

Is There a Correlation Between the Change in  
University Tuition and the Inflation Rate?

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Math Applications and Interpretations SL

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## Statement of the Task:

As a high school senior, much of my time is spent researching and applying for colleges. Something that's always on my mind is the extreme cost of a college education in the United States. During my college search I learned that the price of college has been increasing significantly over the years. That's why I want to explore the relationship between the cost of tuition and the rate of inflation in both public and private universities.

For this investigation I used the price of tuition for 4 year universities in current dollars from the years 2000 through 2018. Tuition costs include room and board, and were estimated by The National Center for Education Statistics (NCES). The tuitions are averages for the year so the change in price will vary from college to college.

According to The Institute for College Access and Success, “in 2016, 1.5 million students graduated from a four-year college with an average of \$29,650 in student loans”. A college education is becoming inaccessible for many people, which led me to wonder about the cause of the change in price. Inflation is a normal part of the economy, so the price of *all* goods should change at a similar rate. College tuition, however, seems to be increasing at a higher rate. This situation led me to wonder if the rapid increase was correlated with the fluctuating inflation rate or if it is separate from the inflation.

## Plan:

Using data that I got from the National Center for Education Statistics, I am going to find the Pearson correlation coefficient between the rate of increase of both public and private 4 year universities, and the rate of inflation for each year using data from 2000 to 2018. I will then also find the Spearman's rank correlation coefficient to see if the correlation is more or less accurate.

The Pearson correlation coefficient is used to determine the strength of the correlation between two variables and Spearman's does a similar thing but has ranks for all of the data.

My first step is to find the percent change from one school year to the next so I will be able to accurately be able to compare that to the inflation rate. To do that I will need to subtract each school year from the year before and then divide the difference by the tuition of the first year. This will give me a percentage that I can accurately compare to inflation's percent change, rather than comparing raw data.

To find the Pearson correlation coefficient ( $r$ ) and Spearman's rank correlation coefficient ( $\rho$ ) I will use the overall US inflation as my x values and the tuition increase percentage as the y values based on my hypothesis that the tuition increase is dependent upon inflation rate (the dependent variable). I predict that there will be a slight correlation between the inflation and tuition rate because it seems reasonable to assume that inflation would make college more expensive.

### Finding the percent change:

In order to find the correlation coefficients I first need to find the percent change of the tuition between years because inflation is a percentage. The tuition increase is the percentage that the tuition increased between two school years. To find the tuition increase I subtract one year from the previous year to get the difference. I then divide the tuition difference by the tuition of the previous year to get the tuition increase in the form of a percentage.

### Public Universities:

For example this is how I found the tuition increase from the 2000-01 school year to the 2001-02 school year.

$$\$12,805 - \$12,263 = \$542$$

$$\$542 \div \$12,263 = 4.42\%$$

Then I repeated these steps for all of the school years until 2017-18 when my data ends, and created table 1.

Table 1: Percent change in tuition at public universities

year	Tuition (\$)	Difference (\$)	Tuition Increase
2000-01	12,263		
2001-02	12,805	542	4.42%
2002-03	13,336	531	4.15%
2003-04	14,233	897	6.73%
2004-05	14,789	556	3.91%
2005-06	15,098	309	2.09%
2006-07	15,557	459	3.04%
2007-08	15,739	182	1.17%
2008-09	16,428	689	4.38%
2009-10	17,214	786	4.78%
2010-11	17,866	652	3.79%
2011-12	18,303	437	2.45%
2012-13	18,742	439	2.40%
2013-14	19,113	371	1.98%
2014-15	19,533	420	2.20%
2015-16	19,998	465	2.38%
2016-17	19,928	-70	-0.35%
2017-18	20,050	122	0.61%

Private Universities:

I used the same method to find the tuition for the private universities and the math for the 2000-01 school year to the 2001-02 school year looked like this.

$$\$31,882 - \$30,973 = \$909$$

$$\$909 \div \$30,973 = 2.00\%$$

I repeated those steps for the rest of the school years and made table 2.

