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Do Chief Executive Officers with Higher Compensation Assume More Innovative Risk Within Their Firms? Unearthing the Relationship Between Chief Executive Officer Compensation and Firm Innovation Levels: An Analysis of S&P 500 Companies

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Throughout the COVID-19 pandemic, executive compensation arose at a rapid scale — with many in the labor force displaced or facing unemployment, many questioned how the excessive compensation packages of Chief Executive Officers (CEOs) reflected in actual firm performance. However, executive compensation has been a mainstay topic in academic literature. Researchers have attempted to unearth the exponentially growing paychecks or the link between compensation and other firm factors (market performance, employee satisfaction, CEO perception, etc.).

This study aims to examine the relationship between S&P 500 CEO compensation and the innovation levels of their firms; through this, we hope to understand the factors driving innovation in a firm and if increased compensation links to sales-oriented research and development. Data was obtained for companies listed on the S&P 500, detailing research quotient, total executive compensation, salary, bonus, restricted stock, and stock options from 2000 to 2020. Year-on-year data was then pooled to provide a detailed picture and measure the impact of these compensation-based variables against the research quotient — defined as a firm's ability to generate revenue growth from R&D investments.

In response to our hypothesis, our data showed significance at the 90% level regarding the impact of total executive compensation and stock options on a higher RQ value. Our regressions, however, did not show statistical significance of the effect of salary, bonus, and restricted stock on the research quotients. From 2010 to 2020, CEO compensation has increased by 59.6%; the proportion contributed by restricted stock of total compensation has increased by 90.6%, while the proportion of stock options to total compensation has decreased by 148.3%. Despite these differences, this research concludes that stock options are the only component of compensation that has a positive statistically significant impact on innovation productivity.

Keywords: CEO, innovation, compensation, restricted stock, stock options, research quotient

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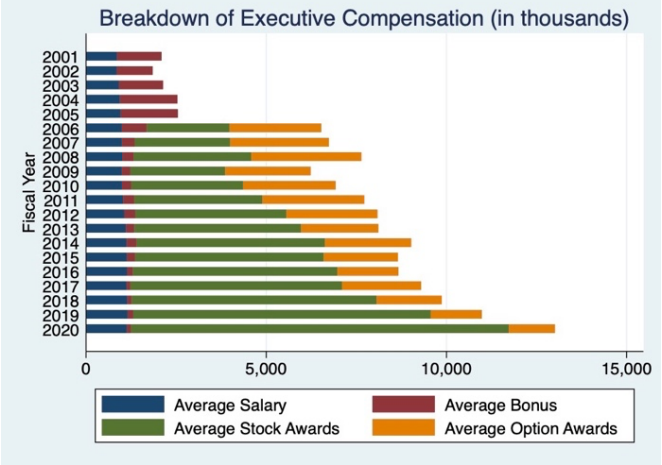
Literature Review

Compensation History

Extensive research has been conducted with regards to Chief Executive Officer (CEO) compensation trends. Over time, real compensation numbers have grown but it is important to understand executive compensation history to grasp current compensation trends.

Frydman and Jenter published a thorough review of S&P 500 compensation history in the National Bureau of Economic Research, in which they classify different eras of chief executive compensation. Prior to the 1980s, most compensation was composed of largely base salaries with additional performance bonuses; these bonuses were tied to basic performance metrics and fulfilled either in cash or stock. In the 1980s and 1990s, however, the rise of compensation linked to stock options rose dramatically. Median CEO pay in the S&P 500 increased 213% from 1992 to 2001, for example while option compensation comprised 20% of CEO pay in 1992 but rose to 49% by 2000.[1]

Table 1: Mean S&P 500 CEO Compensation by Component



The make-up of an average S&P 500 CEO's compensation is categorized by component in Table 1; in post-recession years, another trend emerges by which equity-based incentives (restricted stock, performance shares, etc.) compose chief executive compensation at an increasingly rapid rate. The reduction in options awards can be attributed to dysfunctional consequences that options-laden compensation can induce, such as earnings manipulation, timing of positive or negative news, or malicious use of insider information.[2][3]

[1] Frydman, Carola, and Dirk Jenter. 2010. "CEO Compensation." *National Bureau of Economic Research* 3-8.

[2] Lovett, Steve, Abdul Rasheed, and Wanrong Hou. 2022. "Stock options, restricted stock, salary, or bonus? Managing CEO compensation to maximize organizational performance." *Business Horizons* (Elsevier) 65 (2): 115-123.

