UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

ESSAYS IN CORPORATE GOVERNANCE AND EXECUTIVE COMPENSATION

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By

FANG LIN
Norman, Oklahoma
2015

ESSAYS IN CORPORATE GOVERNANCE AND EXECUTIVE COMPENSATION

A DISSERTATION APPROVED FOR THE
MICHAEL F. PRICE COLLEGE OF BUSINESS

BY

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Dedication

I dedicate this dissertation to my mother Chenhong Li and to my father Jingzhou Lin who invested significant amount of their time, attention, and resources in my education. I am grateful to my uncle Chenyang Li and to my aunt Hong Xiao for being excellent role models for decades. I also thank my uncle Chenliang Li and his family. This work would not have been possible without the endless support and encouragement from my family members. This dissertation is also dedicated to my loving memories of my paternal grandmother Xueqing Wang and my maternal grandfather Renjie Li.

Acknowledgements

I am especially grateful to my wonderful mentor, Bryan Stanhouse, for his guidance, encouragement, and support. I am thankful to my committee members Robert Dauffenbach, Chitru Fernando, Scott Linn, Hamed Mahmudi, and Duane Stock for support and helpful suggestions. I also thank Louis Ederington, William Megginson, Vahap Uysal, and Pradeep Yadav.

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Abstract

This dissertation is a collection of three essays that investigate the issues related to corporate governance and executive compensation. In Chapter 1 I employ a sample of U.S. public firms to investigate the effect of executive compensation, especially short-term incentives, upon corporate innovation strategies. I show that CEOs with longer "*pay duration*" and CEOs receiving a higher "*executive vega*" direct their firms into more *exploratory,* as opposed to *exploitative,* innovations. The results obtained from an instrumental variable estimation establish my conclusions. Chapter 2 examines the expected time to merger for a Special Purpose Acquisition Corporation (SPAC). A SPAC is a company created for the sole purpose of merging with a private firm looking to become publicly traded. A simple target acquisition model is employed in empirical investigation of the determinants of the time to a successful merger between a SPAC and a private firm. We consider seven sources of independent variables including SPAC managerial characteristics, investor characteristics, underwriter characteristics, macroeconomic conditions, financial conditions, the "first mover" phenomenon, and the SPAC characteristics. Survival analysis establishes that these sources yield over twenty right hand side variables as being statistically significant in determining the time to merger. Chapter 3 investigates the influence of the media upon executive compensation. Specifically, we study how incoming CEOs' media exposure influences the changes in compensation relative to their predecessors' during turnover events. While having a media exposure does not influence total compensation of a CEO, it affects the composition of the compensation package. Specifically, the proportion of stocks and options relative to the total pay are significantly higher among incoming CEOs with

higher media exposures. Moreover, the compensation packages provide high *delta* to more visible CEOs. Our results suggest that the media acts as a “watchdog” which provides external monitoring power in setting CEO pays.

Chapter 1: CEO Risk-Taking Incentives and Corporate Innovation

1. Introduction

What drives innovation? Identifying the determinants of innovation is important for at least three reasons. First of all, the economics literature has long characterized innovation as key to sustainable macroeconomic growth (Schumpeter, 1934; Solow, 1957). Second, innovation creates positive externalities that increase the overall output for regional economies (Bottazzi and Peri, 2003; Audretsch and Feldman, 2004). Third, at the firm level, innovation can dramatically boost the productivity and, consequently, the profitability of a company both in the short-run and long-run (Romer, 1986; Aghion and Howitt, 1992; Porter, 1992). A growing literature has empirically examined the links between company characteristics and innovation, however, little is known about the link between managerial incentives and innovation activities. This paper attempts to fill this gap in the literature by investigating the effect of CEO compensation on firm innovation.

The empirical challenge of this paper is the possibility of endogenous right hand side variables in my regressions. Regardless of the source of the problem – omitted variables, joint determination of variables, or reverse causality – explanatory variables must be exogenous. Unattended this issue results in biased and inconsistent parametric estimates. I employ two approaches to overcome this complication. First, I estimate the model with a two-stage-least squares (2SLS) procedure using two instrumental variables (IV): the size of the firm's compensation committee and a dummy variable for whether or not the CEO serves as the chair of the compensation committee. Both instruments are correlated with the control variables but both remain relatively independent of the firm's innovation efforts. Second, I employ a quasi-natural experiment (QNE) proposed by Gormley and Matsa (2011) and Gormley, Matsa, and Milbourn (2013) to insure that risk-seeking incentives (executive vega) can influence corporate innovation decisions. In the QNE certain firms in the semiconductor industry are forced to change their compensation policy due to an unexpected increase in litigation risks. I empirically establish that the CEOs who receive lower risk-seeking incentives (executive vega) subsequently direct their firms towards less risky innovation projects.

My paper adopts novel computational measures of CEO incentives and firm innovative efforts. For instance, "*pay duration*", a weighted average of the vesting periods of the different components of executive pay, is used to capture CEO's short-termism. CEOs with longer *pay duration* are expected to favor long-term investment projects, while CEOs with shorter *pay duration* may meet short-term goals at the expense of long-term benefits. In this essay, "*exploratory innovation*" measures the extent of the firm's exploratory effort, which relies on acquiring new skills and knowledge. "*Exploitative innovation*", on the other hand, is a variable that documents the extent to which the firm's innovation is supported by the existing expertise the firm currently possesses. The overall findings of the paper support the notion that CEOs are sensitive to the incentives provided by their compensation packages and, additionally, those incentives influence the firms' innovation strategies. Specifically, CEOs who suffer less from short-termism and who enjoy a higher "executive vega" direct their firms into exploratory innovation activities. Furthermore, the results suggest that shareholders can effectively influence a firm's long-term investment policy, especially the firm's innovative strategy, with the appropriate configuration of the CEO's compensation package.

The rest of this paper proceeds as follows. Section 2 reviews the related literature on innovation and executive compensation. Section 3 reports the sample formation process, describes the key variables of interest, and presents the descriptive statistics. Section 4 develops the main hypothesis of this paper, and reports the empirical results. Section 5 provides additional robustness tests. Section 6 concludes the paper.

2. Related Literature and Hypothesis Development

2.1.Extant Literature on Innovation

The economic literature on innovation dates back to the 1930s, when Joseph Schumpeter (1934, 1942) labeled innovation as a "creative destruction" process. In this process, new, better-developed products are constantly brought to the market by new firms, replacing old products and thereby eliminating old firms. The "creative destruction" process continues indefinitely as new innovating firms constantly enter the market by learning from the recently introduced products and making improvements upon them.

Subsequent to Schumpeter, researchers have developed various theoretical models to address innovation and its relation to executive compensation configurations. Among them, Holmstrom (1989) shows that the inclusion of tolerance for failures in executive incentive plans is crucial to the success of innovation. He argues that short-term payoffs are a noisy measure of productive innovative activities, and hence, to motivate innovation, a compensation scheme must be less dependent on immediate firm profits. Following Holmstrom (1989), Aghion and Tirole (1994) maintain that it is difficult to develop a contract based upon innovative activities because the outcomes are unpredictable. More recently, Manso (2011) models the innovation process as a combination of the *exploration* of new untested actions and the *exploitation* of well-known knowledge. While the exploitation of well-known actions involves less uncertainty and can ensure reasonable payoffs, it hinders the discovery of new knowledge that can occasion a dramatic competitive advantage for the firm. Exploring new untested actions may reveal potentially superior outcomes, but it is highly risky and may end up as both a waste of time and of resources. Manso (2011) finds that an optimal contract that encourages innovation should provide tolerance for failures in the short run and rewards for innovative success in the long run.

There is ample empirical evidence that establishes a relation between corporate characteristics and their innovative activities. For instance, access to capital, either through public equity or bank loans, increases innovative productivity (Amore, Schneider, and Žaldokas, 2013; Gao, Hsu, and Li, 2014). Corporate innovation prospers when the level of tolerance for failure is high (Tian and Wang, 2014). On the other hand, corporations reduce their innovative efforts when they experience an increase in stock liquidity (Fang, Tian, and Tice, 2013) or analyst coverage (He and Tian, 2013), because both factors pressure managers to boost short-run firm performance.

2.2.Extant Literature on Executive Incentives

Stein (1988) models managerial short-termism and maintains that long-term investment projects carry greater information asymmetry than their short-term counterparts. Stein adds, consequently, target firm shareholders often receive undervalued bids if a takeover takes place before the payoff of a long-term project is known to the public. To avoid undervalued takeovers, managers may choose to substitute short-term investments for long-term projects. Building upon Stein's (1988) model, Bolton, Scheinkman, and Xiong (2006) argue that compensation contracts emphasizing short-term performance at the expense of long-term outlook can be optimal in a market where stock prices are a function of not only the fundamental firm value but also a short-term speculative component. In other words, the short-term firm performance can inflate stock prices above their "true" value and protect current shareholders from "cheap" takeovers. Empirically, Asker, Farre-Mensa, and Ljungqvist (2014) show that short-termism induces public-firm managers to invest at levels less than those that maximize the value of equity. In addition, Edmans, Fang, and Lewellen (2014) show that CEO's concerns for the current stock price lead to reductions in real investments, such as R&D.

3. Data Source, Sample Formation, and Key Variables

3.1.Data Source

The primary data sources include the National Bureau of Economic Research (NBER) U.S. Patent Citations Data File (Hall, Jaffe, and Trajtenberg, 2005), the Harvard Business School (HBS) Patent Network Dataverse (Li, Lai, D'Amour, Doolin, Sun, Torvik, Yu, and Fleming, 2014), Compustat, Execucomp, Incentive Lab, and RiskMetrics.

The NBER U.S. Patent Citation Data File contains detailed information on about 3.2 million U.S. patents granted between 1976 and 2006, and a broad match of patent assignees[1] to Compustat firms. The data obtained from the HBS Patent Network Dataverse has the citation records of about 3.3 million patents granted between 1975 and 2010. Specifically, each patent is linked to several granted patents that are referred to as citations. The executive compensation data comes from the Execucomp and the Incentive Lab. Execucomp provides details on the level and the components of annual executive pay for S&P 1000 firms since 1992, and the Incentive Lab provides information on vesting periods for each stock and option grant. Variables on various firm characteristics are collected from Compustat. The governance data comes from the Director Legacy Table of RiskMetrics database. Specifically, I obtain information on the size of compensation committee for each firm and whether the current CEO serves as the chair of the compensation committee from RiskMetrics.

3.2.Sample Formation

My sample for this study is formed by combining data from the aforementioned sources. First, I combine the patent information from NBER with the citation data from the HBS Patent Network Dataverse by using a unique patent assignee identifier *PDPASS*. With this combination, I am able to identify the patents that are cited by the same firm repeatedly and citations made by a firm's own patents. All of these citations

[1] Based upon the NBER patent data definition, a patent assignee could be an individual or a corporation who is recognized as the patent owner. Often, an individual assignee works for a corporation. The NBER patent data has a match algorithm which matches the individual assignees to their employers.

are considered "exploitative" because they represent the use of a firm's existing knowledge and skills. Second, I aggregate the citation information from the patent level to the firm (*PDPASS*) level. That is, I calculate the percentage of exploratory patents and exploitative patents for each firm. Third, I map each assignee number (*PDPASS*) onto a Compustat identifier (*GVKEY*) using the match provided by the NBER (Hall, Jaffe, and Trajtenberg, 2005). Most *GVKEY*'s can be linked to a unique *PDPASS* with some exceptions. For instance, if assignee A acquires assignee B in year *t*, assignee B will use assignee A's *GVKEY* from year *t* on. At this point, the dataset contains percentage observations of exploratory and exploitative innovation activities at firm-year level. Fourth, I combine datasets from Executivecomp and Incentive Lab. With these two sources, I have information on a) the size of each pay component (salary, bonus, restricted stocks, and option grants) for each CEO, and b) the vesting periods for each grant a CEO receives in any given year. Following the steps introduced by Gopalan, Milbourn, Song, and Thakor (2013), I calculate the executive *pay duration*, which is a variable characterizing the economic life of the firm's intertemporal liabilities to the CEO. Finally, I obtain annual firm characteristics from Compustat and merge this with the innovation dataset from step three and duration dataset from step four. My final sample covers 3019 firm-year observations from 611 distinct public companies during 1998 to 2006. This sample is used in all subsequent analyses except the two-stage-least-square (2SLS) regressions in section 4.4 and the differences-in-differences-in-differences (DIDID) analysis in section 4.5. To address the possibility of endogenous independent variables, I use 2SLS estimation and employ instrumental variables provided by the RiskMetrics database. However, this source only covers a subset of my final sample. Thus I use 2318 firm-year observations from 499 distinct firms, to perform the 2SLS regressions. As an alternative approach to address the issue of jointly determined right-hand-side variables, in section 4.5, I take advantage of a quasi-natural experiment that impacted a segment of firms in my original sample whose SIC code is 3674. Using firms with SIC codes between 3600 and 3699 but except 3674 as a control group, my sample in this section includes 445 firm-year observations from 63 distinct firms.

3.3.Measures of Innovation Strategy

Following Benner and Tushman (2002) and Gao et al. (2014), I categorize a firm's innovation strategy as "*exploratory*" or "*exploitative*" based upon a numeric characteristic ascribed to the firm when it innovates. *Exploratory innovation* introduces a "uniqueness" to the production process from outside knowledge and skills that have not been previously used by the firm, while *exploitative innovation* comes from an application of the firm's existing expertise.