Table 2: Percent change in tuition at private universities

Year	Tuition (\$)	Difference (\$)	Tuition increase
2000-01	30,973		
2001-02	31,882	909	2.00%
2002-03	32,411	529	1.66%
2003-04	33,427	1,016	3.13%
2004-05	33,991	564	1.69%
2005-06	34,082	91	0.27%
2006-07	35,151	1,069	3.14%
2007-08	35,426	275	0.78%
2008-09	36,102	676	1.91%
2009-10	36,459	357	0.99%
2010-11	36,494	35	0.10%
2011-12	36,720	226	0.62%
2012-13	37,614	894	2.43%
2013-14	38,649	1,035	2.75%
2014-15	39,825	1,176	3.04%
2015-16	41,168	1,343	3.37%
2016-17	42,400	1,232	2.99%
2017-18	43,139	739	1.74%

## Pearson's Correlation Coefficient:

The Pearson's Correlation Coefficient is used to determine the strength of the linear correlation between two variables and is represented by the letter r. The closer the number is to zero the weaker the correlation is. To find the correlation I used google sheets but it can also be found using the equation below.  $\bar{x}$  and  $\bar{y}$  are the means of the x and y columns and  $\Sigma$  is the sum of all the data values. An r value of 1 or -1 means that there is a perfect correlation and the closer it is to 0 the weaker the correlation becomes.

$$r = \frac{\Sigma(xi-\bar{x})(yi-\bar{y})}{\sqrt{\Sigma(xi-\bar{x})^2 \Sigma((yi-\bar{y})^2}}$$

## Public Universities

I first found the Pearson's Correlation Coefficient for public universities using table 3.

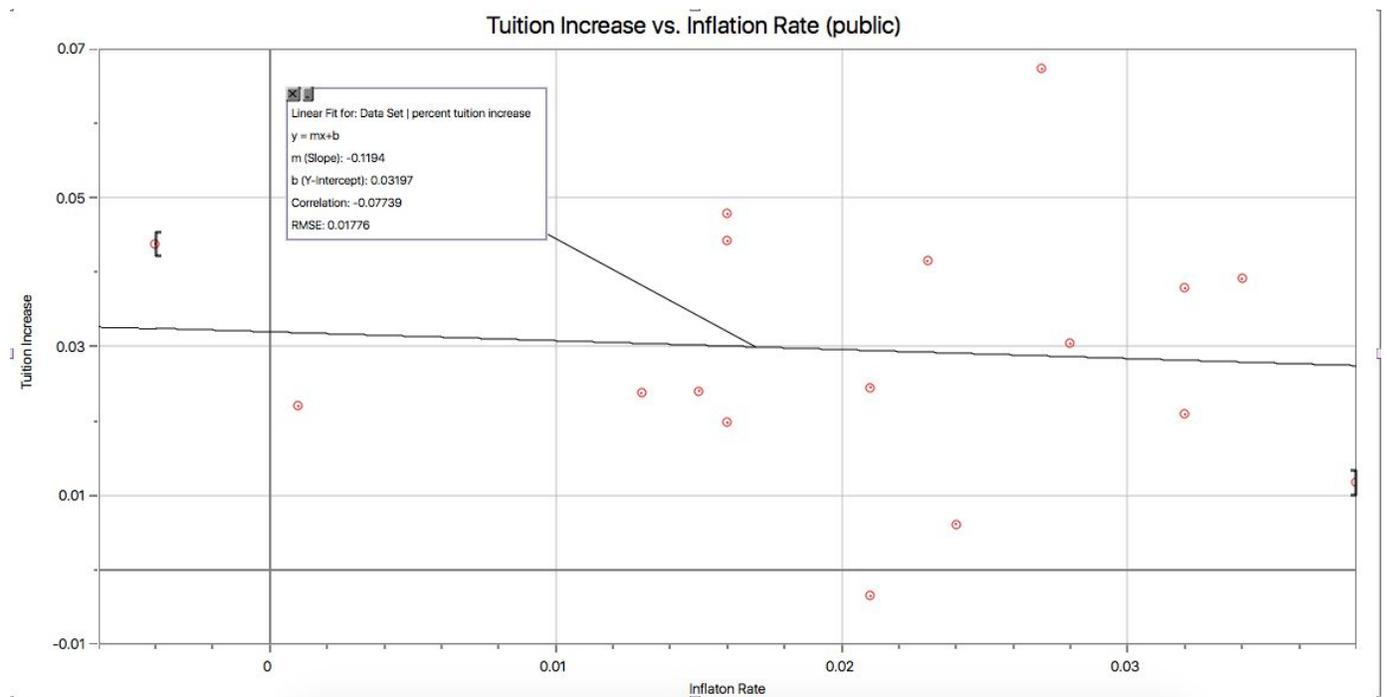
Table 3:

<b>Tuition Increase</b>	<b>US Inflation</b>
y	x
4.42%	1.60%
4.15%	2.30%
6.73%	2.70%
3.91%	3.40%
2.09%	3.20%
3.04%	2.80%
1.17%	3.80%
4.38%	-0.40%
4.78%	1.60%
3.79%	3.20%
2.45%	2.10%
2.40%	1.50%
1.98%	1.60%

2.20%	0.10%
2.38%	1.30%
-0.35%	2.10%
0.61%	2.40%

Using google sheets I found r to be equal to -0.08 which means that there is next to no correlation between the variables and it's negative. I made graph 1 using the values in table one and added a line of best fit and the correlation of the line of best fit is also the Pearson's correlation coefficient.

Graph 1:



Private Universities

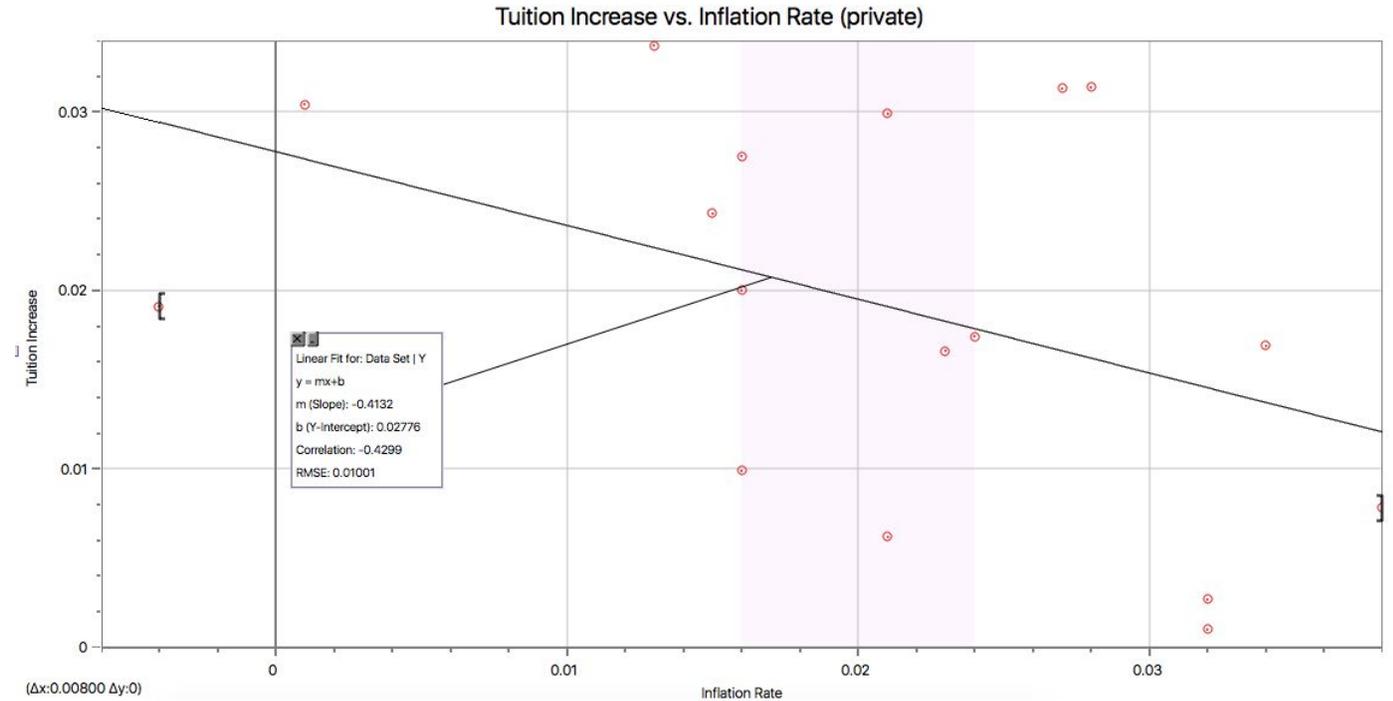
Then I did the same thing for private universities and used table 4 to find Pearson's Correlation Coefficient.

