will be used as the (X) and salary as (Y).

Tuition and salary are quantitative ratio variables, coded in US Dollars. The tuition and salary are average amounts across the US regions and job-categories. Tuition data is also the average tuition across public and private 4-year degrees (Bachelors).

III. Results of the Study

A. Graphics & Descriptive Statistics

Figure 1 shows the salary trend (current dollars) by education level. There is an upward positive trend across the 31 years of data. Observationally, salary for Bachelor's degree seems to be out-pacing high school, as the difference widens over time.

Average and (Trend Slope):
Bachelor Salary: $58,886 (1264 $/year);
HS Salary: $36,301 (669 $/year)

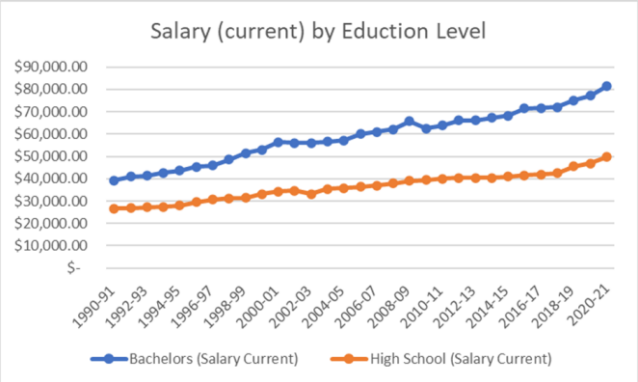

Figure 1. Salary trend for Bachelor's and High School Degrees. (Current $)

Figure 2 shows the salary trend (constant dollars) by education level. The trend for Bachelor's looks reasonably constant, while there is a slight negative trend for High School across the 31 years of data.

Average and (Trend Slope):
Bachelor Salary: $79,435 (2.6 $/year);
HS Salary: $49,572 (-108 $/year)

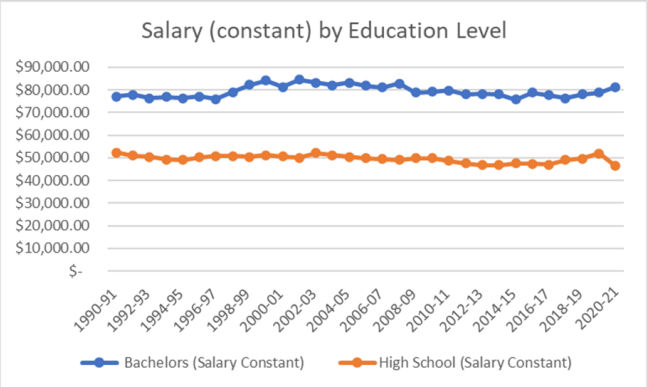

Figure 2. Salary trend for Bachelor's and High School Degrees. (Constant $)

There are graphical trends and comparisons for salary between education levels, but the true relationships will be analyzed later through statistics and the T-Test.

Figure 3 shows the Salary and Tuition Cost trend for current dollars. There is a positive upward trend for both, with Salary graphically outpacing tuition as the gap widens over time.

Average Slope: Tuition: 462 $/yr; Salary: 1264 $/yr.

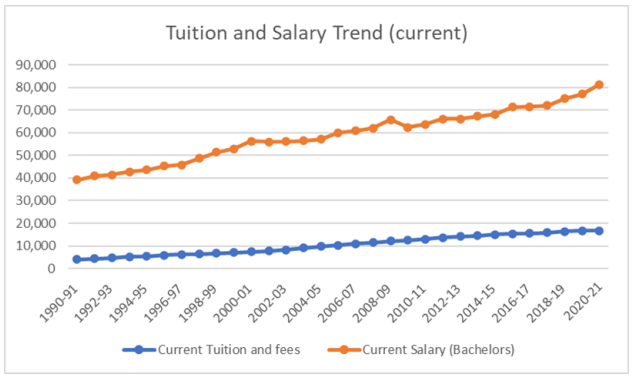

Figure 3. Tuition and Salary trend (Current $)

Figure 4 shows the scatter plot of Tuition and Salary, with a noted linear trend (correlation?).