I first consider a firm's innovation at the patent level. A patent is considered "*exploratory*" if 60% (alternatively 80%) or more of its citations are based on new knowledge outside of a firm's existing expertise (i.e., not citing the existing patents owned by the firm itself nor the citations made by those patents). On the other hand, a patent is considered "*exploitative*" if 60% (alternatively 80%) or more of its citations belong to the firm's existing knowledge (i.e., the firm's existing patents and citations made by those patents).

After characterizing the extent to which each patent is explanatory, I aggregate over all of a firm's patents to characterize the firm's innovations. A firm's exploratory innovation effort is captured by a ratio of the number of exploratory patents applied for in year *t* to year *t+2* over the total number of patents applied for in the same period[2]. Given the fact that there is typically a 2- to 3-year lag between the patent application and its approval, I use the application year instead of the grant year to better capture the underlying innovation activities at the firm level. The variable is bounded between 0 and 1, with a higher ratio suggesting that the firm deviates from its current knowledge base and expands into new technological territories.

Similarly, a firm's exploitative innovation effort is measured as the ratio of the number of exploitative patents applied for in year *t* to year *t+2* over the total number of patents applied for in the same period. This variable also ranges from 0 and 1. A higher exploitative ratio suggests that the firm is utilizing its current expertise and maintaining its competitive advantages in the areas it is currently involved in.

3.4.Measures of CEO Pay Duration

Each year, the typical CEO receives compensation from a variety of sources including salary, bonus, restricted stock grants, option grants, etc. Some pay components, such as stock and option grants, carry a vesting period that typically differs from other components. A CEO could receive multiple stock or option grants in a fiscal year, with each grant having a unique vesting period. Gopalan et. al (2013) construct a novel measure, *pay duration*, to capture the aspects of short-term and long-term

[2] For robustness purpose, I also investigate intervals other than year *t* to *t+2*. Section 5 has more detailed discussions on the robustness tests.

executive pay and to quantify the intertemporal trajectory of executive compensation. As a close cousin of the duration measurement in bond literature, the *pay duration* is the weighted average of the vesting periods of the different components of executive pay, with the weight for each component being the fraction of that component in the total compensation package. Algebraically, the measure is calculated as

$$pay\ duration = \frac{(salary + bonus) \times 0 + \sum_{i=1}^{n_s} restricted\ stock_i \times t_i + \sum_{j=1}^{n_o} option_j \times t_j}{salary + bonus + \sum_{i=1}^{n_s} restricted\ stock_i + \sum_{j=1}^{n_o} option_j} \quad (1)^{34}$$

where *i* and *j* represent a restricted stock grant and an option grant, respectively. *Salary*, *bonus*, *restricted* $stock_i$, and $option_j$ are, respectively, dollar value of annual salary, dollar value of annual bonus, the value of restricted stock grant *i* with vesting period t_i (in years)[5], and the Black-Scholes value of option grant j with vesting period t_j (in years).

The measure of *pay duration* possesses several advantages over other measurements of the intertemporal aspects of CEO pay. First, it quantifies the magnitude to which the overall compensation package provides short-term incentives, as opposed to long-term incentives, to the CEOs. Second, *pay duration* also takes into account the overall effect that each component in executive compensation could have

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[3] There are at least two concerns about the measure. First, it does not take into account the time value of money. Since most of the stock and option grants will become vesting in the "future", CEOs may value those future income on a present value basis. Second, the measure does not account for CEO outside wealth (Chava and Purnanandam, 2010), which refers to executive personal wealth that is not tied to the firm's performance. I choose not to include adjustments for the factors because a) the existing measures for executive individual discount rates and executive outside wealth tend to be noisy and hence may bias my regression results, and b) by using the identical measure of Gopalan et. al (2013), I can ensure my calculation of pay duration is correct by comparing my summary statistics to theirs.

[4] I calculate the *pay duration* relative to the fiscal-year-end, so I assign a vesting period of zero to both *salary* and *bonus*.

[5] Based on Execucomp documentation, the value of the stock grants are determined as of the date of the grant.

upon CEO incentives. This is achieved by assigning a weight parameter that is unique to each component based upon their size relative to total compensation.

Previous literature has proposed several computational measurements of executive compensation. For example, Bushman and Smith (2001) use the proportion of non-cash pay, primarily stock and option grants, in total pay to capture the incentives from the “speculative” and “intangible” part of total compensation; Coles, Daniel, and Naveen (2006) study the sensitivity of executive wealth to stock price movement, which essentially captures executives’ preference to stock volatility or firm risk. *Pay duration* distinguishes itself from previous measures by adding a unique *time* dimension into the characterization of executive incentives.

The time dimension is particularly important when it comes to a firm’s innovation decisions. Innovation decisions are time sensitive: it takes longer to develop innovative projects that are *exploratory* and to realize payoffs from such projects, if any. On the other hand, *exploitative* projects can be generated and outcomes realized over a shorter time horizon. The analysis here tests for a causal relationship between *pay duration* and *innovation* strategies.

3.5.Executive Vega

Following Core and Guay (2002) and Coles, et. al (2006), I also calculate executive *vega* in order to capture other incentives embedded in executive compensation. Executive *vega* measures the dollar change in CEO wealth (in $000s) associated with a 0.01 change in the standard deviation of the firm's stock returns.[6]

Core and Guay (2002) document a major regulatory change for the accounting of equity-based compensation. FAS 123R was issued by the FASB (Financial Accounting Standard Board) in 2004 and enacted in 2006. The new rules in FAS 123R require firms to expense equity-based compensation based at the fair value on the grant date. Consequently, firms report equity-based compensation in different formats both before and after 2006. My calculation of *executive vega* follows the methodology under the "old" reporting format, since the data used in this research covers the period 1998 to 2006.

I assume that the typical CEO receives equity-based incentives from three option portfolios: (1) the current year's option grants, (2) a portfolio of unvested options from previously-granted awards, and (3) a portfolio of vested options. The total equity-based incentives are given by the summation of the dollar amounts provided by these three portfolios. To calculate the incentives from portfolio (1), I obtain the number of options granted during the year, the exercise price, and maturity. The striking prices for portfolios (2) and (3) are not reported in Execucomp and hence are estimated with the technique outlined in Core and Guay (2002).[7]

[6] By using the standard deviation of a firm's stock returns as a proxy for firm risks, Core and Guay (2002) and Coles, et. al (2006), among others, uses the *executive vega* to capture the sensitivity of a CEO's income relative to the changes in firm risks.
[7] Coles, Daniel, and Naveen (2013) provide step-by-step instructions on the calculations of executive delta and vega.

3.6.Summary Statistics

Table 1-1 reports descriptive statistics of the sample. Definitions of all variables can be found in Appendix 1-1. My sample contains 611 unique firms and 3019 firm-year observations during 1998 to 2006. To be included in the sample, I require a) a firm has to have at least one granted patent over the three-year period from year *t* to year *t+2*, and b) a firm has to be covered by all aforementioned data sources, namely NBER, HBS, ExecuComp, Incentive Lab, and Compustat in a given year *t*.

[Insert Table 1-1 about here]

I compare the summary statistics from my sample to those from the extant literature. Specifically, Gao et. al (2014) report the mean and standard deviation of the variable *Explore60* to be 0.51 and 0.29, which are close to the 0.57 and 0.25 reported in my sample. The statistics of *Explore80* are also similar. The mean and standard deviation of variable *pay duration* in my sample are, respectively, 2.25 (mean) and 1.77 (standard deviation), which are similar to the 2.22 (mean) and 2.5 (standard deviation) reported by Gopalan et. al (2013).

4. Main Hypothesis and Empirical Results

4.1.Hypothesis

While empirical evidence suggests that corporate innovation activities can be affected by many characteristics at firm level, there is, however, very little research that establishes a direct link between managerial incentives and firm innovation. In the limited literature, Holthausen, Larcker, and Sloan (1995) examine the innovation activities and executive pay at division level by employing a simultaneous equation model. They document that the proportion of compensation tied to long-term components is related to a division's subsequent innovation activities. Baranchuk, Kieschnick, and Moussawi (2014) investigate the incentives embedded in the executive compensation in the newly public firms and find that length of vesting period is positively related to the firm's innovative activities, which is measured by the number of granted patents.

A typical compensation package for a CEO usually includes salary, bonus, restricted stock grants, option grants, etc. While salary and bonus are paid in cash and are immediately available to the CEO, stocks and options are usually granted with a vesting period during which the grants cannot be sold or exercised. Vesting periods are arguably an effective mechanism to align an executive's self-interest with those of long-term corporate goals (Murphy, 1999; Frydman and Jenter, 2010). Only after the expiration of the vesting period can an executive freely sell their stock awards and exercise their granted options. Therefore, the prospect of profiting from equity sales upon vesting encourages the managers to pursue projects that boost stock prices around the expiration of vesting periods. Although executives receive their compensation from different components with various vesting periods, I use *pay duration* to quantify the "representative" vesting period of the CEO at hand.

Real investment in innovation, especially exploratory innovation, is highly risky and the payoff is usually temporally remote (Phelps, 2010; O'Connor and Rafferty, 2012; Gao et. al, 2014; Tian and Wang, 2014). A "short-termist" CEO faces more pressure to meet short-term goals, possibly at the expense of sacrificing projects with long-term benefits (Gopalan et. al, 2013; Asker, Farre-Mensa, and Ljungqvist , 2014;

Edmans, Fang, and Lewllen, 2014). Thus, I expect “short-termist” CEOs to reduce real investment in exploratory innovations.

H1: *The larger the temporal characterization of executive compensation, pay duration, the greater the tendency of the firm to engage in exploratory innovation.*

Not only can executive incentives arise from the vesting schedule of stock and option grants, the incentives can also come from the association of the CEO wealth[8] relative to the change in firm stock volatility (executive *vega*). Coles et. al (2006) find that higher executive *vega* leads to risker policy choices, including more investment in R&D. Relative to exploitative innovation, exploratory innovation bears higher risks as its payoffs take longer to realize and are of greater uncertainty (Manso, 2011). As McGrath (2001) points out, high levels of exploratory innovation imply variance-seeking instead of mean-seeking learning process. A CEO with higher executive *vega* would benefit from the higher volatility of the firm stocks, and hence would engage the firm in more exploratory innovation activities.

H2: *The higher the firm’s executive vega, the more exploratory a firm’s innovations.*

4.2.Univariate Tests

To gain some basic insights, I first present the findings from univariate analysis of the relationship between executive incentives and firm innovation activities. In Panel A of Table 1-2, I split my sample into firms whose CEO has above- and below-median *pay duration*, and compare the characteristics across the two subsamples. The

[8] The literature, such as Core and Guay (2002) and Coles, et. al (2006), has been using the words “CEO compensation”, “CEO income”, and “CEO wealth” interchangeably.

difference in means of *pay duration* across the subsamples is 2.85 years, which is equivalent to 1.61 standard deviations of the *pay duration* variable. It speaks to the dispersion of my *pay duration* variable. As discussed in Section 3.3, my measurement of innovative strategy at firm level is the ratio of the number of exploratory patents applied for in year *t* to year *t+2* over the total number of patents applied for in the same period. For a patent to be considered as "exploratory", 60% (80%) of its citations must come from outside the firm's current expertise. In other words, these citations can neither be patents granted to the firm nor the patents the firm has cited before. Interestingly, the univariate results document that CEOs with longer *pay duration* are associated with firms that engage in exploratory activates. In terms of firm characteristics, CEOs with longer duration usually come from firms with lower leverage, higher R&D investment, and lower PPE (property, plant, and equipment) investment. These results are statistically significant at 1% confidence interval.

[Insert Table 1-2 about here]

In Panel B of Table 1-2, I split the sample into halves based on CEO incentive *vega*, and compare the characteristics across the two subsamples. The difference in means of executive *vega* across the subsamples is 444.42 (in $000), which is equivalent to 0.92 standard deviations of the *vega* variable. This speaks to the dispersion of my *executive vega* variable. The univariate results support the hypothesis H2 that CEOs with higher *executive vega* engage their firms in more exploratory innovations. CEOs receive higher executive vega from larger and older firms (as shown in the differences in *total assets* and *firm age*), firms with higher R&D investment and ROA, and firms with lower CAPEX (capital expenditures) and PPE (property, plant, and equipment) investment. These results are statistically significant.

4.3.Baseline Multivariate Analysis

In order to investigate the possible determinants of a firm's *exploratory* strategy, I perform regression analysis on the following equation:

$$\begin{aligned} Explore_{it} &= \alpha + \beta_1 PayDuration_{it} + \beta_2 CEOvega_{it} \\ &\quad + \gamma CEO_{it} + \eta Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it} \end{aligned} \tag{2}$$

where *i* indicates firm and *t* denotes time in years. The term *Explore* details the firm's exploratory innovation strategy, measured by *explore60* and *explore80*. *CEO* is a column vector of CEO characteristic variables, including CEO *tenure* at the current firm and the executive's *delta* (Core and Guay, 2002), which measures the dollar change in CEO compensation (in $000s) associated with a 1% change in the firm's stock price. *Firm* is a column vector of firm characteristic variables, including *leverage*, *PPE*, *ROA*, *sales growth*, etc. *FirmFE* and *YearFE* represent the firm and year fixed effects that controls for unobservable firm and time characteristics.