[3] Zhang, Xiaomeng, Kathryn Bartol, Ken Smith, Michael Pfarrer, and Dmitry Khanin. 2008. "CEOs on the Edge: Earnings Manipulation and Stock-Based Incentive Misalignment." *Academy of Management Journal* (Academy of Management) 51 (2): 241-258.

Compensation and Risk-Taking

In a research context, compensation has been defined as the sum of "salary, bonus, cash pay, or equity" and used accordingly in regressions as a proxy for compensation — either by component or cumulatively.[4] While a similar approach is used in this research, there is a variety of literature that uses different models for compensation.[5] However, by separating the various components of compensation, we are able to identify if any have a specific linkage to innovation in a firm.

Frydman and Jenter assert that "stronger equity incentives are associated with less risk taking, whereas convexity in executives' portfolios due to options is correlated with more risk taking."[6] Another work published in the *Journal of Accounting and Economics* notes the relationship between potential CEO payoffs and risk-taking responsiveness: "Options affect corporate risk-taking and highlight the importance of a board structuring its executives' compensation packages to induce the desired level of risk taking."[7] Options provide potentially higher payoffs than equity-based compensation, and CEOs calculate risk-taking accordingly. Compensation in the form of options correlates to risk-taking; literature aside, this is evident in companies that pride themselves on their bold brands — such as Tesla, where 100% of Elon Musk's compensation is received in options. The literature analyzing compensation and risk is especially important in the context of this study, as innovative R&D can be one component of risk, in addition to other "risky" actions such as firm acquisition activity, leverage levels, or labor force planning.

Existing Innovation Research Metrics

Several measures of innovation have been explored; the largest group of metrics come under the category of patent-based measures. Yet, the use of patents as a basis of innovation has long been deemed as an imperfect approach to quantifying a firm's true R&D productivity. For

[4] Banker, Rajiv, Masako Darrough, Rong Huang, and Jose Plehn-Dujowich. 2013. "The Relation between CEO Compensation and Past Performance." *The Accounting Review* (American Accounting Association) 88 (1): 10-13.

[5] Gormley, Todd, David Matsa, and Todd Milbourn. 2013. "CEO compensation and corporate risk: Evidence from a natural experiment." *Journal of Accounting and Economics* (Elsevier) 56 (2-3): 79-101.

[6] Frydman, Carola, and Dirk Jenter. 2010. "CEO Compensation." *National Bureau of Economic Research* 25.

[7] Gormley, Todd, David Matsa, and Todd Milbourn. 2013. "CEO compensation and corporate risk: Evidence from a natural experiment." *Journal of Accounting and Economics* (Elsevier) 56 (2-3): 79-101.

reference, only 50% of firm innovations are ever patented, and are done so only as a last resort; patents put ideas into the public domain, making workarounds possible and affecting a firm's first-mover competitive advantage.[8] Other approaches to measuring innovation vary – from measuring firm stock returns at the time patents are granted, to identifying the number of unique classes of technology a firm's patent count crosses.[9][10] A 2000 study of technology firms concluded that CEO pay contingent on technological milestones resulted in higher levels of innovation; this study used salary and bonus to capture short-term pay, and an estimation process to capture equity-based compensation — unlike our research, where the data for equity-based compensation is readily available on WRDS — and R&D spending and patent count as the basis for innovation.[11] More recent research (published in 2019) analyzes the relationship between option-based compensation and patents filed around the enactment of FAS 123R, an accounting change enacted in 2006 that ensures firms deduct the amount of equity payment for employees.[12] Their study found that option-based compensation did not have a causal impact on corporate innovation. Our work seeks to add to growing literature on the relationship between compensation and innovation, using a less patent-dependent approach to measuring innovation.

Research Quotient (RQ)

Professor Anne Marie Knott of Washington University in St. Louis developed Research Quotient (RQ) as an alternative measure to quantifying innovation. In *RQ Innovative Efficiency and Firm Value*, the authors note that the specific type of innovation measure is important in research design (input, output, and efficiency); as we seek to determine the relationship between compensation and innovation productivity, RQ — defined as a measure of a firm's ability to generate revenue growth from R&D investments— helps in identifying efficient research and development.[13] RQ could be a valuable metric for those looking to understand how to better their

[8] Knott, Anne-Marie, Michael Cooper, and Wenhao Yang. 2015. "RQ Innovative Efficiency and Firm Value." *Journal of Financial and Quantitative Analysis*.

