A Statistical Analysis of CEO Compensation, 2015-2016

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The current age is marked by the expansion and dominance of large corporate entities. Enterprises like financial institutions, technology companies, and retail firms have extended their presence to all parts of the world and have firmly positioned themselves as integral parts of the social, political, and economic make-up of modern civilization. Consequently, information regarding these corporations holds immense credence in assessing the various facets of contemporary society. Whether it be measuring a nation's GDP, or (as demonstrated by the recent Facebook-Cambridge Analytica data scandal) monitoring the degree of personal privacy, information related to these firms is of great value to all members of society.

In particular, the subject of CEO compensation at these companies garners a great deal of interest. The chief executive officer (CEO) is the most senior employer at an organization and is tasked with leading the company's managerial team. The primary goal of the CEO is to maximize shareholder value, which is the value of the company owned by its shareholders. The extensive levels of attention directed towards CEO compensation stem largely from the increasing degree of income inequality in society. Currently, "America's top 10 percent averages more than nine times as much income as the bottom 90 percent."[1] Also, "the gap between worker and CEO pay was eight times larger in 2016 than in 1980."[2] These damning facts provoke several questions about the nature of CEO compensation; particularly, which factors determine compensation levels and, by virtue, whether or not such compensations are justified. Other issues pertaining to the CEO demographic include the unequal representation of women in managerial positions. The purpose of this paper is, beyond all else, not to

1 "Income Inequality," *Inequality.org*, last modified April 21, 2018, https://inequality.org/facts/income-inequality/..

2 Ibid.

provide theoretically-sound answer to these questions; instead, this paper intends to merely explore different factors related to the CEO demographic using various statistical techniques. Specifically, this paper will explore (1) various factors affecting CEO compensation, (2) a comparison between CEO and non-CEO income, (3) issues associated with gender equality, and (4) general performance of companies in the S&P 500, which constitutes a collection of the 500 most valuable companies in the US.

The dataset (see Appendix G) used in this paper was acquired from Equilar—a software company that provides corporate data. Since 2011, Equilar has published an annual CEO Pay Study that details information on CEOs at various companies listed on the S&P 500. This dataset used in this paper includes data on 346 companies for both 2015 and 2016. The analyses in this paper were executed using a combination of the Excel and STATA software packages.The following variables from the study are used:

- Amount: Total financial compensation received by a CEO for the given year.
- Change: The percentage change in compensation between 2015 and 2016.
- Total stock return (from this point forward, tsr): The percentage change in stock price for the company. A popular indicator of a company's and its CEO's annual performance.
- State: The US state which the company is located in.
- Gender: The gender of the CEO.
- Industry: The industry sector that the company belongs to.

First, I test the distribution of the data since the majority of the statistical analyses that are performed are dependent upon the data being normally distributed. I plot the variables: amount, change, and tsr since these are the variables of interest. The histograms (see Appendix A) all demonstrate a bell-shaped curve with one-hump that is typical of a normally distributed set of data. Despite the presence of some outliers, the variables can appropriately be viewed as normally distributed. Additionally, I assume the data was randomly sampled. Indeed, the sample of 346 firms is not entirely random, as they are all obtained from the S&P 500; however, I can assume that the sample of 346 companies is randomly selected from the initial 500 particularly because of how diverse the companies are. To further support this assumption, I narrow the study to solely pertain to CEOs from S&P 500 (S&P) companies.

Income Inequality

A major motivation for this study is to understand the level of income inequality between CEOs and average workers. To test the assertion of income inequality, I compare the median personal income in the USA with the median income of the data set. I use the median instead of the mean because incomes are traditionally cited using their median values. This is due to the median being a far less sensitive parameter than the mean and therefore less affected by outliers. The range of incomes in the dataset is: ($1, $980,012,344); therefore; using the median is necessary. I perform this analysis using the Wilcoxon Sign Test, the calculation displayed below. This test compares and ranks the medians between two population groups. In 2016, the median personal income in the US was $31,099.[3]

H_0: m = 31,099
H_1: m > 31,099, where m = median CEO compensation
Consequently, $Y_i = x_i - 31,099$, where x_i = each individual compensation.