The OLS estimates from Equation (2) can suffer from at least two problems. First, the OLS estimates may become difficult to interpret. Econometricians usually interpret the results as follows: a one unit increase in *duration* and *vega* is associated with $\widehat{\beta_1}$and $\widehat{\beta_2}$ percentage points increase in exploratory ratio. While the dependent variable in Equation (2) is a ratio bounded between 0 and 1, the OLS estimation imposes no restrictions on boundary of the predicted values. When the predicted values exceed the boundary of [0, 1], the interpretation becomes meaningless. Second, the error term $\varepsilon_{it}$is likely to be heteroskedastic in this case. Heteroskedasticity occurs when the variances of the error terms are not constant across observations, which is possible in my case. Even after careful control for firm and CEO characteristics, I still expect to observe greater variation in exploratory innovation activities among more innovative firms than those less innovative counterparts. The variation could arise from other sources that are not controlled for such as location and industry, and therefore may vary across firms. Greene (2008) shows that the OLS estimates under heteroskedasticity are still unbiased but no longer efficient. To address the issues above, I use the Tobit model proposed by James Tobin (1958) which produces maximum likelihood, as opposed to OLS, estimators. Specifically, Tobit model assumes that there exists an unobserved dependent variable y_i^*, which linearly depends on explanatory variables. While the unobserved variable y_i^* is not bounded, its observed counterpart $y_i$is. For instance, the observed dependent variable exploratory ratio in Equation (2) has two boundaries (0 and 1). Algebraically,

$$y_i = \begin{cases} 0, & if\ y_i^* < 0 \\ y_i^*, & if\ 0 \le y_i^* \le 1 \\ 1, & if\ y_i^* > 1 \end{cases}$$

The unobserved $y_i^*$is only measured correctly by y_i when y_i^* is bounded between 0 and 1. Define an indicator function $I(y_i)$ with a boundary indicator variable y_B where

$$I(y_i) = \begin{cases} 0, & if\ y_i = y_B \\ 1, & if\ 0 < y_i < 1 \end{cases}.$$

Let Φbe the standard normal cumulative distribution function and ϕbe the standard normal probability density function. For a dataset with N observations the log likelihood function is:

$$\log L(\beta,\sigma) = \sum_{j=1}^{n} I(Y_j)\log\left(\frac{1}{\sigma}\phi\left(\frac{y_j - X_j\beta}{\sigma}\right)\right) + \left(1 - I\left(y_i\right)\right)\log\left(1 - \Phi\left(\frac{X_j\beta - y_B}{\sigma}\right)\right)$$

[Insert Table 1-3 about here]

In Table 1-3, I relate *pay duration* and executive *vega* to firm exploratory innovation activities. First I estimate Equation (2) with Tobit regression models which are immune to the problems mentioned above, and I report the results in columns (1) to (3). The results in column (3) highlight the notion that longer *pay duration* and higher *executive vega* can incentivize CEOs to engage their firms into exploratory innovations. While the predicted values from Tobit regressions are bounded between 0 and 1, the Tobit model cannot account for unobserved firm-specific factors and unobserved year-specific factors. Therefore, I re-estimate Equation (2) using panel regressions with firm and year fixed effects and report results in columns (4) to (6). Depending on the regression specifications, a one year increase in *pay duration* is associated with a 0.36 to 0.41 percentage points increase in exploratory innovations, and a one standard deviation increase in *executive vega* is associated with 1.25 to 1.30 percentage points increase in exploratory innovation. The results for both *pay duration* and *executive vega* are statistically significant. The panel regression results also show that exploratory innovation is negatively related to CEO tenure, which indicates that CEO entrenchment is detrimental to a firm's innovative activities[9]. In addition, I find a firm's capital expenditures and previous sales growth are statistically significant, both having positive relationships with subsequent exploratory innovations.

[9] Although the CEO tenure only serves as a control variable, its effect on innovation deserves some discussion. I believe the direction of such effect is an empirical matter. On one hand, entrenched CEOs could be very successful in innovation in the past and has therefore been able to secure their job. On the other hand, entrenched CEO may have directed their firms to avoided large losses by disengaging their firms from innovating activities. My empirical results lend support to the latter hypothesis.

In order to test the robustness of my results, in Panel B of Table 1-3 I redefine an exploratory patent as the one of which 80%, rather than 60%, or more citations come from outside the current expertise and recalculate the exploratory ratio. I obtain similar results from both the Tobit regression and the panel regression with fixed effects, which confirm that CEO incentives, especially *pay duration* and *executive vega*, are important determinants in the nature of a firm's innovation activities.

So far the empirical results are supportive of my hypotheses H1 and H2, which maintain that longer *pay duration* and higher executive vega encourage a firm's exploratory innovations. However, my Tobit and panel regression results in this subsection may suffer from having explanatory variables that are not exogenous. If so, the estimated coefficients in Table 1-3 could be biased and inconsistent. To substantiate the empirical results, I propose two approaches to address my apprehensions about endogenous right-hand-side variables: a 2SLS regression approach with instrumental variables and a DIDID approach utilizing a quasi-natural experiment.

4.4.Two Stage Least Square Regressions

The key variables of interest in this study, *pay duration* and *executive vega*, may be contemporaneously determined with the error term in equation (2). The 2SLS approach eliminates the endogeneity problem by using instrumental variables that arguably correlate only with the right-hand-side endogenous variables but not the left-hand-side dependent variables[10]. In other words, instead of making direct impact on the dependent variables, an IV should only influence the dependent variable through its effect on the endogenously-determined variables. While the OLS may produce biased

[10] See Appendix 1-3 for a detailed discussion on instrumental variables.

estimators due to possible correlation between the endogenous variables and the error term, the 2SLS is immune to such problems as the IVs are independent from the error term. I propose to use a) the size of the compensation committee and, b) a binary variable to document whether or not the CEO serves as the chair of the compensation committee as instrumental variables.

Both proposed instrumental variables speak to the composition of the compensation committee, which is in charge of setting executive pay and determining the incentives embedded in the compensation contract. For example, Bertrand and Mullainathan (2000) document that firms with weak governance often suffer from excessive managerial power, such as CEOs chairing the compensation committee. Therefore, I expect such CEOs to receive shorter pay duration and higher vega from their compensation packages. At the same time, it is unclear how the compensation committee, the size or who is in charge, can directly relate to firm innovative activities. In an untabulated OLS regression of *Explore60*1000* on the two instrumental variables, I found neither coefficient on the two IVs to be statistically significant. In fact, the R^2 of 0.0002 suggests that the IVs can hardly explain any variations in the innovative activities.

[Insert Table 1-4 about here]

In the first stage of the 2SLS estimation, I regress *pay duration* and *executive vega*, two variables that could potentially be endogenous, on the proposed IVs. In the second stage, instead of regressing the dependent variables on *pay duration* and *executive vega* directly, I replace these variables with the predicted values obtained in the first stage. In Table 4, I report the results from both stages. The first stage results lend support to Bertrand and Mullainathan (2000), and managerial power literature in general, that CEOs who serve on their own firms' compensation committee receive shorter pay duration and higher vega from their remuneration. The results from the second stage continue to support both hypothesis H1 and H2. Specifically, a one year increase in *pay duration*, or equivalently increasing *pay duration* from the 50th percentile to roughly 70th percentile, can lead to a 13.87 to 18.52 percentage points increase in exploratory innovations. The results are statistically significant. Meanwhile, a one standard deviation increase in *executive vega* can increase exploratory innovations by 16.8 to 24.0 percentage points.

4.5.A Quasi-Natural Experiment

4.5.1. Background

As an alternative approach to overcome possible endogeneity problems, I employ a natural experiment, which was first introduced by Gormley and Matsa (2011) and Gormley, Matsa, and Milbourn (2013), to help identify a causal link between CEO vega and firm innovative efforts. This natural experiment introduces an unexpected increase in litigation risks to certain firms in my sample (treatment firms), while some other firms (control firms) in related industries remain unaffected. This particular scenario provides a unique opportunity to study how firms respond to such changes in terms of their innovation strategies. Since firms are randomly assigned into a treatment group or a control group, it becomes highly unlikely that unobservable firm and executive characteristics can play a role in determining a firm's innovation efforts. By calculating the difference in innovation outcomes between the treatment firms and the control firms before and after the exogenous shock, I am able to establish an association between exploratory ratios and CEO incentives.

About every two years, the National Toxicology Program (NTP) publishes its bi-annual *Report on Carcinogens* (RoC). In the report published in 2000, the NTP updated a list of substances that are known or can be reasonably suspected to be carcinogenic, among which trichloroethylene was added for the first time. Trichloroethylene is widely used as industrial solvent in the semiconductor and related devices industry (SIC 3674). According to the National Occupational Exposure Survey (NOES), 8.5% of employees in this industry are exposed to the substance. As Gormley and Matsa (2011) and Gormley, Matsa, and Milbourn (2013) point out, the addition of trichloroethylene as a potential carcinogen to the RoC exposes firms in the semiconductor industry (SIC 3674) to greater liability risks[11]. In other words, the exogenous increase in legal liabilities would increase firms', and hence managers', exposure to the risk of poor future corporate performance. Consequently, I expect the affected firms (SIC 3674) to react to the sudden shock by decreasing their investment in exploratory innovation because the future payoffs from such investment tend to be highly uncertain. However, managers with longer *pay duration* and higher *executive vega* in the affected industry, may exhibit more resistance to the idea of reducing exploratory investment because their compensation is largely tied to future payoffs. Hence their effort in exploratory innovation should fall less than their counterparts with shorter *pay duration* and lower *executive vega.*

[11] The U.S. legal system requires employers to compensate employees for all job-related illnesses and injuries irrespective of fault. Once the court recognizes employment as at least one of the factors contributing to such illness and injuries, the employer becomes liable for the entire medical expenses. See Schwartz (1985) and Peirce and Dworkin (1988) for details.

4.5.2. Differences-in-differences (DID) Tests

DID is an econometric technique that helps to quantify the outcome of a QNE. It compares the average response of the outcome variable (or dependent variable) over time for the treated group to its counterpart, the control group. The name of DID stems from the particular methodology of measuring the "difference in the differences" between the treatment and control group over time.

To calculate the differences, the DID requires data measured before and after the treatment, which is the QNE in my example. In the generalized simple DID model illustrated in Figure 1, the treated group and the control group are represented by lines *T* and *C*, respectively. The outcome variable *Y* is measured for both groups before the QNE, represented by the points y_{11} and y_{21}. While the QNE occurs unexpectedly to the treatment group only, the outcome variable *Y* is measured again for both groups after the QNE, represented by y_{12} and y_{22}. Note that not all the difference between the treated and the control groups after the QNE (i.e., the difference between y_{12} and y_{22}) can be attributed to the treatment because a difference already exists between the two even before the QNE. The DID therefore excludes the "expected" difference in *y* between the two groups throughout the process regardless of the QNE, represented by the paralleled dashed line *C'* and the solid line *C*. The DID only considers the "net" difference (i.e., the difference between y_{12} and y_{22}') as the treatment effect.

[Insert Figure 1 about here]

Algebraically, consider the model $y_{ist} = \gamma_s + \omega_t + \delta D_{st} + \epsilon_{ist}$, where y_{ist} is the dependent variable for individual i, given state s and time t. γ_s and ω_t is the intercept for s and t, respectively. D_{st} is a dummy variable of treatment status, δ is the treatment effect, and ϵ_{ist} is an error term. Suppose for simplicity s = 1, 2 and t = 1, 2. To obtain an estimate of the "net" effect from a sample consisting of multiple observations, I aggregate the outcome variable Y at each state s and at each time point t to get their averages, $\overline{y_{11}}$, $\overline{y_{12}}$, $\overline{y_{21}}$, and $\overline{y_{22}}$. Then,

$$(\overline{y_{11}} - \overline{y_{12}}) - (\overline{y_{21}} - \overline{y_{22}})$$

$$= [(\gamma_1 + \omega_1 + \delta D_{11} + \overline{\epsilon_{11}}) - (\gamma_1 + \omega_2 + \delta D_{12} + \overline{\epsilon_{12}})]$$

$$- [(\gamma_2 + \omega_1 + \delta D_{21} + \overline{\epsilon_{21}}) - (\gamma_2 + \omega_2 + \delta D_{22} + \overline{\epsilon_{22}})]$$

$$= \delta(D_{11} - D_{12}) + \delta(D_{22} - D_{21}) + \overline{\epsilon_{11}} - \overline{\epsilon_{12}} - \overline{\epsilon_{21}} + \overline{\epsilon_{22}}$$

$$Or, E[(\overline{y_{11}} - \overline{y_{12}}) - (\overline{y_{21}} - \overline{y_{22}})] = \delta(D_{11} - D_{12}) + \delta(D_{22} - D_{21})$$

Without loss of generality, assuming D_{22} = 1 and D_{11} = D_{12} = D_{21} = 0 so that I can solve for an estimate of δ, then

$$\hat{\delta} = (\overline{y_{11}} - \overline{y_{12}}) - (\overline{y_{21}} - \overline{y_{22}})$$

which can be interpreted as the treatment effect of the QNE.