[9] Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman. 2017. "Technological Innovation, Resource Allocation, and Growth." *The Quarterly Journal of Economics* 132 (2): 665-712.

[10] Hirshleifer, David, Po-Hsuan Hsu, and Dongmei Li. 2017. "Innovative Originality, Profitability, and Stock Returns." *National Bureau of Economic Research*.

[11] Balkin, David, Gideon Markman, and Luis Gomez-Mejia. 2000. "Is CEO Pay in High-Technology Firms Related to Innovation?" *The Academy of Management Journal* (Academy of Management) 43 (6): 1118-1129.

[12] Biggerstaff, Lee, Brian Blank, and Brad Goldie. 2019. "Do incentives work? Option-based compensation and corporate innovation ." *Journal of Corporate Finance* 415-430.

[13] Knott, Anne-Marie, Michael Cooper, and Wenhao Yang. 2015. "RQ Innovative Efficiency and Firm Value." *Journal of Financial and Quantitative Analysis*.

own organization's R&D-to-revenue pipeline; the metric also provides broader coverage compared to patent-based measures of innovation. RQ has also been used in previous chief executive research, one example being the examination of R&D productivity between "outsider" versus insider CEOs.[14] In this work, the authors used RQ, along with a newer metric called "Idea TFP", to conclude that firms with outside CEOs display lower RQ levels than firms with internal chief executives — thus have lower R&D productivity.

Research Overview

Executive compensation varies in form — from incentive-ridden contracts to standard salaries; with the selected sample of S&P 500 companies, this research will focus on CEOs with base salaries, performance-based incentives, or a combination of the two. Borne from an overabundance of existing measures to determine a firm's innovation level that were largely dependent on patent counts, RQ reflects the percentage increase in revenue a company obtains from a one percent increase in R&D, holding all else constant.

S&P 500 firms were chosen as a representative for all large-cap companies; the S&P 500 is a credible sample pool as its composition covers a breadth of different markets. A commonly cited disadvantage to using the S&P 500 is that the index is weighted, meaning that the performance of larger companies (such as Microsoft, Amazon, Apple, etc.) influences the index significantly. However, this research will focus on each firm individually and there will be no weighting of the sum of S&P 500 firms.

By analyzing the relationship between CEO compensation and RQ, we will learn how compensation affects a CEO's propensity to invest into innovation at their firm. Through this research, we hope to identify compensation patterns that result in high yields of productive innovation — an insight that would be useful for firms experiencing a lag in innovation looking to restructure management. This research is beneficial to managers and executives seeking to understand how to position their innovation policies (across factors including R&D spending, capital investments, marketing expenses, etc.) to improve both their firms' innovative productivity.

[14] Cummings, Trey, and Anne Marie Knott. 2017. "Outside CEOs and Innovation." *Strategic Management Journal* (Strategic Management Journal) 39 (1): 1-48.

Empirical Approach

Our goal is to determine if our hypothesis that CEOs who receive a sizable proportion of incentive-based clauses as compensation are more likely to manage firms with higher innovation levels holds under a large-scale quantitative analysis. Our empirical approach begins with simple fixed-effects regressions of the relationship between CEO compensation and RQ:

$$RQ_{it} = \beta_1 * (CEO\ Compensation)_{it} + \beta_2 * (Log\_Size)_{it} + \eta_i + \lambda_t + \varepsilon_{it}$$

We model RQ of firm i in fiscal year t (RQ_{it}) as a function of CEO Compensation and firm size measured as the log of employees and revenue. We include firm-fixed effects (η_i) as well as year effects (λ_t), and cluster standard errors by firm.

Research Quotient (RQ) is the firm-specific output of R&D – the γ exponent in firm i's production function. It is interpreted as the percentage increase in revenues from a 1% increase in R&D when other inputs and their elasticities are held constant.

$$Output = Capital^{\alpha_i} * Labor^{\beta_i} * R\&D^{\gamma_i} * Spillovers^{\delta_i} * Advertising^{\phi_i}$$

RQ is estimated with a random coefficients model using successive seven-year windows of firm financial data, with *Output* defined as the firm's operating margin. This estimation process and its robustness checks are described in the user manual for the WRDS RQ database, where we obtained the RQ data for our model.

We decided to use RQ in our model as the R&D measure because it is universal, uniform, and dependable. Other measures of R&D – such as patent counts – aren't universal as not all firms engaging in R&D patent their innovations. In any given year, less than 50% of firms engaged in R&D file patents. In addition, even among the firms that patent their innovations, they do not always patent *all* of their innovations as its typically more effective to protect intellectual property by keeping it a secret. Finally, a higher number of patents does not reliably predict higher profits and market value which is the expected outcome from R&D investments.