$$W = (-3) + 60028 = 60025$$

Consequently: $$Z = \frac{60025}{\sqrt{\frac{346(347)(693)}{6}}} = 16.119$$

And the subsequent p-value = P (Z ≥ 16.119) ≈ 0. Therefore, there is statistical evidence to reject the null hypothesis (H_0) at every significance level. Essentially, the median S&P CEO income does exceed that of the national median. For interest's sake, the median of the sample is: $11,471,061 which is approximately 368.86 times larger than the national median. Also, the 95 percent CI for the mean income is:

$$\bar{x} \pm (1.96)\frac{8336150}{\sqrt{346}}, \text{ where } \bar{x} = \$12,769,269.00$$

which equals = ($11,890,886.77; $13,647,651.23); therefore, I can be 95 percent confident that the average value of CEO income is within this range.

Regression

I now wish to test a possible predictor of CEO compensation within the S&P. If, according to theory, a CEO's primary aim is to maximize shareholder value, then annual shareholder return should be a good indicator of CEO performance and thence changes in their annual compensation. Therefore, I perform the following regression:

3 "Real Median Personal Income in the United States," *US Bureau of the Census,* retrieved from Federal Reserve Bank of St Louis, last modified September 13, 2017, https://fred.stlouisfed.org/series/MEPAINUSA672N.

Change in compensation = f(tsr) + μ, where $\mu \sim N(0, \sigma^2)$, I have already confirmed that the variables are random and distributed normally.

Appendix B shows the results. The regression line (Appendix C) is:

Change = 0.876224 + 0.2094612**tsr**

This regression is statistically reasonable because the confidence interval for β (0.0223323,0.3965901) does not include zero at the five-percent significance level. This implies that in 95 percent of cases, tsr has the above impact on changes in compensation. Also, Appendix D shows the various scatterplots of the residuals against tsr and change values. All plots show a random scatter with no discernable pattern about the line y = 0 with most points between y = ± 3; therefore, I can confirm that each data point varies with great similarity from the average effect of tsr, and that there is no autocorrelation with regards to the error terms. I can also ascertain that α and β are distributed normally in accordance with the nature of the linear regression model. The model explains that an increase in tsr of one percent results in an increase of 0.002095 percent in CEO compensation, all else equal. This result makes sense and is significant at the five-percent significance level but not at the one percent level since its p-value is 0.028. The model has a correlation coefficient of 0.0139; therefore, only 1.39 percent of the variation in change is explained by tsr —this is demonstrated by the regression line shown in Appendix C with the data points spread out widely apart from the regression line. This is a low value which implies that other factors aside from shareholder value impact a CEO's compensation.

Industry-Specific

Average S&P CEO income could be affected by the industry that the firm belongs to. The sample includes eight industries: basic materials, consumer goods, financial, healthcare, industrial goods, service, technology, and utilities. To test the relationship between industry and mean income, I utilize a one-factor ANOVA test, which compares the averages across the population groups. I can utilize this test by assuming that incomes across industries (x_i) are distributed normally: $x_i \sim N(\mu_i, \sigma^2)$ and that each x_i is independent of others. For the dataset, it is reasonable to presume independence since there is no reason to believe that the income of one CEO should affect another.

H_0: $\mu_{BM} = \mu_F = \mu_C = \mu_H = \mu_I = \mu_S = \mu_T = \mu_U$
H_1: Not all μ_i's equal

From Appendix E, the F-stat (19.966) > Critical value (3.5) therefore I can reject the null hypothesis at the five percent significance level. The p-value is very small (0.00018); therefore, I can essentially reject the null hypothesis at all significance levels. Hence, mean incomes do vary across industries, implying that CEO compensations are affected by their respective industries.

State-Specific

I perform another one-factor ANOVA test to determine whether location across the US affects mean S&P CEO compensation. The previous assumptions still apply. Thirty-seven states are represented:

H_0: $\mu_{ALABAMA} = \mu_{ARKANSAS} = \ldots = \mu_{WISCONSIN}$
H_1: Not all μ_i's equal

From Appendix F, the F-stat (11.77) > Critical value (1.73) therefore I can reject the null hypothesis at the five percent significance level. The p-value is incredibly small (8.92×10^{-12}); therefore; I can effectively reject the null hypothesis at all significance levels. Hence, mean incomes do vary across states which implies that location does affect CEO compensation.