Empirically, the DID test can be implemented according to the table below, in which the lower right cell represents the DID estimator.

y_{st}	s = 2	s = 1	Difference
t = 2	$\overline{y_{22}}$	$\overline{y_{12}}$	$\overline{y_{12}} - \overline{y_{22}}$
t = 1	$\overline{y_{21}}$	$\overline{y_{11}}$	$\overline{y_{11}} - \overline{y_{21}}$
Change	$\overline{y_{21}} - \overline{y_{22}}$	$\overline{y_{11}} - \overline{y_{12}}$	$(\overline{y_{11}} - \overline{y_{21}}) - (\overline{y_{12}} - \overline{y_{22}})$

Although the method documented above is intuitively straightforward, its application in statistical packages can be very tedious. To make the estimation more software-friendly, researchers have been using an OLS framework to obtain the DID estimators that are equivalent to the ones obtained from the tabled method:

$$y = \beta_0 + \beta_1 T + \beta_2 S + \beta_3 (T * S) + \varepsilon$$

where *T* is a dummy variable for after QNE, and *S* is a dummy variable for the treated group. The interaction term T*S is then a dummy variable indicating when *S* = *T* = *1*. While the estimated coefficientβ_1 and β_2 measures the difference between the two time periods and that between the two groups, β_3 is an estimator for the treatment effect (i.e. the lower right cell of the table above).

I adopted one differences-in-differences model and one differences-in-differences-in-differences model to quantify the impact of *pay duration* and executive *vega* upon exploratory innovation under the quasi-natural experiment setting. In the DID model, I investigate if and how CEO incentives, *pay duration* and *executive vega*, among the treated and controlled firms react differently to the sudden increase in litigation risks with the following specification:

$$\begin{aligned} Incentive_{it} &= \alpha + \beta_1 treat_i * after_t + \beta_2 treat_i + \beta_3 after_t + CEO_{it} \\ &+ Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it} \end{aligned} \quad (3)$$

Here *i* indicates firm and *t* denotes time in years. *Incentive* refers, alternatively, to CEO *pay duration* and CEO *vega*; treat and after are dummy variables for treated firms and post-treatment years, respectively. The key variable of interest is β_1, and I expect it to be negative as Gormley et al. (2013) found that corporate boards reduce CEO's risk exposure immediately following unfavorable shocks that could hurt firm value.

Extending the DID model, I examine if and how corporate innovative efforts change in response to the quasi-natural experiment, conditional upon the treatment group assignment and incentive levels. A differences-in-differences-in-differences (DIDID) model provides statistical tests for this circumstance. The first difference comes from CEO incentives. I characterize a CEO as having high pay duration (executive vega) if average pay duration (executive vega) prior to 2000 is above the median. Alternatively, a CEO has a low pay duration (executive vega) if his average pay duration (executive vega) is below the median. The second difference pertains to whether a firm is affected by the exogenous shock. According to Gormley and Matsa (2011), firms with an SIC code 3674 belong to the "treatment group", while other firms with an SIC code between 3600 and 3699 (except 3674) belong to the "control group"[12]. The third difference arises from the time dimension – whether the observation belongs to the epoch before or after the exogenous shock which occurred in 2000. In Table 1-5 I report the sample distributions based on the three differences.

[Insert Table 1-5 about here]

$$\begin{aligned} Explore_{it} = {} & \alpha + \beta_1 high\_duration_i * treat_i * after_t + \beta_2 high\_duration_i * treat_i \\ & + \beta_3 high\_duration_i * after_t + \beta_4 treat_i * after_t + \beta_5 high\_duration_i \\ & + \beta_6 treat_i + \beta_7 after_t + CEO_{it} + Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it} \end{aligned} \tag{4}$$

$$\begin{aligned} Explore_{it} = {} & \alpha + \beta_1 high\_vega_i * treat_i * after_t + \beta_2 high\_vega_i * treat_i \\ & + \beta_3 high\_vega_i * after_t + \beta_4 treat_i * after_t + \beta_5 high\_vega_i + \beta_6 treat_i \\ & + \beta_7 after_t + CEO_{it} + Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it} \end{aligned} \tag{5}$$

Here *i* indicates firm and *t* indicates time in years, and $high\_duration_i$ ($high\_vega_i$), $treat_i$, and $after_i$ are dummy variables of the first, second, and third difference,

[12] According to the definition of U.S. Department of Labor, the 2-digit SIC code of 36 represent an industry that specializes in "electronic and other electrical equipment and components, except computer equipment".

respectively. The key coefficient of interest is β_1, which I expect to be positive based on the analysis above.

4.5.3. Empirical Results from DID Models

Table 1-6 reports the regression results for the DID model, which examines how *vega* and *pay duration* react to the exogenous shock. The estimates presented in columns (1) through (3) suggest that CEOs from treated firms receive less *vega* following the unexpected increase in corporate risks. Depending on model specification, the decrease in *vega* ranges from 46.04 (in $000s) to 72.07 (in $000s), or equivalently 0.10 to 0.15 standard deviations, is statistically significant. The estimates for *pay duration* are not statistically significant. The results suggest that while the executives in the treated firms experience a decline in vega after the sudden shock, their pay duration exhibits little change following the QNE. Consequently, the pay duration results from the DIDID models shall not be interpreted as causal.

[Insert Table 1-6 about here]

Panel A of Table 1-7 presents the results from estimating the DIDID model with equation (4). The estimated coefficients are positive and significant, indicating that longer pay duration is associated with more exploratory innovation.

[Insert Table 1-7 about here]

In Panel B, I report the results from estimating equation (5) where the exploratory innovation efforts are regressed on the three differences as well as CEO and firm characteristics. Although the estimated coefficients of β_1 from the panel regression fixed effect model becomes insignificant, those from the Tobit estimations are positive and statistically significant. The Tobit results support the notion that CEOs with higher executive vega exert higher effort in exploratory innovations.

4.5.4. Parallel Trends Assumption and Placebo Tests

In order to have consistent estimators from DID models, the “parallel trends assumption” has to be satisfied. The assumption states that the change in the response variable would have been the same for both the treated and the control group in the absence of treatment. This means that if the quasi-natural experiment did not occur, the exploratory innovation activity should have been the same for all firms regardless of their incentive level and treatment assignment.

While the “parallel trends assumption” cannot be directly tested, I conduct paired t-tests suggested by Roberts and Whited (2013) to evaluate if the assumption is likely to be violated in my quasi-natural experiment setting. The tests compare various firm characteristics prior to the shock in 2000 along three dimensions, namely *pay duration*, *vega*, and *treatment* assignment. If firms are similar in characteristics along these classifications, it is unlikely that they would respond differently had the event not occurred. Results from the paired t-tests in Table A.1 largely support the notion that firms possess similar characteristics in the pre-treatment period. In other words, it is unlikely that my DID findings would be contaminated by violations of the “parallel trends assumption”.

In addition to the paired t-tests, I perform a placebo (falsification) test to establish that the DID results are unique to the unexpected shock occurred in 2000. The placebo test uses year 2001, instead of year 2000 when the shock actually took place, as the event year. I repeat the baseline experiment for both the DID and the DIDID models with the same treated and control firms in my real tests. Results are reported in Table A.2. The estimated coefficients of the treatment effect (i.e. β_1 in Eqn. 3, 4, &5) are statistically insignificant in all cases (highlighted numbers), which indicates the changes in CEO incentives and corporate exploratory innovation efforts are similar between the treated and the control groups. Overall, the placebo tests lend support to the notion that the treated and control firms behave similarly in innovative activities in all periods other than the event window in 2000.

5. Additional Robustness Tests

5.1.Exploratory Innovation and Cash Flow Volatility

In this subsection, I investigate the empirical validity of Manso's (2011) theoretical model which suggests that exploratory innovation leads to higher corporate risks. Following Bakke et al. (2015) I use cash flow volatility to proxy for corporate risks, and I calculate cash flow volatility as the standard deviation of quarterly net cash flows from investing activities over total assets. Specifically, for firm *i* in year *t*, I obtain eight quarters of net cash flows from investment activities, scaled by total assets, in year t and year t+1. I then calculate the standard deviation of the eight quarterly ratios. My estimate regression coefficients from the following model.

$$CF\,vol_{it} = \alpha + \beta_1 L.Explore_{it} + \gamma Firm_{it} + +\eta CEO_{it} + \varepsilon_{it} \qquad (6)$$

CF vol refers to cash flow volatility, *L.Explore* refers to lagged corporate exploratory innovation efforts. *Firm* and *CEO* are two vectors of control variables on firm characteristics and CEO characteristics.

[Insert Table 1-8 about here]

Regression results are presented in Table 1-8, which show that increases in previous exploratory innovation activities do lead to future increase in cash flow volatilities. The estimates are both statistically and economically significant. For example, the estimated coefficient from specification (1) suggests that a one percentage point increase in exploratory ratio leads to 0.047 units (or equivalently, 0.99 standard deviation) increase in my cash flow volatility measure. My results remain robust when I use twelve quarters, instead of eight quarters, or cash flows to calculate standard deviations. The results lend support to Manso's (2011) predictions. That is exploratory innovation activities is associated with increasing corporate risks in general.

5.2.Other Measures of Exploratory Innovation Activities

My current empirical characterization on exploratory innovation stems from Benner and Tushman (2002) and Gao et. al (2014), in which I define firm *i*'s exploratory ratio in year *t* as the number of exploratory patents applied for in year *t* to year *t+2* divided by the total number of patents applied for over the same period. In this subsection, I investigate whether my main results are robust to alternative measures on exploratory innovation. More specifically, I first replace the year [*t* to *t+2*] window in the above exploratory ratio calculation with three alternative windows: (a) year [*t* to *t+1*]; (b) year [*t*] only; and (c) year [*t-1* to *t+1*][13]. Then I rerun the 2SLS model with these alternative exploratory ratios as the new dependent variable. Results are reported in Table 1-9.

[13] Take alternative (a) for example, my exploratory ratio is calculated as the number of exploratory patents applied for in year *t* to year *t+1* divided by the total number of patents applied for over year *t* to year *t+1*. Measures based on alternatives (b) and (c) are calculated in a similar manner.

[Insert Table 1-9 about here]

The estimated coefficients in Table 1-9 are quantitatively similar to those in Table 1-4, of which the exploratory ratio is measured over a period of year *t* to year *t+2*. The regression results and statistical significance in Table 1-9 remain large the same. For example, a one year increase in pay duration, or equivalently increasing pay duration from the 50th percentile to roughly the 70th percentile, leads to a significant increase in exploratory ratio by 14.41 percentage points in model (1) of Table 1-9. This result is comparable to the estimation of 13.87 percentage points in model (1) of Table 1-4. Overall, Table 1-9 suggests that my main results, that longer *pay duration* and higher *vega* can lead to more exploratory innovation, are robust to alternative measures of exploratory activities.

6. Conclusions

Literature on executive short-termism suggests that a short-termist CEO may over emphasize short-term corporate goals by reducing long-term risky investment, such as R&D, which jeopardizes a firm's long-term benefits. In this paper, I investigate the empirical link between CEO incentives from compensation package and corporate innovation strategies. I find that CEOs with longer pay duration, hence less short-term pressure, tend to increase their firm's involvement in exploratory innovation activities. Furthermore, CEOs with higher executive vega also direct their firms into innovations that tend to be more exploratory than exploitative in nature. Results from the two-stage-least-squares regressions suggest that the findings are not driven by endogeneity. The

DID findings for pay duration, which show no significant difference between the treated and the control group, are interesting and worth further investigations.

This paper establishes the importance of managerial incentives in the determination of corporate innovation. While many previous studies have identified factors that influence innovation at corporate and industry level, this paper highlights the importance of including managerial incentives as a consideration. Another interesting question for future research is which innovation strategy, exploratory or exploitative, is beneficial to the shareholders.

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Appendix 1-1: Variable Definitions

Variables	Detailed Definitions
Explore60 (80)	This measure is constructed following Benner and Tushman (2002) and Gao et. al (2014). First, for each patent applied for by firm *i* in year *t* to year *t+2*, I calculate the percentage of its citations that are based on existing expertise – either citing the firm's own patents or citing the patents that firm has cited before. Second, a patent is considered "exploratory" if 60% (80%) or more of its citations come from outside the firm's existing expertise, which is defined in the first step. Lastly, I calculate firm *i*'s exploratory ratio in year *t* as the number of exploratory patents applied for in year *t* to year *t+2* divided by the total number of patents applied for over the same period.
Pay duration	The weighted average of the vesting periods of the different components of executive pay, with the weight for each component being the fraction of that component in the total compensation package. Algebraically, the measure is calculated as $$duration = \frac{(salary + bonus)\times 0 + \sum_{i=1}^{n_s} restricted\ stock_i \times t_i + \sum_{j=1}^{n_o} option_j \times t_j}{salary + bonus + \sum_{i=1}^{n_s} restricted\ stock_i + \sum_{j=1}^{n_o} option_j}$$ where *i* and *j* represent a restricted stock grant and an option grant, respectively. *Salary*, *bonus*, $restricted\ stock_i$, and $option_j$ are, respectively, dollar value of annual salary, dollar value of annual bonus, the value of restricted stock grant *i* with vesting period t_i (in years), and the Black-Scholes value of option grant j with vesting period t_j (in years).

Executive vega	The dollar change in CEO wealth (in $000s) associated with a 0.01 change in the standard deviation of the firm's stock returns.
Executive Delta	The dollar change in CEO wealth (in $000s) associated with a 1% change in the firm's stock price.
CEO tenure	The number of years between the current fiscal year and the year the executive became CEO.
Firm age	The number of years between the current fiscal year and the year the firm went public.
Leverage	Total debt, including debt in current liabilities and long-term debt, relative to total assets.
R&D	R&D expenditures relative to total assets.
CAPEX	Capital expenditures relative to total assets.
ROA	Return on assets, calculated as EBIT divided by total assets.
PPE	Gross property, plant, and equipment, relative to total assets
Sales Growth	Sales (t) / sales (t-1)
CEO Comp Cmt Chair	A dummy variable. It equals to 1 when the current CEO serves as the chair of the compensation committee.
Comp Cmt Size	The number of members in the compensation committee
High_duratoin	A dummy variable. It equals to 1 when the average pay duration for a CEO before 2000 is above the sample median
High_vega	A dummy variable. It equals to 1 when the average executive vega for a CEO before 2000 is above the sample median.
Treat	A dummy variable for the treatment group in the DID tests. It equals to 1 when a firm belongs to SIC code 3674, and it equals to 0 if the SIC falls between 3600 and 3699 except 3674.