RQ is estimated entirely from standard financial data, so it can be calculated for any firm doing R&D. Since it is a ratio, it is uniform across all firms regardless of currency. It is reliable as firm

behavior and economic outcomes are consistent with endogenous growth theory (and validated over 47 years): Optimal R&D, market value, and firm growth all increase in RQ (A. M. Knott 2012).

Hypothesis

We hypothesize that CEOs who receive a sizable proportion of incentive-based clauses as compensation are more likely to manage firms with higher innovation levels; since their compensation is based on performance, chief executives are eager to differentiate their firms from others through an increased focus on innovation and long-term sustainability. Therefore, our first hypothesis relates total executive compensation and research quotient:

> **H1:** Total executive compensation is positively associated with the research quotient.
> **Regression:** $RQ_{it} = \beta_0 + \beta_1 * (Log\_TDC1)_{it} + \beta_2 * (Log\_Revenues)_{it} + \beta_3 * (Log\_Employees)_{it} + \eta_i + \lambda_t + \varepsilon_{it}$

Previous literature has shown that the prevalence of salary, bonus, and perks have remained constant in the S&P 500 over the last 11 years. This is indicative of the growing reliance on performance-related vehicles of compensation. Therefore, it is important to understand which of the four components of stock compensation have the largest impact on RQ.

> **H2:** Restricted stock and stock options will have a greater significance when predicting RQ than salary and bonus.
> **Regression:** $RQ_{it} = \beta_0 + \beta_1 * (Log\_Salary)_{it} + \beta_2 * (Log\_Bonus)_{it} + \beta_3 * (Log\_Stock\ Awards)_{it} + \beta_4 * (Log\_Option\ Awards)_{it} + \beta_5 * (Log\_Revenues)_{it} + \beta_6 * (Log\_Employees)_{it} + \eta_i + \lambda_t + \varepsilon_{it}$

As previous literature has proven, compensation risk is imposed on executives by linking executive's wealth to firm performance to motivate the executive to take actions that are in the best interest of the shareholders[15]. Therefore, in addition to our previous hypotheses, we hypothesize that restricted stocks granted (*var: stock_awards_fv*) would be positively significant when estimating RQ, while stock options granted (*var: option_awards_fv*) would not be

[15] Core, Guay, and Larcker, "Executive Equity Compensation and Incentives."

significant. Restricted stock represents actual ownership in the company which grant the employee all the same voting rights and responsibilities as any other owner of the same class of shares. In contrast, stock options do not have an actual ownership over the company at the time of issuance. They merely function as an agreement between the company and the employee that gives the employee the option to purchase the company's stock at a predetermined price by a set date in the future. Therefore, the CEOs that are offered restricted stock as a portion of their total executive compensation likely have the same ownership rights as the founders of the company and thus would have more of a stake in the future success of the company, thus are more likely to be innovative.[16]

H3: The sum of restricted stocks granted and stock options as a fraction of total executive compensation is positively correlated with RQ.

Regression: $RQ_{it} = \beta_0 + \beta_1 * (\frac{Stock\ Awards+Option\ Awards}{Total\ Compensation})_{it} + \beta_2 * (Log\_Revenues)_{it} + \beta_3 * (Log\_Employees)_{it} + \eta_i + \lambda_t + \varepsilon_{it}$

H3a: Restricted stocks granted as a fraction of total executive compensation is positively associated with RQ.

Regression: $RQ_{it} = \beta_0 + \beta_1 * (\frac{Stock\ Awards}{Total\ Compensation})_{it} + \beta_2 * (Log\_Revenues)_{it} + \beta_3 * (Log\_Employees)_{it} + \eta_i + \lambda_t + \varepsilon_{it}$

H3b: Stock options as a fraction of total executive compensation is negatively associated with RQ.

Regression: *Regression:* $RQ_{it} = \beta_0 + \beta_1 * (\frac{Option\ Awards}{Total\ Compensation})_{it} + \beta_2 * (Log\_Revenues)_{it} + \beta_3 * (Log\_Employees)_{it} + \eta_i + \lambda_t + \varepsilon_{it}$

[16] Moisan, "Council Post."