**Note: I perform two separate one-factor ANOVA tests as opposed to a single two-factor ANOVA test due to a lack of experience/confidence in executing a two-factor test correctly.

Male vs. Female

Another contentious issue currently is the discrepancy in income levels between males and females, as well as the matter of females being underrepresented in senior managerial positions. Consequently, I test these claims.

Representation

To test if females are equally represented in managerial positions, I utilize a population proportion test, which tests if 50 percent of the companies in the dataset have female CEOs. I take p = 0.50, where p = proportion female CEOs to represent equal representation of genders.

H_0: $p = 0.50$
H_1: $p < 0.50$

$$\hat{p} = \frac{21}{346} = 0.06069 \rightarrow$$

$$0.06069 \pm 1.96\sqrt{\frac{0.06069(0.93931)}{346}} = (0.03553;0.08585)$$

Therefore, I can be 95 percent confident that $\hat{p}$ is between 3.55 percent and 8.585 percent; therefore, there is sufficient evidence to reject the null hypothesis at the five-percent significance level. In sum, women are underrepresented in CEO positions amongst S&P 500 companies.

Income

To test for the gender wage gap and investigate if men earn more, I utilize the following test statistic:

$$\frac{\overline{y}-\overline{x}}{s_p\sqrt{\frac{1}{n}+\frac{1}{m}}} \sim T_{n+m-2}, \text{ where } S_p = \sqrt{\frac{(n-1)s_x^2+(m-1)s_y^2}{n+m-2}}$$

n = number of male CEOs

m= number of female CEOs

I use this test statistic because incomes for both genders can be assumed to be distributed normally. Also, it seems reasonable to presume that compensation levels between male and females CEOs varies equally. Additionally, m is not large which is important for this assumption.

$\bar{x}$ (mean male income) = $12,648,009.79
$\bar{y}$ (mean female income) = $14,488,643.29
$s_x^2 = 7.0320 \times 10^{13}$
$s_y^2 = 5.6196 \times 10^{13}$

$H_0: \mu_F = \mu_M$
$H_1: \mu_M > \mu_F$
$t_{0.05}^{344} = 1.649$

T = - 0.981 < 1.649; therefore, there is insufficient evidence to reject the null hypothesis at the five-percent significance level. P-value = P(t ≥ 0.981) = 0.1636 → It is only possible to reject the null hypothesis at the 17 percent significance level or higher. Thence, I conclude that there does not exist a gender pay gap amongst S&P CEOs; in fact, the sample shows females earning more than males, on average.

Performance

After concluding that I cannot statistically observe any significant discrepancy in incomes between male and female CEOs, I move to determining if there is any significant difference in a company's performance (measured by tsr) between male- and female-led companies. Again, I can use the following test statistic:

$$\frac{\overline{y}-\overline{x}}{s_p\sqrt{\frac{1}{n}+\frac{1}{m}}} \sim T_{n+m-2} \quad , \text{ where } S_p = \sqrt{\frac{(n-1)s_x^2+(m-1)s_y^2}{n+m-2}}$$

n = number of companies with male CEOs;
m= number of companies with female CEOs
H_0: μF = μM
H_1: μF ≠ μM
t_0.025344 = 1.649

$\bar{x}$ = 0.1599
$\bar{y}$ = 0.2767
s_x^2 = 0.02514
s_y^2= 0.07883

$|T|$ = 3.09 > 1.9669 therefore, there is sufficient evidence to reject the null hypothesis at the five-percent significance level.

P-value = P (t ≥ 3.09) = 0.0022 → It is only possible to reject the null hypothesis at 0.22 percent significance level or higher. Thence, from the test, I can conclude that S&P companies performed differently depending on the gender of the CEO; namely, companies led by male CEOs tended to perform better.

Are Compensations Justified?

Lastly, I turn to a macroeconomic outlook and consider the overall performance of the companies in the dataset. In 2015 and 2016, the S&P 500 stock index grew substantially. Given the large compensations that these CEOs typically received, it is worthwhile to test if their companies performed well in order to evaluate if these large compensations are justified.

H_0: p = 0.5
H_1: p ≠ 0.5 , where $\hat{p}$ = proportion of companies with positive tsr values.