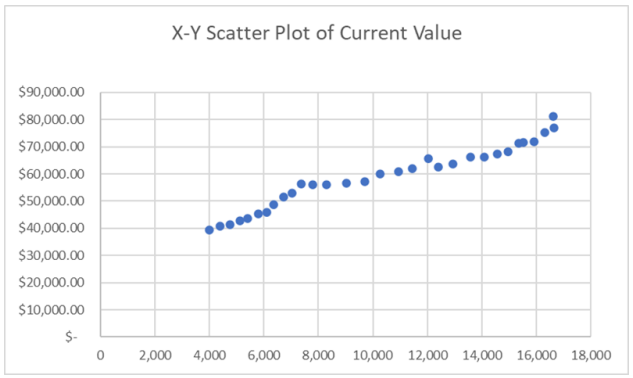

Figure 4. Scatter plot of Tuition (X) and Salary (Y).

Figure 5 shows Salary and Tuition Cost trend for constant dollars. In this case, Salary appears relative flat over time, but there is a positive upward trend for tuition.

Average Slope: Tuition: 331 $/yr; Salary: $2/yr.

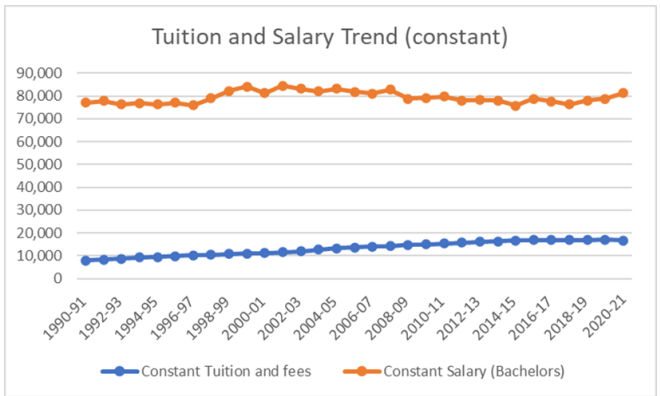

Figure 5. Tuition and Salary trend (Constant $)

Figure 6 shows the scatter plot for Tuition (X) and Salary (Y). There is no apparent relationship predicted from this graph.

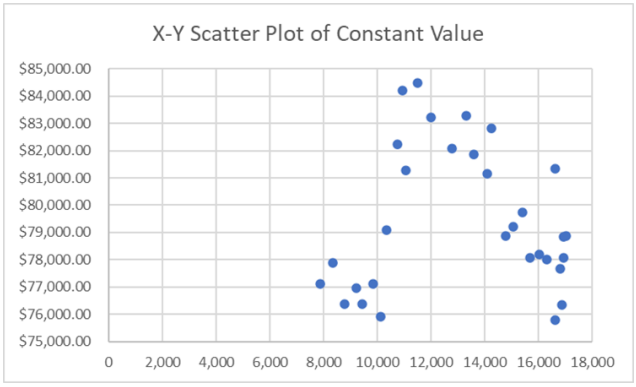

Figure 6. Scatter plot of Tuition (X) and Salary (Y).

B. Statistical Results, Test Statistic, & Statistical Decision

a) Comparison of Wages

A paired T-test was used to analyze the current and constant value salaries for 4-year degree and high school education. Results are shown in Figure 7.

t-Test: Paired Two Sample for Means

	Bachelors (Salary Current)	*High School (Salary Current)*
Mean	58886.12903	36301.29032
Variance	134779731.2	38151544.95
Observations	31	31
Pearson Correlation	0.991692875	
Hypothesized Mean Difference	0	
df	30	
t Stat	22.69255244	
P(T<=t) one-tail	9.58706E-21	
t Critical one-tail	2.457261542	
P(T<=t) two-tail	1.91741E-20	
t Critical two-tail	2.749995654	

t-Test: Paired Two Sample for Means

	Bachelors (Salary Constant)	*High School (Salary Constant)*
Mean	79435.17219	49572.62697
Variance	6804320.657	2705719.039
Observations	31	31
Pearson Correlation	0.239810519	
Hypothesized Mean Difference	0	
df	30	
t Stat	60.90714404	
P(T<=t) one-tail	2.65872E-33	
t Critical one-tail	2.457261542	
P(T<=t) two-tail	5.31743E-33	
t Critical two-tail	2.749995654	

Figure 7. Paired T-Test Results. p< .001

Q1: The probability, P(T<=t), of the means being equal (or H0: μ1- μ2 = 0) is less than .001, so the Null Hypothesis is rejected, and the Alternate Hypothesis (Halt: μ1- μ2 ≠ 0) is accepted or μ1 ≠ μ2.

b) Tuition Rate & Salary

Pearson's coefficient represents the amount of correlation from -1 to 1, with 1 being perfect, positive correlation. A Regression Analysis and Pearson Correlation Coefficient were calculated using Excel Data Analysis for Current value: Tuition and Salary.