After	A dummy variable. It equals to 1 when an observation belongs to fiscal year after 2000.
Cash Flow Volatility	Standard deviation of quarterly net cash flows from investing activities over total assets. For cash flow volatility in year t, 8 quarterly net cash flows from investing activities (4 from year t, and another 4 from year t+1) are used to calculate the standard deviation.

Appendix 1-2: GLM Regressions

In subsection 4.3, I estimate the baseline multivariate model using Tobit and panel regressions. There are two potential problems associated with the baseline multivariate model: a) the dependent variable, exploratory ratio, is bounded between 0 and 1, and b) there may exist unobserved firm- and year-specific factors that cannot be controlled for. While the Tobit analysis takes care of the former problem and produces predicted values between 0 and 1, it is unable to deal with the latter. Similarly, the panel regression analysis corrects the latter problem by adding firm- and year- fixed effects, but its predicted values are not bounded. In this subsection, I propose a third method, the Generalized Linear Models (GLM), to account for both problems.

Papke and Wooldrige (2008) propose a panel data method for fractional dependent variables, in which the dependent variables y_{it} are bounded between 0 and 1 with the following distribution:

$$E(y_{it}|\boldsymbol{x_{it}}, c_i) = \Phi(\boldsymbol{x_{it}\beta} + c_i), t = 1, \ldots, T,$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function (cdf), $\boldsymbol{x_{it}}$ is a set of explanatory variables, and c_i represents the unobserved effect. While the derivations of the methodology is detailed in their 13-page long manuscript, repetition of such derivations is unnecessary and irrelevant to the main focus of this paper. Using the built-in functions of Papke and Wooldrige (2008) methodology in statistical software packages, I obtained the GLM estimators of the following equation:

$$\begin{aligned} Explore_{it} &= \alpha + \beta_1 PayDuration_{it} + \beta_2 CEOvega_{it} + \gamma CEO_{it} + \eta Firm_{it} \\ &\quad + FirmFE_i + YearFE_t + \varepsilon_{it} \end{aligned}$$

The GLM regression results are presented in Table A.3, which are qualitatively similar to the results from the Tobit and panel regressions presented in Table 1-3. In particular, the statistically significant and positive coefficients on pay duration suggest that the longer pay duration is associated with more exploratory innovation activities. While the estimates on vega are no longer significant, the signs remain positive which are indicative of a positive relationship between vega and exploratory innovation. Overall, the GLM results lend support to the main results in Table 1-3 that exploratory innovations are increasing with the increase in pay duration and vega.

Appendix 1-3: Instrumental Variables

Suppose I have the equation:

$$y_t = \beta x_t + u_t \tag{i}$$

where the variables are written as derivations from their means. Multiplying through by x_t and summing over t from 1 to T yields

$$\sum x_t y_t = \beta \sum x_t^2 + \sum x_t u_t$$

If I divide through by $\sum x_t^2$ I have

$$\frac{\sum x_t y_t}{\sum x_t^2} = \beta + \frac{\sum x_t u_t}{\sum x_t^2}.$$

Notice that the LHS is the OLS estimator $\hat{\beta}$, so

$$\hat{\beta} = \beta + \frac{\sum x_t u_t}{\sum x_t^2} \tag{ii}$$

and taking the expected value of this expression yields

$$E\left(\hat{\beta}\right) = \beta + E\left[\frac{\sum x_t u_t}{\sum x_t^2}\right].$$

I could easily rewrite $\frac{x_t}{\sum x_t^2}$ as w_t, so that $E\left(\hat{\beta}\right) = \beta + E[\sum w_t u_t]$. Consequently, when the assumption is that the regressor is a fixed variable and as such is uncorrelated with the disturbance, I can write $E[\sum w_t u_t] = \sum w_t E(u_t)$. If this were the case, $E\left(\hat{\beta}\right)$ would be β so that my OLS estimator would be unbiased and consistent. But in this research, it is my fear that the RHS variable x_t is endogenous and not necessarily independent of u_t. To examine the consistency of an OLS estimator under these circumstance, I take the *plim* of equation (ii):

$$p\lim\left(\hat{\beta}\right) = \beta + p\lim\left(\frac{\sum x_t u_t}{\sum x_t^2}\right), \text{ or}$$

$$p\lim\left(\hat{\beta}\right) = \beta + p\lim\left(\frac{\frac{\sum x_t u_t}{T}}{\frac{\sum x_t^2}{T}}\right).$$

I know that $plim(\frac{\sum x_t u_t}{T})$ is the population covariance of x_t and u_t. Furthermore, $(\frac{\sum x_t^2}{T})$ is the population variance of x_t. In this case, covariance of x_t and u_t cannot be assumed to be zero. Hence I cannot write $plim(\hat{\beta}) = \beta$ and the OLS estimator is seen to be inconsistent.

A general method of obtaining consistent estimates for the parameters of endogenous RHS variables is called instrumental variables. Broadly speaking, an instrumental variable is a variable that is uncorrelated with the error term but correlated with the explanatory variables in the equation. Consider, once again,

$$y_t = \beta x_t + u_t$$

If I can find a variable z_t that is uncorrelated with u, I can get a consistent estimator for β. I replace the condition $cov(z, u) = 0$ with its sample counterpart

$$\frac{1}{T}\sum z_t (y_t - \beta x_t) = 0 .$$

This yields,

$$\hat{\beta} = \frac{\sum z_t y_t}{\sum z_t x_t} = \frac{\sum z_t (\beta x_t + u_t)}{\sum z_t x_t}$$

$$\hat{\beta} = \beta + \frac{\sum z_t u_t}{\sum z_t x_t} .$$

The probability limit of $\hat{\beta}$ would be

$$p\lim\left(\hat{\beta}\right) = \beta + p\lim\left(\frac{\frac{\sum z_t u_t}{T}}{\frac{\sum z_t x_t}{T}}\right)$$

$$p\lim\left(\hat{\beta}\right) = \beta + \frac{p\lim\left(\frac{\sum z_t u_t}{T}\right)}{p\lim\left(\frac{\sum z_t x_t}{T}\right)}$$

$$p\lim\left(\hat{\beta}\right) = \beta \text{ since } p\lim\left(\frac{\sum z_t u_t}{T}\right) = 0 \text{ and } p\lim\left(\frac{\sum z_t x_t}{T}\right) \neq 0.$$

Hence, proving that $\hat{\beta}$ is a consistent estimator for β. Note that I require z_t to be correlated with x_t so that $cov(Z, X) \neq 0$.

The sampling variance of the instrumental variable estimator of the slope is given by

$$\frac{s^2 \sum z_t^2}{\left(\sum z_t x_t\right)^2}$$

where s^2 is an estimate for the regression error term. Clearly, with only a small correlation between *Z* and *X*, I may be paying a very high price for consistency.

Appendix 1-4: Tables and Figures

Table 1-1 Descriptive Statistics

The sample consists of 3019 firm-year observations (611 unique firms) from 1998 to 2006. Data source includes NBER U.S. Patent Citations Database, HBS Patent Network, Incentive Lab, ExecuComp, Compustat and RiskMetrics. To be included in the sample, a firm is required to have at least one granted patent over the three-year period from year *t-2* to year *t*. Appendix 1-1 documents the detailed definitions of all variables.

	Mean	Std Dev	P25	Median	P75	N
Explore60	0.57	0.25	0.40	0.57	0.75	3019
Explore80	0.47	0.26	0.27	0.43	0.63	3019
Pay Duration	2.25	1.77	0.69	2.22	3.41	3019
Vega (in $000s)	279.88	480.48	54.86	136.63	314.79	3019
Delta (in $000s)	3158.54	23153.80	195.52	462.70	1150.72	3019
CEO age	55.04	7.22	50.00	56.00	60.00	3019
CEO tenure	5.97	6.46	1.00	4.00	8.00	3019
Total Assets	15214.24	61563.68	1188.97	2796.07	9891.50	3019
Firm Age	8.63	5.84	4.00	8.00	12.00	3019
Leverage	0.23	0.18	0.07	0.22	0.33	3019
R&D	0.06	0.06	0.02	0.05	0.09	3019
Capex	0.05	0.04	0.03	0.04	0.06	3019
ROA	0.09	0.12	0.05	0.10	0.15	3019
PPE	0.49	0.34	0.24	0.41	0.65	3019
Sales growth	1.20	1.04	0.99	1.09	1.21	3019
CEO Comp Cmt Chair	0.13	0.33	0.00	0.00	0.00	2318
Comp Cmt Size	3.51	1.30	3.00	3.00	4.00	2318

Table 1-2: Univariate Analysis

The table compares the mean values of the key variables across subsamples. In Panel A, the subsamples are formed based on *pay duration*; in Panel B, the subsamples are formed based on *executive vega*. Appendix 1-1 documents the detailed definitions of all variables. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

Panel A: Univariate Comparison Based on *pay duration*

Variable	Below-Median pay duration	Above-Median pay duration	Difference	
explore60	0.5628	0.5897	-0.0269	***
explore80	0.4548	0.4823	-0.0275	***
vega	212.20	338.97	-126.77	***
delta	3307.40	2715.64	591.76	
Total Assets	15785.13	14044.58	1740.55	
Firm Age	8.46	8.68	-0.22	
Leverage	0.25	0.20	0.04	***
R&D	0.05	0.08	-0.02	***
Capex	0.05	0.05	0.00	
ROA	0.09	0.09	0.00	
PPE	0.54	0.44	0.10	***
Sales growth	1.18	1.22	-0.04	

Panel B: Univariate Comparison Based on *executive vega*

Variable	Below-Median vega	Above-Median vega	Difference	
explore60	0.5451	0.5991	-0.0540	***
explore80	0.4383	0.4896	-0.0513	***
pay duration	1.86	2.63	-0.77	***
delta	2659.00	3659.47	-1000.47	
Total Assets	4406.16	25320.30	-20914.14	***
Firm Age	8.16	9.98	-1.81	***
Leverage	0.22	0.23	-0.01	
R&D	0.06	0.07	-0.01	**
Capex	0.05	0.05	0.01	***
ROA	0.08	0.11	-0.03	***
PPE	0.50	0.48	0.03	**
Sales growth	1.19	1.14	0.06	**

Table 1-3: Baseline Multivariate Estimation

This table reports the baseline multivariate estimations of the following equation:

$$Explore_{it} = \alpha + \beta_1 duration_{it} + \beta_2 vega_{it} + \gamma CEO_{it} + \eta Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it}$$

where i indicates firm and t indicates time in years. Appendix 1-1 documents the detailed definitions of all variables. Columns (1) - (3) reports the estimates from Tobit regressions with firm and year clustering, and columns (4) - (6) reports the estimates from panel regressions with firm and year fixed effects. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

Panel A: Dependent Variable = ***Explore60*1,000***						
	Tobit with firm and year clustering			Firm and year fixed effect		
	(1)	(2)	(3)	(4)	(5)	(6)
Pay Duration	12.299		10.483***	4.052**		3.568*
	(0.717)		(0.001)	(0.039)		(0.070)
Vega		0.046***	0.041***		0.026**	0.027**
		(0.004)	(0.009)		(0.016)	(0.014)
CEO Tenure	1.495	1.814	1.629	-6.809***	-5.987***	-6.153***
	(0.254)	(0.563)	(0.830)	(0.000)	(0.000)	(0.000)
Delta	-0.000	-0.000	-0.000	0.000**	0.000*	0.000**
	(0.517)	(0.975)	(0.835)	(0.039)	(0.064)	(0.042)
Leverage	29.017	39.785	31.208	31.416	22.985	26.208
	(0.723)	(0.607)	(0.816)	(0.344)	(0.488)	(0.429)
ROA	24.044	45.326	43.901	-13.463	-12.035	-13.252
	(0.803)	(0.379)	(0.825)	(0.721)	(0.750)	(0.725)
CAPEX	81.830	-11.157	47.435	369.091***	356.803***	365.414***
	(0.626)	(0.969)	(0.778)	(0.002)	(0.002)	(0.002)
PPE	-1.155	7.101	-0.686	62.677*	51.468	53.328
	(0.973)	(0.863)	(0.984)	(0.070)	(0.138)	(0.124)
Sales Growth	0.822	0.855	0.288	12.076**	11.369**	11.648**
	(0.877)	(0.874)	(0.956)	(0.012)	(0.017)	(0.015)
Constant	539.402***	517.661***	545.295***	514.008***	516.027***	522.656***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3019	3019	3019	3019	3019	3019
R-squared	-	-	-	0.055	0.055	0.059
F	-	-	-	8.530	8.626	8.280
Two-way Cluster	Y	Y	Y	N	N	N
Firm&Year FE	N	N	N	Y	Y	Y