Data

The main data for our research comes from sources within the Wharton Research Data Services (WRDS): Compustat, RQ, and Execucomp databases. The Compustat is used for a firm's financial data; the RQ database for firms' research quotient (RQ); and the Execucomp database for detailed executive compensation packages. Our raw data consists of companies publicly listed on the S&P500 that have published R&D expenditure over the years 2000 to 2020 which were merged in Stata using the combined gvkey-fyear that identifies each firm by year.

Variable Name	Database Name	Meaning	Units
Executive Total Compensation	tdc1	Calculated under the 1992 reporting format. The amount is the sum of the following: Salary, Bonus, Non-Equity Incentive Plan Compensation, Grant-Date Fair Value of Option Awards, Grant-Date Fair Value of Stock Awards, Deferred Compensation Earnings Reported as Compensation, and Other Compensation	thousands
Salary	salary	Dollar value of base salary earned by the named executive officer during the fiscal year	thousands
Bonus	bonus	Dollar value of bonus earned by the named executive officer during the fiscal year	thousands
Restricted Stock	stock_awards_fv	Fair value of restricted stock granted	thousands
Stock Options	option_awards_fv	Fair value of stock options granted	thousands
Fraction of Equity Compensation	(stock_awards_fv + option_awards_fv)/tdc1	Equity compensation (restricted stock plus stock options) as a fraction of executive total compensation	decimal
Fraction of Restricted Stock	stock_awards_fv/tdc1	Restricted Stock as a fraction of executive total compensation	decimal
Fraction of Stock Options	option_awards_fv/tdc1	Stock Options as a fraction of executive total compensation	decimal

Table 1. Independent Variables

Variables

RQ, our primary dependent variable, is the firm-specific output elasticity of R&D and was gathered directly from the WRDS RQ database. In addition to our dependent variable and explanatory variables, we introduced various control variables in our full model. To control for the known relationship between firm scale and R&D spending, we used two measures of firm size: Employees and Revenue.

Variable Name	Database Name	Meaning	Units
Employees	log(1+emp)	the log value of full-time equivalent employees measured	1,000 employees
Revenues	log(1+revt)	the log value of company revenues in million dollars	millions

Table 2. Control Variables.

In addition to the control variables, we include year effects and firm-fixed effects to control for macroeconomic variations across time and time invariant firm effects, respectively. We used the logarithmic transformation to help reduce the skewness in the control and independent variables. After the transformation, the mean of each compensation variable is approximately equal to the median.

Analysis was limited to firms that had a reported total asset, raw RQ values, and executive total compensation. Duplicate observations were deleted. Observations for which any variable lies in the top or bottom 1 percent of its distribution were deleted. Execucomp and Compustat had missing values, thus limiting the analysis. This limited analysis left us with 3,609 observations across 227 firms in 20 years. Table 3 shows the descriptive statistics that characterize our sample of firms.

Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
RQ	3609	0.098	0.035	0.008	0.547
Total Executive Compensation	3609	10698.210	11112.270	0.001	280621.600
Employees	3609	44.517	70.707	0.313	1298
Revenues	3609	20498.290	40044.470	58.941	433526.000
Salary	3609	1043.947	463.088	0	4000
Bonus	3609	472.893	1275.061	0	43511.540

Restricted Stock	3609	3960.373	8598.757	0	276612.100
Stock Options	3609	1777.473	4342.180	0	90693.400
Fraction Restricted Stock + Stock Option Based Compensation	3609	0.445	0.324	0	0.999
Fraction of Restricted Stock Based Compensation	3609	0.290	0.291	0	0.999
Fraction of Stock Option Based Compensation	3609	0.155	0.218	0	0.999

Table 3. Data Descriptive Statistics

Results

Our results present several key findings for understanding the effect of CEO compensation on risk innovation. We will first discuss total executive compensation effect, then break it down into its components of salary, bonus, restricted stock, and stock options. Finally, we will look at the effect of the fraction of equity compensation over total executive compensation as it pertains to risk innovation.

Regression Results (Total Executive Compensation)

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Total Executive Compensation	0.073	0.038	1.95	0.052	-0.001	0.148
Revenues	0.022	0.004	5.04	0.000	0.013	0.031
Employees	-0.031	0.004	-8.74	0.000	-0.038	-0.024
Constant	-0.011	0.029	-0.38	0.703	-0.068	0.046

Table 4. Total Executive Compensation Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors.