Table 4:

Tuition Increase	US inflation
y	x
2.00%	1.60%
1.66%	2.30%
3.13%	2.70%
1.69%	3.40%
0.27%	3.20%
3.14%	2.80%
0.78%	3.80%
1.91%	-0.40%
0.99%	1.60%
0.10%	3.20%
0.62%	2.10%
2.43%	1.50%
2.75%	1.60%
3.04%	0.10%
3.37%	1.30%
2.99%	2.10%
1.74%	2.40%

Using Google Sheets I found  $r$  to be  $-0.43$  which means there is basically no correlation but it is negative. I graphed the data in table 4 and made graph 2 below and added a line of best fit. The line of best fit can be used to check the value of  $r$  and it's correct.

Graph 2:



### Analysis of Pearson's Correlation Coefficient:

For both public and private universities there is a very weak negative correlation. The correlation for private universities was slightly higher than public so maybe there is a small relationship but it is so small that we cannot conclude that the change in college tuition is a result of inflation. To be sure I'm going to also do a Spearman's Rank Correlation Coefficient to see if there is a correlation there.

### Spearman's Rank Correlation Coefficient:

Since there was little to no correlation between the tuition and the inflation using Pearson correlation coefficient I decided to try and use Spearman's to see if there is a correlation

using ranks. Spearman's is similar to Pearson's except that each variable has a rank and is used in cases when Pearson's is not appropriate. The variable that's used with Spearman's is  $\rho$  and is found using this equation.  $\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$ .  $d_i$  is the difference in the ranks and n is the number of observations. This is the equation used to calculate Spearman's rank correlation coefficient but for this exploration I used technology to find  $\rho$ . A  $\rho$  value of 1 or -1 means its a perfect correlation and the closer it is to 0 the weaker the correlation gets, just like for Pearson's.

Public Universities:

I started with the public university data in table 5. I ranked the inflation and the tuition from greatest to least and used google sheets to find  $\rho$ .

Table 5:

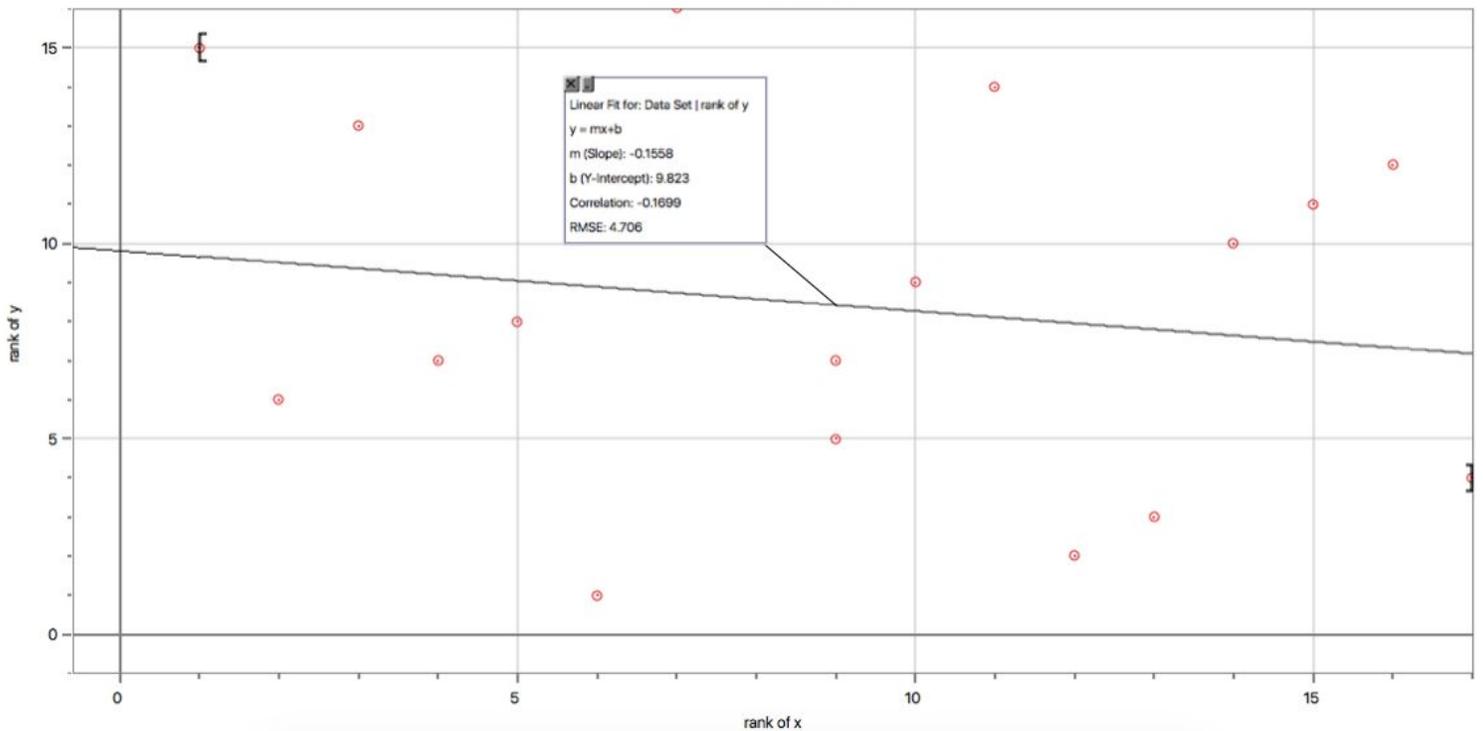
US inflation (x)	Rank of x	Tuition increase (y)	Rank of y
1.60%	13	4.42%	3
2.30%	8	4.15%	5
2.70%	6	6.73%	1
3.40%	2	3.91%	6
3.20%	3	2.09%	13
2.80%	5	3.04%	8
3.80%	1	1.17%	15
-0.40%	17	4.38%	4
1.60%	12	4.78%	2
3.20%	4	3.79%	7
2.10%	10	2.45%	9

1.50%	14	2.40%	10
1.60%	11	1.98%	14
0.10%	16	2.20%	12
1.30%	15	2.38%	11
2.10%	9	-0.35%	17
2.40%	7	0.61%	16

Using google sheets I found the Spearman's rank correlation for public universities to be -0.17. This is slightly higher than Pearson's but still very small. Using the ranks I graphed the data in graph 3 and found the line of best fit.

Graph 3:

rank of y vs rank of x



Private Universities:

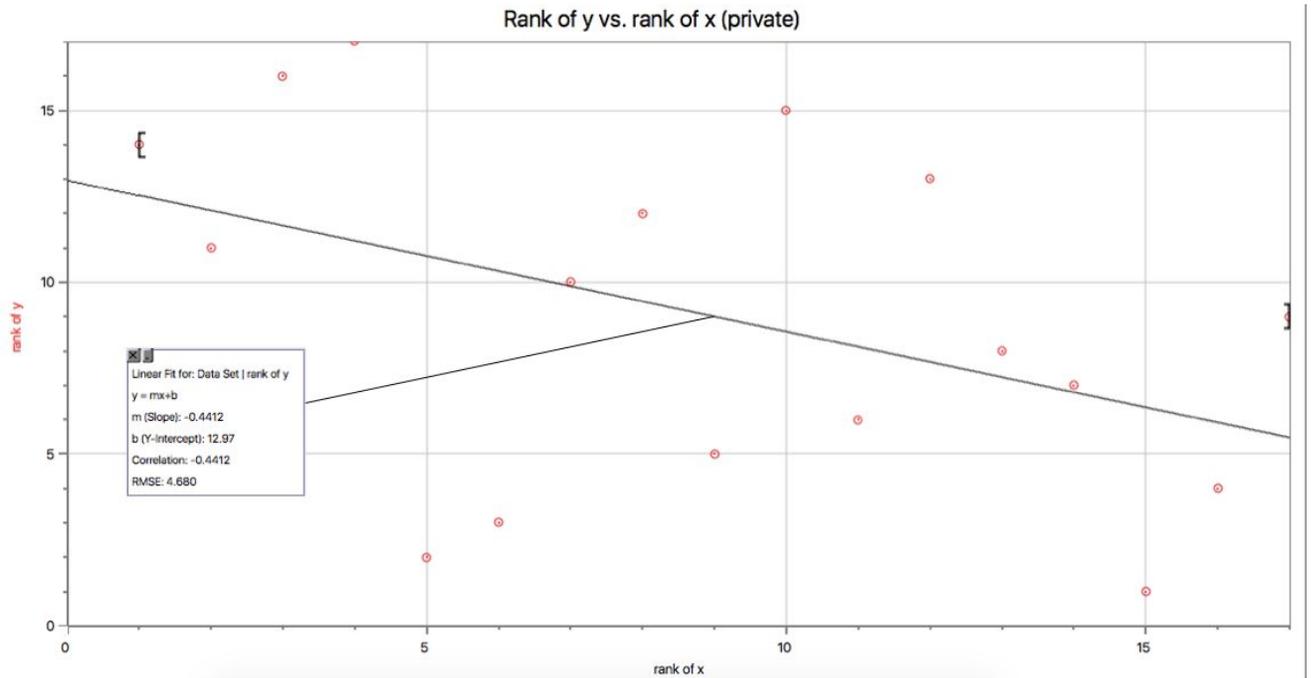
To find Spearman's rank correlation for public universities I did the same thing that I did for the public universities. The data and their ranks are shown in table 6.

Table 6:

US inflation (x)	Rank of x	Tuition increase (y)	Rank of y
1.60%	13	2.00%	8
2.30%	8	1.66%	12
2.70%	6	3.13%	3
3.40%	2	1.69%	11
3.20%	3	0.27%	16
2.80%	5	3.14%	2
3.80%	1	0.78%	14
-0.40%	17	1.91%	9
1.60%	12	0.99%	13
3.20%	4	0.10%	17
2.10%	10	0.62%	15
1.50%	14	2.43%	7
1.60%	11	2.75%	6
0.10%	16	3.04%	4
1.30%	15	3.37%	1
2.10%	9	2.99%	5
2.40%	7	1.74%	10

The correlation came out to be -0.44 which is about the same as the Pearson's correlation that I found earlier. Graph 4 below shows the rankings of the inflations and the change in tuition.

Graph 4:



### Analysis of Spearman's:

Using Spearman's rank, the correlations did not change a lot from the correlation using Pearsons. A correlation of -0.17 for public universities signifies a very low correlation as does the -0.44 for private universities. This means that there is little to no relationship between the inflation rate and the rate of change of college tuition because I got the same result when I tested using Pearson's correlation coefficient and Spearman's rank correlation coefficient. The increase in tuition must be caused by other factors.

## Conclusion:

To conclude, for both public and private universities, there is a very weak negative correlation between the inflation rate and the tuition increase. This is supported by the results for the Pearson's correlation coefficient and the Spearman's correlation coefficient as they both had very weak negative results for both university types. This means that inflation is not the cause of the increase in college tuition and that there must be another economic cause. This makes sense because the cost of tuition is increasing a lot faster than other products.

I got my data for this exploration from the National Center for Education Statistics which is very credible, and means that I don't have to worry about the quality of the data. However, since the tuition data is an average, the actual costs of college will vary a lot. The data is also just the solid amount that the universities are charging and doesn't include financial aid and scholarships. If it did, this whole exploration could possibly have different results which is why I just focused on the amount that the colleges are asking for. The data is also limited because the cost of tuition information only dates back to 2000. More data could have made this exploration more in depth and possibly, a slightly more accurate result. Despite this, I don't think that the correlation coefficients would have changed that much with more data, just because the correlations were so small.

It would be interesting to do a separate exploration that finds if there is a correlation between the amount of financial aid offered over the years and the college tuition for those same years. This could possibly provide an answer to why college is becoming so expensive. In other countries college is a lot more affordable.

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