Table 1-3: Baseline Multivariate Estimation – *Continued*

Panel B: Dependent Variable = *Explore80*1,000*						
	Tobit with firm and year clustering			Firm and year fixed effect		
	(1)	(2)	(3)	(4)	(5)	(6)
Pay Duration	12.772		10.889***	3.759**		3.472*
	(0.499)		(0.000)	(0.048)		(0.069)
Vega		0.048***	0.043***		0.015	0.016
		(0.003)	(0.006)		(0.137)	(0.135)
CEO Tenure	1.982	2.307	2.121	-5.827***	-5.281***	-5.439***
	(0.157)	(0.193)	(0.650)	(0.000)	(0.000)	(0.000)
Delta	-0.000	-0.000	-0.000	0.000	0.000	0.000
	(0.212)	(0.606)	(0.511)	(0.101)	(0.142)	(0.106)
Leverage	48.815	60.263	51.096	43.203	36.995	40.121
	(0.525)	(0.194)	(0.617)	(0.178)	(0.249)	(0.211)
ROA	30.910	52.692	51.511	26.563	27.583	26.688
	(0.767)	(0.527)	(0.724)	(0.467)	(0.450)	(0.464)
CAPEX	125.613	28.877	89.953	333.528***	322.800***	331.352***
	(0.466)	(0.907)	(0.600)	(0.003)	(0.004)	(0.003)
PPE	-22.810	-14.439	-22.329	62.612*	55.140	57.079*
	(0.518)	(0.647)	(0.620)	(0.061)	(0.100)	(0.089)
Sales Growth	-0.352	-0.287	-0.903	8.207*	7.692*	7.954*
	(0.939)	(0.953)	(0.862)	(0.076)	(0.096)	(0.085)
Constant	428.140***	405.627***	434.246***	393.558***	392.388***	398.676***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3019	3019	3019	3019	3019	3019
R-squared	-	-	-	0.046	0.044	0.048
F	-	-	-	7.122	6.798	6.587
Two-way Cluster	Y	Y	Y	N	N	N
Firm&Year FE	N	N	N	Y	Y	Y

Table 1-4: 2SLS Regression Results

This table reports regression results from estimating the following equation using 2-stage-least-square methodology:

$$Explore_{it} = \alpha + \beta_1 duration_{it} + \beta_2 vega_{it} + \gamma CEO_{it} + \eta Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it}$$

where *i* indicates firm and *t* indicates time in years. The endogenous variables are duration and vega, and the instrumental variables are 1) a dummy variable which equals to 1 if the CEO is also the Chair of the compensation committee, and 2) the compensation committee size. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels. Appendix 1-1 documents the detailed definitions of all variables.

	Stage One		Stage Two					
	Pay Duration	Vega	Explore60*1000			Explore80*1000		
			(1)	(2)	(3)	(4)	(5)	(6)
CEO Chair CC	-0.059*	246.172***						
	(0.085)	(0.004)						
CC size	0.113***	-35.473***						
	(0.003)	(0.005)						
Pred. Duration			138.656***		46.449	185.219***		91.208
			(0.005)		(0.479)	(0.002)		(0.210)
Pred. Vega				0.428***	0.359**		0.507***	0.358*
				(0.001)	(0.036)		(0.000)	(0.059)
Leverage	-0.481	-285.430**	-139.115*	-196.648**	-203.420**	-119.356	-179.927**	-179.881**
	(0.220)	(0.028)	(0.054)	(0.014)	(0.010)	(0.169)	(0.043)	(0.041)
CAPEX	-4.930**	14.758	468.212	-192.562	15.956	503.264	-351.882	63.217
	(0.045)	(0.986)	(0.328)	(0.676)	(0.976)	(0.382)	(0.491)	(0.915)
PPE	-1.349***	-370.841***	-217.238***	-201.506***	-228.554***	-257.617***	-217.585***	-269.331***
	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)	(0.001)
Firm Age	-0.001	7.198	-6.819**	-3.612	-3.412	-7.456**	-3.765	-3.900
	(0.964)	(0.158)	(0.012)	(0.240)	(0.265)	(0.022)	(0.269)	(0.250)
ROA	-1.133*	305.353	42.993	335.165**	263.564	31.260	394.335***	253.147
	(0.078)	(0.153)	(0.724)	(0.011)	(0.104)	(0.831)	(0.007)	(0.160)
Sales Growth	0.178	-24.930	-35.812	-70.337**	-62.032*	-15.463	-60.019	-43.120
	(0.313)	(0.671)	(0.275)	(0.036)	(0.074)	(0.695)	(0.107)	(0.263)
Constant	1.506***	86.664	1090.050***	879.366***	973.084***	1092.263***	787.995***	969.029***
	(0.001)	(0.546)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2318	2318	2318	2318	2318	2318	2318	2318
R-squared	0.05	0.074	0.651	0.622	0.649	0.291	0.348	0.392
F	4.04	6.14	3.500	3.709	3.573	3.007	3.503	3.467

Table 1-5: Summary Statistics on the Natural Experiment

This table reports the number of firms in each group of the natural experiment. The sample only includes firms with an SIC from 3600 to 3699. Among them, firms with an SIC of 3674 belong to the *treatment group*, while others belong to the control group. If a CEO's average *pay duration* before 2000 is below (above) the median *duration* of all CEOs in this sample, her firm belongs to the *low*- (*high*-) *duration* group. Similarly, If a CEO's average *executive vega* before 2000 is below (above) the median *executive vega* of all CEOs in this sample, her firm belongs to the *low*- (*high*-) *executive vega* group.

	Duration		Vega		Treatment	
fiscal year	low_duration	high_duration	low_vega	high_vega	treatment group	control group
1998	21	24	18	27	24	21
1999	29	28	29	28	29	28
2000	30	29	29	30	29	30
2001	29	27	26	30	27	29
2002	27	28	25	30	25	30
2003	28	27	26	29	26	29
2004	27	28	26	29	26	29
2005	24	22	22	24	21	25
2006	8	9	5	12	8	9

Table 1-6: Differences-in-Differences Analysis

This table reports the Differences-in-Differences (DID) estimations of the following equation:

$$Incentive_{it} = \alpha + \beta_1 treat_i * after_t + \beta_2 treat_i + \beta_3 after_t + CEO_{it} + Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it}$$

where i indicates firm and t indicates time in years. The sample only includes firms with an SIC code between 3600 and 3699. Firms with an SIC code 3674 belong to the treatment group (treat), while firms with SIC code between 3600 and 3699 except 3674 belong to the control group. After is a dummy variable for fiscal years after 2000. Appendix 1-1 documents the detailed definitions of all variables. Columns (1) and (4) report the estimates from OLS regressions, and columns (2), (3), (5) and (6) report the estimates from panel regressions with firm and year fixed effects. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

Dep = Vega			Dep = Pay Duration		
(1) OLS	(2) FE	(3) FE	(4) OLS	(5) FE	(6) FE
-72.069*	-46.044*	-68.712***	-0.031	-0.067	-0.396
(0.059)	(0.074)	(0.009)	(0.938)	(0.876)	(0.408)
61.343**			1.084***		
(0.044)			(0.001)		
44.059	65.475***	70.132***	0.275	0.241	0.067
(0.104)	(0.001)	(0.002)	(0.337)	(0.478)	(0.871)
		0.005			-0.000
		(0.106)			(0.105)
		4.572**			-0.023
		(0.036)			(0.577)
		81.843			2.594
		(0.646)			(0.425)
		6.559			1.576
		(0.903)			(0.118)
		49.749***			-0.056
		(0.001)			(0.837)
98.073***	124.787***	79.408*	1.855***	2.421***	2.097***
(0.000)	(0.000)	(0.062)	(0.000)	(0.000)	(0.008)
437	437	437	437	437	437
0.117	0.157	0.284	0.076	0.006	0.037
19.117	30.251	12.809	11.624	0.931	1.183
N	Y	Y	N	Y	Y

Table 1-7: Differences-in-Differences-in-Differences Analysis

This table reports the Differences-in-Differences-in-Differences (DIDID) estimations of the following equations:

$$
\begin{aligned}
Explore_{it} = {} & \alpha + \beta_1 high\_duration_i * treat_i * after_t + \beta_2 high\_duration_i * treat_i \\
& + \beta_3 high\_duration_i * after_t + \beta_4 treat_i * after_t + \beta_5 high\_duration_i + \beta_6 treat_i \\
& + \beta_7 after_t + CEO_{it} + Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it}
\end{aligned}
$$

$$
\begin{aligned}
Explore_{it} = {} & \alpha + \beta_1 high\_vega_i * treat_i * after_t + \beta_2 high\_vega_i * treat_i \\
& + \beta_3 high\_vega_i * after_t + \beta_4 treat_i * after_t + \beta_5 high\_vega_i + \beta_6 treat_i \\
& + \beta_7 after_t + CEO_{it} + Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it}
\end{aligned}
$$

where *i* indicates firm and *t* indicates time in years. The sample only includes firms with an SIC code between 3600 and 3699. Firms with an SIC code 3674 belong to the treatment group (*treat*), while firms with SIC code between 3600 and 3699 except 3674 belong to the control group. *After* is a dummy variable for fiscal years after 2000. *High_duration* is a dummy variable which equals to 1 if a firm's average duration before 2000 is above the median of all firms in sample. Appendix 1-1 documents the detailed definitions of all variables. Columns (1) and (3) report the estimates from Tobit regressions with firm and year clustering, and columns (2) and (4) report the estimates from panel regressions with firm and year fixed effects. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

Table 1-7: Differences-in-Differences-in-Differences Analysis – *Continued*

Panel A: Effect of Duration				
	Dep Var = Explore60*1,000		Dep Var = Explore80*1,000	
	(1) Tobit	(2) FE	(3) Tobit	(4) FE
high_duration*treat*after	57.043**	91.216**	66.722*	79.258*
	(0.029)	(0.050)	(0.058)	(0.084)
high_duration*treat	17.791		-21.311	
	(0.836)		(0.820)	
high_duration*after	-30.112	-68.683*	-42.944	-77.070**
	(0.466)	(0.062)	(0.332)	(0.034)
treat*after	-28.509	-58.686*	-9.392	-44.082
	(0.173)	(0.067)	(0.484)	(0.164)
high_duration	35.778		50.074	
	(0.577)		(0.484)	
treat	-11.694		20.684	
	(0.833)		(0.731)	
after	-65.043***	-15.925	-73.914***	-29.829
	(0.001)	(0.524)	(0.003)	(0.228)
duration	1.675	4.159	1.337	5.322*
	(0.611)	(0.168)	(0.645)	(0.075)
vega	-0.081	0.012	-0.144	0.048
	(0.476)	(0.819)	(0.268)	(0.350)
delta	0.002	0.000	-0.001	-0.000
	(0.624)	(0.898)	(0.901)	(0.921)
CEO tenure	0.534	-2.334	1.187	-3.024
	(0.820)	(0.248)	(0.645)	(0.130)
leverage	-0.754	-114.133*	-11.821	-130.406**
	(0.994)	(0.059)	(0.915)	(0.029)
CAPEX	-8.544	301.894*	43.225	309.334**
	(0.981)	(0.056)	(0.911)	(0.048)
Constant	669.485***	585.250***	572.572***	478.880***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	445	445	445	445
R-squared	-	0.187	-	0.237
F	-	5.808	-	7.828
Two-way Cluster	Y	N	Y	N
Firm FE	N	Y	N	Y

Table 1-7: Differences-in-Differences-in-Differences Analysis – *Continued*

Panel B: Effect of Vega				
	Dep Var = Explore60*1,000		Dep Var = Explore80*1,000	
	(1) Tobit	(2) FE	(3) Tobit	(4) FE
high_vega*treat*after	131.680**	50.739	139.397*	74.567
	(0.034)	(0.295)	(0.067)	(0.118)
high_vega*treat	-91.683		-105.445	
	(0.307)		(0.353)	
high_vega*after	9.875	27.777	8.076	14.800
	(0.796)	(0.455)	(0.877)	(0.686)
treat*after	-106.979**	-59.522*	-92.949*	-66.881*
	(0.043)	(0.088)	(0.082)	(0.051)
high_vega	-125.970**		-140.638**	
	(0.014)		(0.012)	
treat	98.505**		127.130**	
	(0.047)		(0.045)	
after	-120.203***	-54.403**	-142.903***	-66.648***
	(0.000)	(0.027)	(0.000)	(0.006)
duration	4.917	4.842*	4.199	6.600**
	(0.275)	(0.099)	(0.359)	(0.023)
vega	0.119	-0.009	0.068	0.015
	(0.278)	(0.861)	(0.564)	(0.762)
delta	-0.000	-0.001	-0.003	-0.001
	(0.941)	(0.833)	(0.453)	(0.731)
CEO tenure	0.731	-2.422	1.695	-2.959
	(0.701)	(0.227)	(0.438)	(0.134)
leverage	27.206	-132.708**	3.506	-148.764**
	(0.796)	(0.027)	(0.975)	(0.012)
CAPEX	-625.246*	259.667*	-813.580**	259.657*
	(0.090)	(0.100)	(0.030)	(0.095)
Constant	711.404***	635.786***	616.615***	520.806***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	445	445	445	445
R-squared	-	0.186	-	0.241
F	-	6.339	-	8.850
Two-way Cluster	Y	N	Y	N
Firm FE	N	Y	N	Y

Table 1-8: Cash Flow Volatility and Exploratory Innovation

This table reports the results from the following regression model:

$$CF\ vol_{it} = \alpha + \beta_1 L.Explore_{it} + \gamma Firm_{it} + +\eta CEO_{it} + \varepsilon_{it} \qquad (6)$$