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Salary	-0.029	0.044	-0.65	0.513	-0.116	0.058
Bonus	-0.032	0.030	-1.08	0.282	-0.091	0.027
Restricted Stock	0.008	0.018	0.46	0.644	-0.027	0.043
Stock Options	0.049	0.020	2.45	0.015	0.010	0.088
Revenues	0.023	0.004	5.34	0.000	0.014	0.031
Employees	-0.031	0.003	-9.11	0.000	-0.038	-0.024
Constant	-0.005	0.028	-0.19	0.846	-0.061	0.050

Table 5. Executive Compensation Components Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors.

Table 4 presents the empirical results in line with H1 which indicate that Total Executive Compensation is positively associated with RQ (Coeff = 0.073, t-statistic = 1.95) at a 10% significance level. It indicates that a change in Total Executive Compensation of 1 unit ($1,000) is correlated with a .005 increase in RQ holding all else constant.

Table 5 presents evidence that both Salary and Bonus are negative but not statistically significant (Coeff. = -0.029, t-statistic = -0.65, Coeff. = -0.032, t-statistic = -1.08 respectively). Restricted Stock is positive but not statistically significant (Coeff. = 0.008, t-statistic = 0.46). Stock Options, on the other hand, is positively correlated with RQ at a 5% significance level (Coeff. = 0.049, t-statistic = 2.45). For a one thousand dollar increase in the face value of Stock Options, there is a 0.003 increase in RQ. This is in line with H2 as stock options have a higher significance when predicting RQ than salary and bonus; however, it also shows that restricted stock is not as significant as these variables.

Regression Outputs (Fraction of Equity Compensation)

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Fraction of RS + Stock Options	0.230	0.273	0.84	0.401	-0.308	0.768
Revenues	0.022	0.004	5.21	0.000	0.014	0.031
Employees	-0.031	0.004	-8.81	0.000	-0.038	-0.024
Constant	-0.008	0.029	-0.27	0.788	-0.064	0.049

Table 6. Fraction of Equity Compensation Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors.

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Fraction of Restricted Stock	-0.180	0.262	-0.69	0.492	-0.698	0.337
Revenues	0.023	0.004	5.23	0.000	0.014	0.031
Employees	-0.031	0.003	-8.84	0.000	-0.038	-0.024
Constant	-0.008	0.029	-0.27	0.784	-0.065	0.049

Table 7. Fraction of Restricted Stock Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors.

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Fraction of Stock Options	0.561	0.292	1.92	0.056	-0.014	1.135
Revenues	0.023	0.004	5.29	0.000	0.014	0.031
Employees	-0.031	0.003	-8.93	0.000	-0.038	-0.024
Constant	-0.008	0.029	-0.29	0.769	-0.065	0.048

Table 8. Fraction of Stock Options Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors.

Table 6 depicts a positive, yet not statistically significant relationship between the fraction of restricted stock and stock option awards of total executive compensation (Coeff. = 0.230, t-statistic = 0.84). Table 7 presents the empirical results indicating that fraction of restricted stock of total executive compensation is not associated with RQ. The coefficient is negative but not significant (Coeff. = -0.180, t-statistic = -0.69). Table 8 presents empirical results that fraction of stock option awards of total executive compensation is positive and correlated with RQ at a 10%

significance level (Coeff. = 0.561, t-statistic = 1.92). A one unit increase in the fraction of stock options as a part of total executive compensation increases RQ by 0.005.

This finding is contrary to our original hypothesis H3 that the sum of restricted stock and stock options as a fraction of total executive compensation is positively correlated with RQ. Due to the positive association of stock options with RQ (contrary to H3B), it can be noted that the fraction of restricted stock over total executive compensation, which is not correlated with RQ (contrary to H3A), counteracts the positive association of stock options causing the sum of restricted stock and stock options as a fraction of total executive compensation to be not statistically significant.

Limitations

One limitation within our study was that some companies listed on the S&P500 did either: (1) not appear on WRDS's Compustat, Execucomp, and/or RQ databases; (2) not have sufficient data for the 2000-2020 years that we were examining. Our research was very dependent on having all values for the research quotient, executive compensation, salary, bonus, restricted stock, and stock options, and therefore, companies that did not publicly list all of these data points were removed as observations. However, our findings still align with past economic models, and could be used for future research.

Additionally, while we were able to find past literature that stated there is a definitive link between CEO compensation and innovation productivity within a firm and addressed one potential avenue of causality through lagging RQ, there is still a potential for endogeneity within our data.

Future Research

There are several different avenues this research could progress in the future. One such way would be a more in-depth examination of S&P 500 companies, segmenting by industry for executives to have more clarity on how their respective firms innovate compared to competitors. Another way of furthering this research could include examining compensation structures of senior executives (and chief executives) in startups; this research would be beneficial for founders seeking optimal compensation structures for innovative yield in their companies.