**Note: I use 0.50 due to the zero-sum game nature of the stock market (i.e. for every winner there exists a loser).

$$\hat{p} = \frac{261}{346} = 0.75434$$

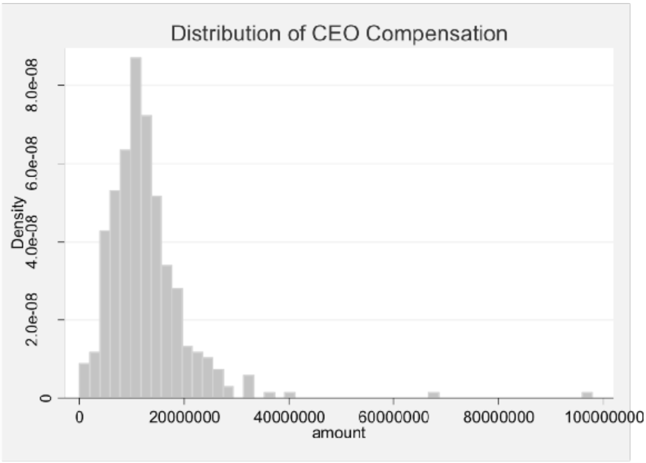
$$0.75434 \pm 1.96\sqrt{\frac{0.75434(0.24566)}{346}} = (0.70898;0.7997)$$

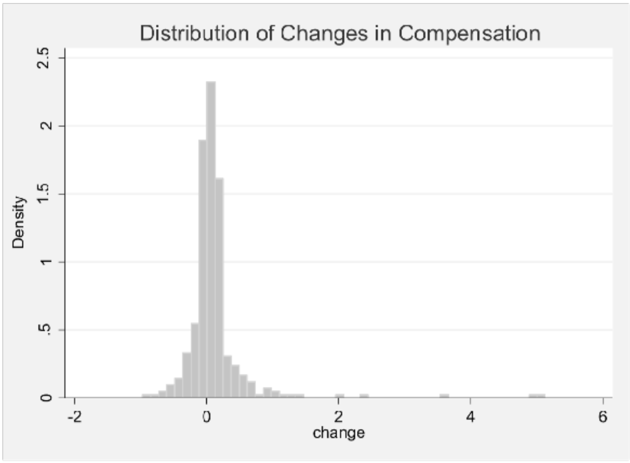
I can be 95 percent confident that 70.9 percent to 79.97 percent of companies in the S&P 500 had positive stock price growth, which ultimately aligns with market trends. Thus, large compensations appear to be justified.

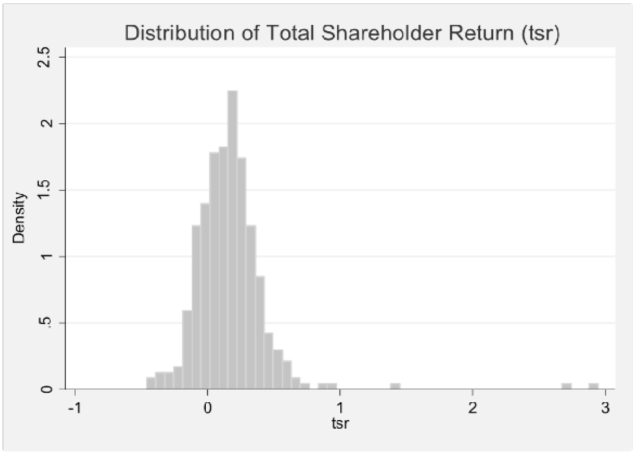
Conclusion

I went through several procedures testing average S&P CEO compensation, essentially testing the basis for their incomes. The results were: CEOs are compensated far more than average workers; some industries and locations are associated with higher compensation packages; women are a minority in CEO positions but they are not underpaid; however, companies with male CEOs seem to have performed better than those with female CEOs. Additionally, I saw that companies performed well during these years, and technology firms seemed to have outperformed service firms by a small margin. It is important to recognize that these conclusions are appropriate for S&P 500 companies, not for all companies. Also, these conclusions are based on statistical analyses that are highly dependent on the sample of data used; therefore, these results are always open to statistical error and bias. Further studies in this area might include firms from outside the S&P 500 and may look at additional factors like CEO experience, age, education, and relation to CEO compensation packages. Lastly, any errors, statistical or otherwise, are my own.