CF vol refers to cash flow volatility, *L.Explore* refers to lagged corporate exploratory innovation efforts. *Firm* and *CEO* are two vectors of control variables on firm characteristics and CEO characteristics. Appendix 1-1 documents the detailed definitions of all variables, and subsection 5.1 discusses the detailed empirical implications. Estimates in colums (1) and (3) are obtained from panel regressions with firm and year fixed effects; estimates in columns (2) and (4) are obtained from OLS regressions with two-way clustering (firm and year clustering). p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

	Dep = CF Vol (8 qtr)		Dep = CF Vol (12 qtr)	
	(1)	(2)	(3)	(4)
Explore 60 (Lagged)	0.047***	0.014**	0.040***	0.014*
	(0.000)	(0.034)	(0.000)	(0.062)
ROA	-0.081***	-0.074***	-0.079***	-0.102***
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	0.013	0.149***	0.056**	0.167***
	(0.625)	(0.000)	(0.032)	(0.000)
Sales Growth	-0.001	0.007	-0.010***	0.002
	(0.597)	(0.146)	(0.000)	(0.595)
Vega	-0.000*	-0.000***	-0.000**	-0.000***
	(0.093)	(0.009)	(0.022)	(0.001)
Delta	0.000***	0.000**	0.000*	0.000**
	(0.007)	(0.028)	(0.062)	(0.045)
Constant	0.037***	0.037***	0.056***	0.051***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2405	2405	2405	2405
R-squared	0.053	0.114	0.079	0.138
F	17.946	22.820	27.866	29.167
Two-way Cluster	N	Y	N	Y
Firm FE	Y	N	Y	N

Table 1-9: 2SLS Regression Results on Alternative Exploratory Ratios

This table reports estimation results from the second stage of the 2SLS model:

where i indicates firm and t indicates time in years. The endogenous variables are duration and vega, and the instrumental variables are 1) a dummy variable which equals to 1 if the CEO is also the Chair of the compensation committee, and 2) the compensation committee size. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels. Subsection 5.2 discusses the definitions of dependent variables, and Appendix 1 documents the detailed definitions of independent variables.

	Explore60[t, t+1]*1000		Explore60[t]*1000		Explore60[t-1, t+1]*1000	
	(1)	(2)	(3)	(4)	(5)	(6)
Duration	144.123***		131.417**		142.432***	
	(0.006)		(0.020)		(0.006)	
Vega		0.376***		0.314**		0.372***
		(0.003)		(0.019)		(0.003)
Leverage	-142.213*	-182.763**	-138.453*	-171.290**	-137.808*	-177.419**
	(0.064)	(0.021)	(0.093)	(0.038)	(0.070)	(0.022)
CAPEX	323.577	-326.343	454.237	-200.890	411.102	-213.763
	(0.526)	(0.472)	(0.406)	(0.671)	(0.415)	(0.632)
PPE	-212.493***	-173.106***	-170.503**	-118.759*	-205.628***	-168.266***
	(0.007)	(0.008)	(0.044)	(0.082)	(0.008)	(0.009)
Firm Age	-7.775***	-5.293*	-8.646***	-6.770**	-7.405***	-4.893*
	(0.007)	(0.080)	(0.005)	(0.032)	(0.009)	(0.100)
ROA	26.924	310.049**	-1.823	244.743*	6.837	288.145**
	(0.836)	(0.017)	(0.990)	(0.071)	(0.957)	(0.024)
Sales Growth	-40.579	-72.861**	-38.304	-66.034*	-42.115	-74.081**
	(0.246)	(0.027)	(0.307)	(0.055)	(0.223)	(0.023)
Constant	1113.320***	864.664***	1052.777***	817.685***	1091.685***	845.455***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2318	2318	2318	2318	2318	2318
F	3.437	3.803	2.778	3.126	3.262	3.636

Table A 1: Pre-Treatment Firm Characteristics Comparison

This table reports the mean values from paired t-tests on firm characteristics during pre-treatment period. The sample period covers from 1998 to 2000. Firms are grouped based upon incentive levels (pay duration and vega) and upon treatment groups. A firm-year observation is assigned to low duration (vega) group if its CEO's pay duration (vega) is below the sample median prior to 2000; a firm-year observation is assigned to high duration (vega) group if its CEO's pay duration (vega) is above the sample median prior to 2000. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

Panel A: Comparison Based upon *Pay Duration*

Variable	Low Duration	High Duration	Difference	
log(assets)	7.316	7.367	-0.051	
Firm Age	6.892	10.104	-3.212	**
Leverage	0.160	0.102	0.057	**
R&D	0.074	0.099	-0.025	***
Capex	0.087	0.082	0.005	
ROA	0.140	0.139	0.001	
PPE	0.520	0.400	0.119	***
Sales growth	1.349	1.400	-0.051	

Panel B: Comparison Based upon *vega*

Variable	Low Vega	High Vega	Difference	
log(assets)	6.674	7.939	-1.265	***
Firm Age	6.809	11.053	-4.244	***
Leverage	0.124	0.137	-0.014	
R&D	0.085	0.088	-0.004	
Capex	0.093	0.076	0.017	*
ROA	0.154	0.126	0.027	
PPE	0.440	0.477	-0.037	
Sales growth	1.408	1.344	0.064	

Panel C: Comparison Based upon *Treatment*Groups

Variable	Control Group	Treated Group	Difference	
log(assets)	7.425	7.255	0.171	
Firm Age	7.079	10.021	-2.942	*
Leverage	0.133	0.128	0.005	
R&D	0.073	0.100	-0.027	***
Capex	0.072	0.097	-0.026	***
ROA	0.143	0.135	0.008	
PPE	0.431	0.489	-0.058	
Sales growth	1.328	1.423	-0.096	

Table A 2: Placebo Tests

This table reports the results from the Placebo tests. The estimates in columns (1), (2), (3) and (4), and correspond to Eqn. (3), (3), (5), and (4), respectively. The highlighted numbers are the estimates for β_1 in aforementioned equations. The sample only includes firms with an SIC code between 3600 and 3699. Firms with an SIC code 3674 belong to the treatment group (treat), while firms with SIC code between 3600 and 3699 except 3674 belong to the control group. After is a dummy variable for fiscal years after 2000. High_duration is a dummy variable which equals to 1 if a firm's average duration before 2000 is above the median of all firms in sample. Appendix 1-1 documents the detailed definitions of all variables. All estimates are obtained from panel regressions with firm and year fixed effects. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels. Control variables on CEO characteristics and firm characteristics are not reported to conserve space.

	DID		DIDID	
			Incentive = vega	Incentive = pay duration
Dependent Variable	(1) vega	(2) pay duration	(3) Explore 60	(4) Explore 60
high_incentive*treat*after			21.927	50.652
			(0.637)	(0.257)
high_incentive*treat			.	.
			.	.
high_incentive*after			30.133	-23.557
			(0.392)	(0.497)
treat*after	40.018	0.079	-14.054	-21.193
	(0.132)	(0.864)	(0.678)	(0.509)
high_incentive			.	.
			.	.
treat	.	.	.	.
	.	.	.	.
after	45.154**	-0.234	-58.066**	-35.790
	(0.043)	(0.542)	(0.017)	(0.154)
duration			3.619	3.381
			(0.226)	(0.277)
Constant	142.200***	2.221***	635.044***	585.764***
	(0.001)	(0.004)	(0.000)	(0.000)
Observations	394	394	394	394
R-squared	0.203	0.032	0.157	0.159
F	8.227	1.036	5.186	4.758
Two-way Cluster	N	N	N	N
Firm FE	Y	Y	Y	Y

Table A 3: GLM Regression Results on the Baseline Multivariate Model

This table reports the results from using GLM regressions to estimate the baseline multivariate model below:

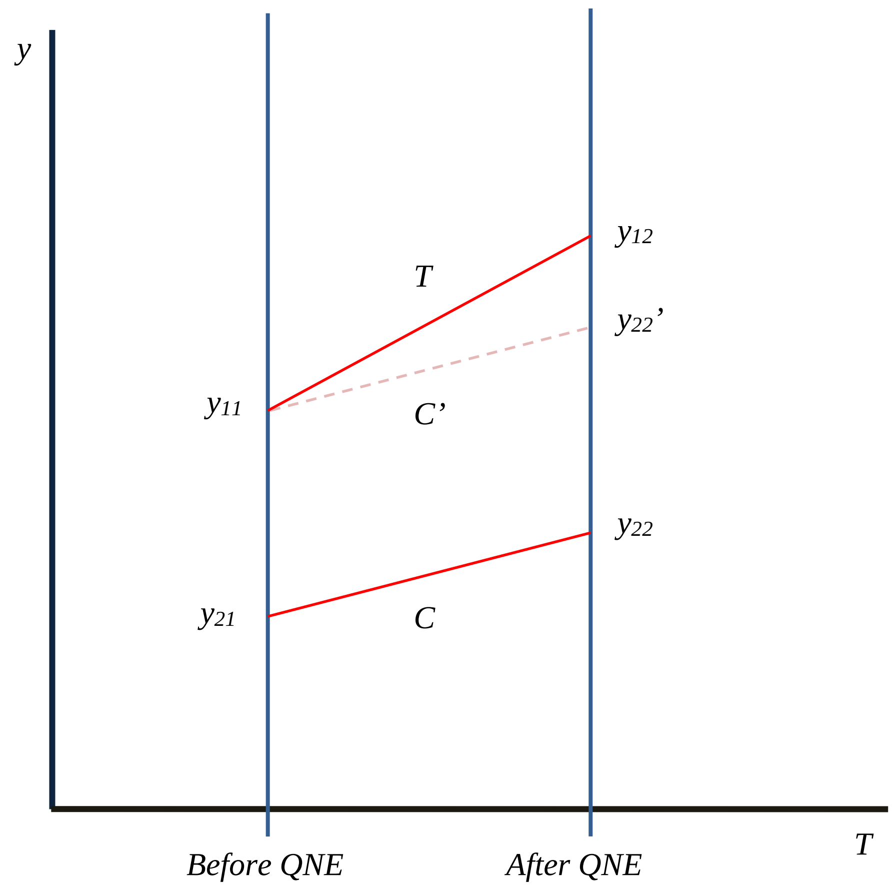
$$Explore_{it} = \alpha + \beta_1 duration_{it} + \beta_2 vega_{it} + \gamma CEO_{it} + \eta Firm_{it} + FirmFE_i + YearFE_t + \varepsilon_{it}$$

where i indicates firm and t indicates time in years. Appendix 1-1 documents the detailed definitions of all variables, and Appendix 1-2 discusses the rationale for using GLM regressions. p-values are reported in the parentheses. Asterisks denote statistical significance level at the 1% (***), 5% (**), and 10% (*) levels.

	Dep var = Explore60			Dep var = Explore80		
	(1)	(2)	(3)	(4)	(5)	(6)
Pay Duration	0.034**		0.030*	0.036**		0.031*
	(0.033)		(0.064)	(0.025)		(0.052)
Vega		0.000	0.000		0.000*	0.000
		(0.104)	(0.155)		(0.080)	(0.111)
CEO Tenure	0.004	0.005	0.004	0.005	0.006	0.006
	(0.535)	(0.417)	(0.497)	(0.374)	(0.293)	(0.340)
Delta	-0.000*	-0.000	-0.000	-0.000**	-0.000	-0.000
	(0.094)	(0.299)	(0.238)	(0.047)	(0.150)	(0.125)
Leverage	0.004	0.032	0.010	0.115	0.140	0.122
	(0.985)	(0.883)	(0.964)	(0.594)	(0.521)	(0.572)
ROA	-0.376	-0.325	-0.332	-0.291	-0.242	-0.242
	(0.199)	(0.262)	(0.253)	(0.298)	(0.383)	(0.384)
CAPEX	-0.590	-0.767	-0.619	-0.446	-0.658	-0.479
	(0.579)	(0.469)	(0.559)	(0.690)	(0.555)	(0.668)
PPE	0.041	0.064	0.039	0.035	0.058	0.033
	(0.757)	(0.637)	(0.770)	(0.791)	(0.664)	(0.804)
Sales Growth	0.016	0.017	0.016	0.032	0.034	0.032
	(0.647)	(0.605)	(0.652)	(0.384)	(0.340)	(0.387)
Constant	-0.069	-0.128	0.066	-0.560***	-0.616***	-0.430***
	(0.569)	(0.265)	(0.578)	(0.000)	(0.000)	(0.000)
Observations	3019	3019	3019	3019	3019	3019
Firm&Year FE	Y	Y	Y	Y	Y	Y

Figure 1-1: Differences-in-Differences (DID) Illustration

This figure illustrates the general idea behind a DID model. The treated group and the control group is represented by lines T and C, respectively. The outcome variable *Y* is measured both before and after the QNE. Note that not all the difference between the treated and the control groups after the QNE (i.e., the difference between y_{12} and y_{22}) can be attributed to the treatment because the different already exists even before the QNE. The DID only considers the "additional" difference (i.e., the difference between y_{12} and y_{22}') as the treatment effect.