However, the compensation structures would look different for startups versus the publicly traded companies discussed in this paper, and many more estimations would be needed in calculating research quotient than required for the firms listed in this paper. Future research could additionally expand to examine smaller-scale companies and what percentage of total executive compensation should be salary, bonus, restricted stock, and stock options for CEOs. It would be interesting to see if there is a correlation between growth rate of a company and the percentage of each component that yields the highest research quotient (gamma value) for that firm.

Conclusion

To promote innovation from a CEO — if companies are only focused on the research quotient as a measure of firm innovation — then our study shows that CEO compensation could theoretically be granted in the form of entirely stock options. This would give the highest research quotient for the firm, as proven by our data. However, there are reasons as to why companies might not want to give their CEOs compensation in the form of 100% stock options, which include: (1) base salary provides security for CEOs; (2) bonuses help drive performance against short term objectives set by the board; (3) restricted stock increases ownership and aligns interests with shareholders.

In alignment with the Black-Scholes model for option pricing, CEOs can increase the price of their option in two manners: (1) Increasing current stock price; (2) Increasing volatility of underlying asset. By undergoing riskier projects, CEOs can increase stock volatility, which in turn increases the stock price and the call option, thus giving CEOs a higher payout. Stock options promote this sense of high-risk decision making; CEOs share the upside, if successful, but do not share the downside risk with the company. Restricted stock pay, on the other hand, discourages CEOs from investing in high-risk, potentially high-margin products as they have ownership in the company, thus face the risk of sharing the losses if the project does not have high returns.

Bibliography

Balkin, David, Gideon Markman, and Luis Gomez-Mejia. 2000. "Is CEO Pay in High-Technology Firms Related to Innovation?" *The Academy of Management Journal* (Academy of Management) 43 (6): 1118-1129.

Banker, Rajiv, Masako Darrough, Rong Huang, and Jose Plehn-Dujowich. 2013. "The Relation between CEO Compensation and Past Performance." *The Accounting Review* (American Accounting Association) 88 (1): 10-13.

Biggerstaff, Lee, Brian Blank, and Brad Goldie. 2019. "Do incentives work? Option-based compensation and corporate innovation ." *Journal of Corporate Finance* 415-430.

Frydman, Carola, and Dirk Jenter. 2010. "CEO Compensation." *National Bureau of Economic Research* (National Bureau of Economic Research) 16585: 3-8.

Gormley, Todd, David Matsa, and Todd Milbourn. 2013. "CEO compensation and corporate risk: Evidence from a natural experiment." *Journal of Accounting and Economics* (Elsevier) 56 (2-3): 79-101.

Hirshleifer, David, Po-Hsuan Hsu, and Dongmei Li. 2017. "Innovative Originality, Profitability, and Stock Returns." *National Bureau of Economic Research.*

Hodgson, Paul, and Matteo Tonello. 2020. *CEO and Executive Compensation Practices in the Russell 3000 and S&P 500.* Conference Board, 1-22.

Knott, Anne Marie. 2012. "The Trillion-Dollar R&D Fix." *Harvard Business Review*, May.

Knott, Anne-Marie, Michael Cooper, and Wenhao Yang. 2015. "RQ Innovative Efficiency and Firm Value." *Journal of Financial and Quantitative Analysis.*

Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman. 2017. "Technological Innovation, Resource Allocation, and Growth." *The Quarterly Journal of Economics* 132 (2): 665-712.

Lovett, Steve, Abdul Rasheed, and Wanrong Hou. 2022. "Stock options, restricted stock, salary, or bonus? Managing CEO compensation to maximize organizational performance." *Business Horizons* (Elsevier) 65 (2): 115-123.

Moisan, Matthew. 2018. "Council Post: What's The Difference Between Restricted Stock And Stock Options?" *Forbes*, July 12.

Zhang, Xiaomeng, Kathryn Bartol, Ken Smith, Michael Pfarrer, and Dmitry Khanin. 2008. "CEOs on the Edge: Earnings Manipulation and Stock-Based Incentive Misalignment." *Academy of Management Journal* (Academy of Management) 51 (2): 241-258.