The Pearson correlation is r(29) = .977 (reasonably high positive correlation).

Using Excel Regression Analysis: Multiple R = .977 (Person coefficient) along with the significance

analysis p < .001 (α=.01). Excel results are shown in Figure 8.

Regression Statistics	
Multiple R	0.97747624
R Square	0.955459799
Adjusted R Squa	0.95392393
Standard Error	907.020483
Observations	31

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	511790752.3	5.12E+08	622.0972	3.82955E-21
Residual	29	23857898.54	822686.2		
Total	30	535648650.8			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-10579.6591	855.608811	-12.3651	4.36E-13
X Variable 1	0.355773255	0.014264093	24.94188	3.83E-21

Figure 8. Excel Regression Analysis for Current Value Tuition and Salary.

There is a significant positive correlation between Current Value Tuition and Salary.

In order to further investigate the possible relationship between Tuition and Salary, a Regression Analysis and Pearson Correlation Coefficient were calculated using Excel Data Analysis for Constant value: Tuition and Salary (adjusted for inflation).

Excel results shown in Figure 9.

Regression Statistics	
Multiple R	0.000415309
R Square	1.72481E-07
Adjusted R	-0.03448258
Standard E	3108.223651
Observatio	31

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	1	48.32420415	48.3242	5E-06	0.998230842
Residual	29	280170573.7	9661054		
Total	30	280170622			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	13245.71542	17290.14269	0.766085	0.449817
X Variable	-0.000486552	0.21755008	-0.00224	0.998231

Figure 9. Excel Regression Analysis for Constant Value Tuition and Salary.

Using Excel Regression Analysis: Multiple R = -0.0004 (Person coefficient) along with the significance analysis p = .998 (α=.01). There is no significant correlation between Constant Value Tuition and Salary.

C. Interpretations and Conclusions

The relationship between salaries of persons with Bachelor's degree and High School education was examined with paired T-test and found to have statistically significant difference. In 2010 current dollars the average difference in wages over time was approx. $25k/year.

A simple payback analysis can also be done for college investment. The cost for a Bachelor's degree in 2010 was $13k (current dollar) with a total cost of about $52k over 4 years. The lost wages for four years earning with a High School degree was $39k, totaling about $156k over four years. Along with the outlay for four years of tuition costs, total invested is about $208k, assuming no tuition assistance, no student loan interest, etc. When graduating in 2014, the salary for Bachelor's degree was $67k, $25k more than High School education. Accepting the reasonably constant graphic trend, payback is then total invested divided by the additional amount of wage/year, or about 8.5 years ($208k/25k). After the payback period, Bachelor's degree salary far outpaces High School education, resulting in a much larger lifetime earnings, as common sources suggests[1]. A similar analysis in constant dollars ($15k tuition. $50k HS wages, $30k difference in wages), calculates payback to be even better at 8.7 years.

The 'simple' payback calculations are shown in Figure 10.

Payback - Current Dollars				
	Amount	Years	Total	
Total Tuition	$ 13,000	4	$ 52,000	
Lost wages	$ 39,000	4	$ 156,000	
			$ 208,000	Total Invested at graduation
Difference in salary			$ 25,000	
			8.3	Payback (years)
Payback - Constant Dollars				
Total Tuition	$ 15,000	4	$ 60,000	
Lost wages	$ 50,000	4	$ 200,000	
			$ 260,000	Total Invested at graduation
Difference in salary			$ 30,000	
			8.7	Payback (years)

Figure 10. Payback calculations for Investment in College (2010).

The trend for payback period is reasonably flat, with an average of 8.5 years (see Figure 11).

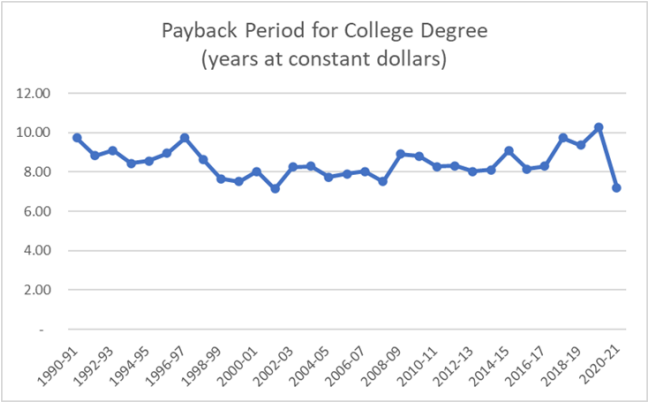

Figure 11. Payback period trend for college education.