Appendix A


Distribution of CEO Compensation
Density
0
2.0e-08
4.0e-08
6.0e-08
8.0e-08
0
20000000
40000000
60000000
80000000
100000000
amount


Distribution of Changes in Compensation
Density
0
.5
1
1.5
2
2.5
-2
0
2
4
6
change


Distribution of Total Shareholder Return (tsr)
Density
0
.5
1
1.5
2
2.5
-1
0
1
2
3
tsr

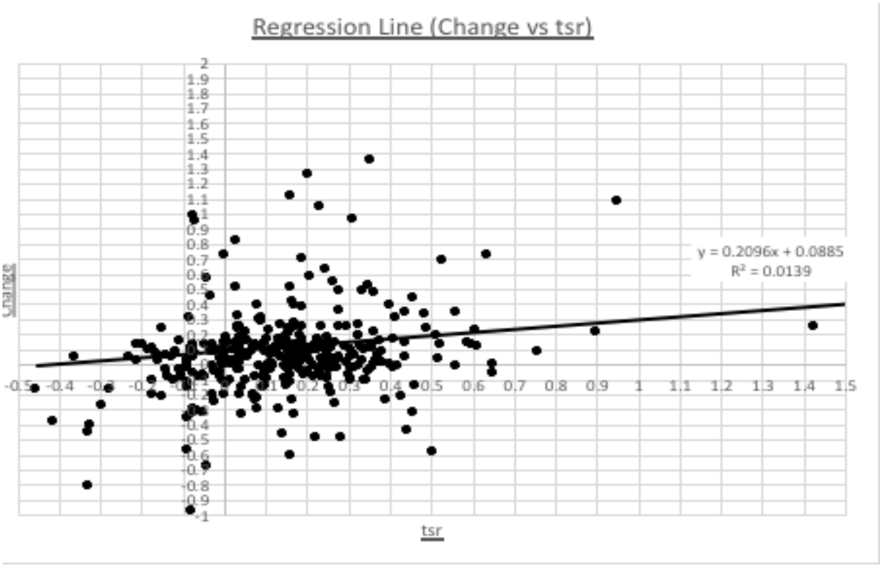
Appendix B

Source	SS	df	MS
Model	1.33586066	1	1.33586066
Residual	94.8061963	344	.275599408
Total	96.142057	345	.27867269

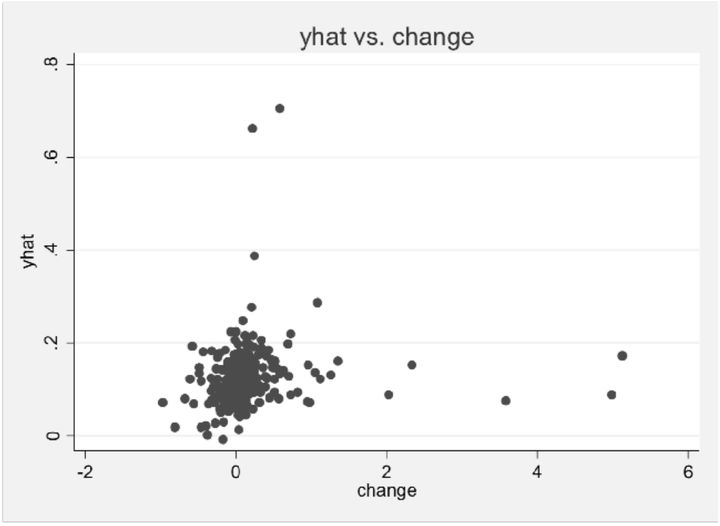
Number of obs	=	346
F(1, 344)	=	4.85
Prob > F	=	0.0284
R-squared	=	0.0139
Adj R-squared	=	0.0110
Root MSE	=	.52498

change	Coef.	Std. Err.	t	P > | t |	(95% Conf. Interval)	
tsr	.2094612	.0951398	2.20	0.028	.0223323	.3965901
_cons	.0876224	.0323875	2.71	0.007	.0239198	.1513249