Appendix

Variable Name	Database Name	Meaning	Units
Executive Total Compensation	tdc1	Calculated under the 1992 reporting format. The amount is the sum of the following: Salary, Bonus, Non-Equity Incentive Plan Compensation, Grant-Date Fair Value of Option Awards, Grant-Date Fair Value of Stock Awards, Deferred Compensation Earnings Reported as Compensation, and Other Compensation	thousands
Salary	salary	Dollar value of base salary earned by the named executive officer during the fiscal year	thousands
Bonus	bonus	Dollar value of bonus earned by the named executive officer during the fiscal year	thousands
Restricted Stock	stock_awards_fv	Fair value of restricted stock granted	thousands
Stock Options	option_awards_fv	Fair value of stock options granted	thousands
Fraction of Equity Compensation	(stock_awards_fv + option_awards_fv)/tdc1	Equity compensation (restricted stock plus stock options) as a fraction of executive total compensation	decimal
Fraction of Restricted Stock	stock_awards_fv/tdc1	Restricted Stock as a fraction of executive total compensation	decimal
Fraction of Stock Options	option_awards_fv/tdc1	Stock Options as a fraction of executive total compensation	decimal

Table 1. *Independent Variables*

Variable Name	Database Name	Meaning	Units
Employees	log(1+emp)	the log value of full-time equivalent employees measured	1,000 employees
Revenues	log(1+revt)	the log value of company revenues in million dollars	millions

Table 2. *Control Variables*

Variables	Obs.	Mean	Std. Dev.	Min	Max
RQ	3609	0.098	0.035	0.008	0.547
Total Executive Compensation	3609	10698.210	11112.270	0.001	280621.600
Employees	3609	44.517	70.707	0.313	1298
Revenues	3609	20498.290	40044.470	58.941	433526.000
Salary	3609	1043.947	463.088	0	4000
Bonus	3609	472.893	1275.061	0	43511.540
Restricted Stock	3609	3960.373	8598.757	0	276612.100
Stock Options	3609	1777.473	4342.180	0	90693.400
Fraction Restricted Stock + Stock Option Based Compensation	3609	0.445	0.324	0	0.999
Fraction of Restricted Stock Based Compensation	3609	0.290	0.291	0	0.999
Fraction of Stock Option Based Compensation	3609	0.155	0.218	0	0.999

Table 3. *Data Descriptive Statistics*

Regression Results (Total Executive Compensation)

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Total Executive Compensation	0.073	0.038	1.95	0.052	-0.001	0.148
Revenues	0.022	0.004	5.04	0.000	0.013	0.031
Employees	-0.031	0.004	-8.74	0.000	-0.038	-0.024
Constant	-0.011	0.029	-0.38	0.703	-0.068	0.046

Table 4. *Total Executive Compensation Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors*

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Salary	-0.029	0.044	-0.65	0.513	-0.116	0.058
Bonus	-0.032	0.030	-1.08	0.282	-0.091	0.027
Restricted Stock	0.008	0.018	0.46	0.644	-0.027	0.043
Stock Options	0.049	0.020	2.45	0.015	0.010	0.088
Revenues	0.023	0.004	5.34	0.000	0.014	0.031
Employees	-0.031	0.003	-9.11	0.000	-0.038	-0.024
Constant	-0.005	0.028	-0.19	0.846	-0.061	0.050

Table 5. *Executive Compensation Components Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors*

Regression Outputs (Fraction of Equity Compensation)

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Fraction of RS + Stock Options	0.230	0.273	0.84	0.401	-0.308	0.768
Revenues	0.022	0.004	5.21	0.000	0.014	0.031
Employees	-0.031	0.004	-8.81	0.000	-0.038	-0.024
Constant	-0.008	0.029	-0.27	0.788	-0.064	0.049

Table 6. *Fraction of Equity Compensation Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors*

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Fraction of Restricted Stock	-0.180	0.262	-0.69	0.492	-0.698	0.337
Revenues	0.023	0.004	5.23	0.000	0.014	0.031
Employees	-0.031	0.003	-8.84	0.000	-0.038	-0.024
Constant	-0.008	0.029	-0.27	0.784	-0.065	0.049

Table 7. *Fraction of Restricted Stock Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors*

Variable	Coefficient	Standard Error	t	P>|T|	95% Confidence Interval	
Fraction of Stock Options	0.561	0.292	1.92	0.056	-0.014	1.135
Revenues	0.023	0.004	5.29	0.000	0.014	0.031
Employees	-0.031	0.003	-8.93	0.000	-0.038	-0.024
Constant	-0.008	0.029	-0.29	0.769	-0.065	0.048

Table 8. *Fraction of Stock Options Regression Outputs for Fixed Effect Model with Cluster-Robust Standard Errors*