Moving on to cost of tuition over time, the trends in current dollars correlate very well, at .977. On the surface the rising cost of tuition seems justified—rising tuition correlated to rising salaries. Further, when investigated using constant dollars, salary's graphical trend is flat while tuition is increasing, (but no statistical relationship or correlation). This points toward an unjustified trend in increasing tuition rates, if the 'purported' reason is an associated higher salary trend.

In all, this study investigated the relationships between tuition cost trends and salaries for four-year degree and high school educated workers. Clearly it does not include an exhaustive analysis using all combinations of variations in jobs, scholarships, interest rates, and circumstances—but overall, some solid conclusions can be made. Thirty-one years of NCES data for tuition and educational outcomes were analyzed[4,5] and found a statistically significant higher wage for college graduates, with a payback period for college degree investment of about eight and a half years. However, in constant dollars, the increasing trend for tuition cost over time outpaces the relatively flat trend in college graduate salaries, signaling an unsupported level of surging tuition costs if based solely on a relationship to wages.

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[3] Current Versus Constant Dollars. (n.d.). United States Census Bureau. https://www.census.gov/topics/income-poverty/income/guidance/current-vs-constant-dollars.html

[4] Occupation and Earnings of Educational Attainment Table 502.20. (2022). Digest of Educational Statistics. National Center for Education Statistics. https://nces.ed.gov/programs/digest/d22/tables/dt22_502.20.asp?

[5] Student Charges Table 330.10. (2022). Digest of Educational Statistics. National Center for Education Statistics. https://nces.ed.gov/programs/digest/d22/tables/dt22_330.10.asp?

Summary Salary and Tuition Data from NCES

Year	Bachelors (Salary Current)	High School (Salary Current)	Bachelors (Salary Constant)	High School (Salary Constant)
1990-91	$ 39,240	$ 26,650	$ 77,108	$ 52,368
1991-92	$ 40,910	$ 26,780	$ 77,894	$ 50,990
1992-93	$ 41,360	$ 27,280	$ 76,365	$ 50,368
1993-94	$ 42,760	$ 27,370	$ 76,956	$ 49,259
1994-95	$ 43,660	$ 28,040	$ 76,387	$ 49,058
1995-96	$ 45,270	$ 29,510	$ 77,106	$ 50,263
1996-97	$ 45,850	$ 30,710	$ 75,927	$ 50,856
1997-98	$ 48,620	$ 31,220	$ 79,104	$ 50,794
1998-99	$ 51,410	$ 31,480	$ 82,220	$ 50,346
1999-2000	$ 52,990	$ 33,180	$ 84,200	$ 51,130
2000-01	$ 56,330	$ 34,300	$ 81,270	$ 50,560
2001-02	$ 55,930	$ 34,720	$ 84,480	$ 50,020
2002-03	$ 56,080	$ 33,210	$ 83,230	$ 52,160
2003-04	$ 56,500	$ 35,410	$ 82,090	$ 51,250
2004-05	$ 57,220	$ 35,730	$ 83,280	$ 50,370
2005-06	$ 60,020	$ 36,300	$ 81,870	$ 49,780
2006-07	$ 60,910	$ 37,030	$ 81,140	$ 49,470
2007-08	$ 62,090	$ 37,860	$ 82,810	$ 49,090
2008-09	$ 65,800	$ 39,010	$ 78,870	$ 49,860
2009-10	$ 62,440	$ 39,480	$ 79,200	$ 49,770
2010-11	$ 63,740	$ 40,060	$ 79,740	$ 48,720
2011-12	$ 66,200	$ 40,450	$ 78,080	$ 47,620
2012-13	$ 66,150	$ 40,350	$ 78,210	$ 46,860
2013-14	$ 67,240	$ 40,290	$ 78,010	$ 46,850
2014-15	$ 68,160	$ 40,930	$ 75,784	$ 47,520
2015-16	$ 71,390	$ 41,570	$ 78,844	$ 47,300
2016-17	$ 71,630	$ 41,890	$ 77,680	$ 46,920
2017-18	$ 71,990	$ 42,440	$ 76,349	$ 49,180
2018-19	$ 75,150	$ 45,580	$ 78,082	$ 49,660
2019-20	$ 77,090	$ 46,850	$ 78,864	$ 51,990
2020-21	$ 81,340	$ 49,660	$ 81,340	$ 46,370

(Occupation and Earnings of Educational Attainment Table 502.20, 2022). [4]

(Student Charges Table 330.10, 2022). [5]