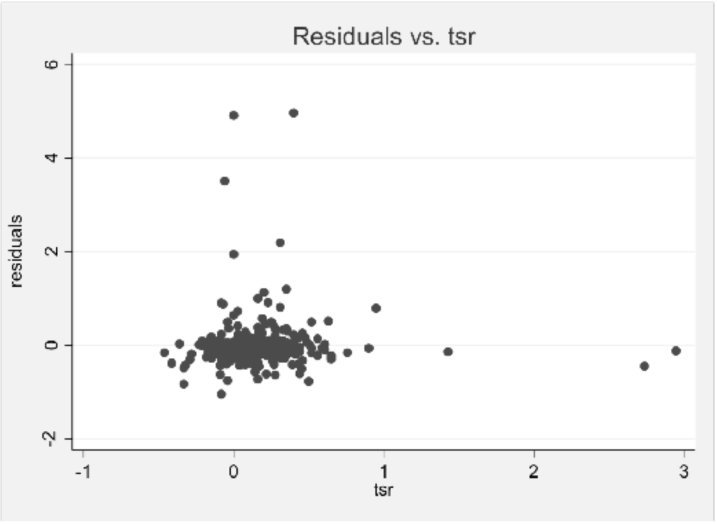
Appendix C



Appendix D



yhat vs. change
yhat
0
.2
.4
.6
.8
-2
0
2
4
6
change



Residuals vs. tsr
residuals
-2
0
2
4
6
-1
0
1
2
3
tsr

Appendix E

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	2	24823158	12411579	7.26E+10
Column 2	2	24429666	12214833	6.35E+11
Column 3	2	22507948	11253974	2.81E+09
Column 4	2	28527121	14263560	1.34E+11
Column 5	2	26275610	13137805	2.08E+10
Column 6	2	29994439	14997219	3.94E+11
Column 7	2	23905531	11952765	1.06E+12
Column 8	2	18122939	9061470	3.61E+11

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.69E+13	7	6.7E+12	19.96565	0.00018	3.500464
Within Groups	2.69E+12	8	3.36E+11			
Total	4.96E+13	15				

Appendix F

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Column 1	2	14144160	7072080	5.6E+11
Column 2	2	19342125	9671063	1.43E+13
Column 3	2	20751752	10375876	1.29E+13
Column 4	2	21666706	10833353	3.69E+11
Column 5	2	20418322	10209161	2.44E+12
Column 6	2	21840935	10920467	1.09E+12
Column 7	2	23548090	11774045	2.8E+12
Column 8	2	13119233	6559617	7.47E+11
Column 9	2	21322739	10661370	1.61E+12
Column 10	2	22677373	11338687	2.23E+11
Column 11	2	22587143	11293572	2.18E+12
Column 12	2	26842755	13421378	6.72E+10
Column 13	2	22701544	11350772	1.19E+13
Column 14	2	20781341	10390670	2.45E+12
Column 15	2	23085940	11542970	8.12E+10
Column 16	2	20368623	10184311	1.02E+12
Column 17	2	10631386	5315693	6.01E+11
Column 18	2	25746132	12873066	5.84E+11
Column 19	2	27504894	13752447	1.17E+12
Column 20	2	12254010	6127005	6.36E+08
Column 21	2	23296433	11648217	2.09E+12
Column 22	2	958125	479062.5	1.56E+08
Column 23	2	22486431	11243216	1E+12
Column 24	2	48837376	24418688	2.79E+13
Column 25	2	29734698	14867349	3.35E+11
Column 26	2	22748764	11374382	1.39E+11
Column 27	2	12810603	6405302	1.25E+12
Column 28	2	10881198	5440599	1.84E+11
Column 29	2	22104847	11052424	1.75E+12
Column 30	2	22120313	11060156	4.64E+10
Column 31	2	11194836	5597418	2.68E+10
Column 32	2	18833011	9416506	4.01E+12
Column 33	2	21624019	10812010	1.06E+11
Column 34	2	5791557	2895779	1.11E+10
Column 35	2	22241455	11120728	1.89+12
Column 36	2	11103930	5551965	3.49E+11
Column 37	2	17924238	8962119	3.69E+10

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.12E+15	36	3.12E+13	11.77135	8.92E-12	1.73416
Within Groups	9.81E+13	37	2.65E+12			
Total	1.22E+15	73				