Chapter 2: Expected Time to a Special Purpose Acquisition Corporation (SPAC) Merger[14]

1. Introduction

Corporations receive many benefits by going public. Besides the obvious reason of raising capital, studies such as Pagano, Panetta, and Zingales (1998), Brau and Fawcett (2006), and Maug (1998) have found that public firms have a lower cost of capital, make more acquisitions, have higher valuations and more effective corporate governance than private firms. However, a firm's initial public offering (IPO) has significant financial costs (such as underwriting fees) that are well documented in Ibottson, Ritter and Sindelar (1998) and Lee, Lochhead, Ritter, and Zhao (1996). Recently many private firms have been seeking alternative, less expensive, ways to go public. Many corporations have opted to go public via a reverse merger.[15] A reverse merger is where a larger private firm merges with a smaller publicly traded firm, sometimes with little or no physical assets; the private firms take over the publicly traded entity of the smaller firm, thereby "going public" without the IPO. The smaller public firm is often referred to as a "shell" when it has no operations. The literature in mergers and acquisition is extensive, while the research in the field of reverse mergers is surging. Gleason, Rosenthal, and Wiggins (2006) and Gleason, Jain and Rosenthal (2006) provide two excellent introductions to this topic. In response to the demand for shells or publicly traded entities for facilitating reverse mergers, special purpose

[14] This chapter is based on collaborative work with Bryan E. Stanhouse.
[15] CFO Magazine, "Honest Shell Games?" April 2005.

acquisition corporations (SPACs) have grown in popularity over the last ten years.[16] A SPAC is a "blank check" company, or in other words, a company created for the specific purpose to merge or form a business combination with a private firm looking to become publicly traded.[17] It has no business operations.

SPACs have a variety of interesting characteristics. SPAC units, rather than straight equity, are sold to the public. These units usually contain one share and one or two warrants. The common stock and the warrants usually begin to trade separately on the 90th day after the units begin trading. According to Schultz (1993), firms that issue units are smaller, have less income than other firms their size, and less likely to survive. The warrants can be exercised within one year from the IPO date, and expire in four years, with various restrictions. The units, warrants and shares are listed on the same exchange, either the OTC Bulletin Board Market (OTCBB) or the American Stock Exchange (AMEX). SPAC underwriting spreads are slightly larger than most IPOs, and much larger if one includes a deferred underwriting fee and purchase option.[18] The largest fees are paid by the smaller SPACs[19]. All the completed mergers end up on the NASDSAQ Global Market or Capital Market rather than the OTCBB, where many SPACs begin.[20,21]

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[16] They are also known as TACs, or targeted acquisition corporations.
[17] SPACs are not technically "blank check" firms as defined by the SEC rule 419; a firm can avoid the onerous restrictions of Rule 419 by filing an 8K form, having an audited balance sheet and at least $5 million in net assets.
[18] Most IPOs cost 7% as documented by Chen and Ritter (2000).
[19] This is consistent with the findings of Fernando, Gatchev, and Spindt (2006) that low reputation firms seek low reputation investment banks and pay accordingly.
[20] See nasdaq.com for detail on these leading over-the-counter markets.
[21] Harris, Panchapegasan and Werner (2006) find that the OTCBB market has lower volume and three times the effective spread than the NASDAQ; potential merger partners may view the SPAC merger as preferred to the standard reverse merger with a shell that lingers on the OTCBB.

The SPAC places the cash from the IPO in a trust account and only spends proceeds on the expenses associated with maintaining the firm. There is evidence that investors are demanding more money in the trust account. Over time the amount in the trust account has grown, on average, from 90% to 95% of net assets.

Once the SPAC managers find an acquisition target, the majority of shareholders must approve the deal and less than 20% of the shareholders are allowed to exercise their redemption option. The redemption option is a put option that the shareholder can exercise that allows them to redeem their shares with the company at the NAV which typically is about 95% of IPO price. Shareholders can also sell in the open market. Occurrences of SPACs selling below their NAV are rare.

Perhaps the most important feature of a SPAC is the “merger window”; that is the time period stated in the prospectus when a merger must take place, or the manager’s shares become worthless and the NAV is returned to the shareholders in cash. The merger window typically extends twenty four months from the IPO date; the firm must have a letter of intent to effect a merger by this time, but some SPACs have as little as 18 months to consummate a deal.[22] Firms that announce mergers early in the window generally outperform firms that announce later in the window. Equity returns get worse and worse the longer firms wait before reaching any agreement. If a majority of shareholders vote against the merger agreement, or if 20% of shareholders exercise their redemption option, the SPAC may ask for more time to find a partner. If shareholders reject that offer, the SPAC liquidates and initial investors receive the NAV (net asset value) of the company. In other words, the money in the trust account is returned. The NAV is reported every quarter in the 10-Q SEC filing. SPAC managers

[22] Firms may even ask shareholders for an extension of this window.

can go to the shareholders and ask for an extension to the merger window before a vote takes place[23].

According to each SPAC prospectus, the merger target must be at least 80% of the net assets of the SPAC. The managers or the executive officers of the SPAC have the job of selecting a merger partner. The managers receive no salary compensation for their work; instead they are allowed to purchase a 20% stake in the firm for a minimal cost (usually 1 cent per share) before the initial public offering (IPO) and the public is sold the remaining 80% in return for their willingness to fund the SPAC, i.e., buy the IPO units. It is important to know that the manager's shares are restricted, "lock-up" fashion. While the public's shares and warrants are easily tradable in the market, manager's shares are restricted for 3 years or unless all the shares are exchanged for cash in 'the terms" of a merger agreement[24]. Management also puts some "skin in the game" by agreeing to purchase warrants in the open market or via a private placement in conjunction with the IPO. SPACs have a board of directors; many on the board own shares in the company; the board is composed of executive officers and independent directors. It is important to note that although the SPAC is almost completely funded by outside investors, those investors only own, on average, 80% of the firm, demonstrating the significant dilution of the ownership rights of those IPO investors.

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[23] Shareholders can still exercise the right to reject the merger agreement even if they vote for an extension.

[24] Brav and Gompers (2003) argue that these lock-up agreements are designed to alleviate the moral hazard problem by insiders.

2. A Simple Target Acquisition Model for SPAC Managers

In this section we propose a simple target acquisition model for SPAC managers. The model's intent is to merely create a sense of how SPAC managers might think about merger targets in order to help determine what economic variables, and how those variables, impact a SPAC's time to merger.

We begin by detailing just how much of the new firm's value SPAC managers would be entitled to at the time a merger is consummated which is given by

$$\left\{\alpha(1-P)\left[I_0+T-C\right]\right\}.$$

The proportion of the new firm's value that the original SPAC owns is given by α, while [1-*P*] is the fraction of the SPAC that managers own. The product of α[*1-P*] is the proportion SPAC managers are entitled to at the time the SPAC and the target are merged. I_0 is the money the SPAC raises with IPO, *T* is the true market value of the merger target, and *C* is the cost of running the SPAC until the merger is effectuated. Our model assumes that I_0 is given deterministically while both *T* and *C* are only available stochastically. Each private firm in the target industry has only one true value "*t*" relevant to the acquirer and it is not easily discernible. When the targets are considered in cross section they create a pdf for *T*, *f*(*t*).[25,26] *C* is the cost of running the SPAC until a target is acquired. The rate of which these costs are accrued is "*vc*." For the SPAC this would be the day to day expenses of running a publicly traded firm: rent for office space, insurance, listing fees with the exchanges, filing fees with the SEC,

[25] T is net of any debt occasioned by the purchase of the target.

[26] α, *P* and I_0 are treated as being deterministically given in this analysis.

payments to auditors, etc. While "*vc*" is not random, the length of time the SPAC must incur these expenses is unknown, making *C* a random variable

$$C = vc \cdot (TM)$$

where *TM* = Time to Merger.

We presume that candidate targets for merger are made aware to the SPAC managers according to a Poisson process. A random variable distributed according to the Poisson has a mean number of occurrences equal to λ and a likelihood of occurrence which is given by $\frac{e^{-\lambda}\lambda^{\# of\ occurrences}}{(\# of\ occurrences)!}$.[27]

We assume that SPAC managers maximize the expected value of their share of the new firm by employing a policy of accepting the first target that has a "*t*" which is greater than some minimum value *M*, M^*. To determine the optimal value of *M*, SPAC management would consider

$$E_{t,c}\left[\alpha(1-P)\{I_0 + T - C | T > M\}\right]$$

or

$$\left[\alpha(1-P)E_{t,c}\{I_0 + T - C | T > M\}\right]$$

as their objective function.[28] Distributing the expectation operator yields

$$\alpha(1-P)I_0 + \alpha(1-P)E_{t,c}\{T | T > M\} - \alpha(1-P)E_{t,c}\{C | T > M\}.$$

which can eventually be written as

$$\alpha(1-P)I_0 + \alpha(1-P)E_t\{T | T > M\} - \alpha(1-P)E_c\{C\}$$

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[27] Occurrences in our model would be the arrival of private firms within the purview of the SPAC but the target would not necessarily be acceptable to SPAC managers.

[28] Constants pass through expectation operators.

where $E_t\{T|T>M\}=\left\{\int_M^\infty t\,\frac{f(t)}{[1-F(M)]}\,dt\right.$

from Bayes rule we know:

$$P(A\cap B)=P(B|A)P(A)$$

$$P(B|A)=\frac{P(A\cap B)}{P(A)}=\frac{\int_M^\infty t\,f(t)dt}{1-\int_0^M f(t)dt}$$

where $P(B|A)=f(t|t>M)$.

While the expected value of *T* is straight forward, the determination of $E_c(C)$ is a little more subtle, with C being the product of "*vc*" and the time to merger. Our evaluation of the mean of *C* takes advantage of a relationship between Poisson and exponentially distributed variables in order to make the analysis temporal. In particular, we let Y_τ be equal to the number of occurrences (arrival of merger targets) during a time interval τ let's say the time to expiration of the SPAC. That is, for any fixed interval of time τ, the random variable is a Poisson process with parameter $\lambda\tau$.

We assume that $Y_\tau = 1$ if and only if at least one arrival of a merger target takes place and let *X* be the time to that occurrence, consequently, I have

$$P(X\leq\tau)=1-P(X>\tau)$$

or

$$P(X\leq\tau)=1-P(Y_\tau=0)$$

or

$$P(X\leq\tau)=1-e^{-\lambda\tau}$$

because the likelihood of zero target arrivals for a variate distributed according to the Poisson is $\frac{e^{-\lambda\tau}(\lambda\tau)^{\# of occurences}}{(\# of occurences)!} = \frac{e^{-\lambda\tau}(\lambda\tau)^{0}}{0!}$.[29]

If $P\{X \le \tau\} = 1 - e^{-\lambda\tau}$ and $P\{X \le \tau\} \equiv \int_0^\tau f(x)dx$ then $\int_0^\tau f(x)dx = 1 - e^{-\lambda\tau}$. So

$$F(\tau) - F(0) = 1 - e^{-\lambda\tau}$$

or $F(\tau) = 1 - e^{-\lambda\tau}$, consequently, $\frac{\partial F(\tau)}{\partial \tau} = f(\tau) = \lambda e^{-\lambda\tau}$. So that $f(x) = \lambda e^{-\lambda x}$ and $\lambda e^{-\lambda x}$ is, by inspection, the probability density function of an exponentially distributed variable.

The expected value of an exponentially distributed random variable is $\frac{1}{\lambda}$ for $f(x) = \lambda e^{-\lambda x}$. But, according to the analysis that follows, the mean time to acceptance of a merger target would be $\frac{1}{\lambda[1 - F(M^*)]}$ since the SPAC employs an optimal acquisition policy which demands that the target's "t" be greater than M^* which has a likelihood of $\int_{M^*}^{\infty} f(t)dt = 1 - F(M^*)$.

Though targets become available to the SPACs according to a Poisson process with a parameter of $(\lambda\tau)$, there is a constant probability $F(M^*)$ that the appearance of a target will not result in an acquisition by the SPAC. That is the target may have a true value "*t*" that is less than the minimum value the SPAC's optimal merger strategy demands. In this case, $X > \tau$ (during the interval $[0, \tau]$) if and only if no targets arrive,

[29] We think of λ as being the monthly rate of arrival and τ would be 18 or 24 months depending on the SPAC.

one target arrives but its "*t*" is less than M^*, two targets appear, but neither have "*t*" values that are greater than M^*, etc. Hence, we have

$$P(X \le \tau) = 1 - P(X > \tau)\text{. Recall}$$

$$P(\#of\,occurences) = \frac{e^{-\lambda\tau} \cdot (\lambda\tau)^{\#of\,occurences}}{(\#of\,occurences)!}$$

$$P(X \le \tau) = 1 - \left[e^{-\lambda\tau} + e^{-\lambda\tau}(\lambda\tau)F(M^*) + \frac{e^{-\lambda\tau}(\lambda\tau)^2[F(M^*)]^2}{2!} + \ldots \right]$$

$$P(X \le \tau) = 1 - e^{-\lambda\tau}\left[1 + \lambda\tau F(M^*) + \frac{1}{2}\left(\lambda\tau F(M^*)\right)^2 + \ldots + \ldots\right]$$

$$P(X \le \tau) = 1 - e^{-\lambda\tau}[e^{\lambda\tau F(M^*)}]$$

$$P(X \le \tau) = 1 - e^{-\lambda\tau(1 - F(M^*))}.$$

Thus the likelihood that the SPAC acquires a target before τ (the time to expiration of the SPAC in months) is given by

$$P(X \le \tau) = 1 - e^{-\lambda\tau(1 - F(M^*))}.$$

Putting it all together, the original objective function

$$\alpha(1-P)\left[I_0 + E_t\left[T \middle| T > M\right] - E_c[C]\right]$$

becomes

$$\alpha(1-P)I_0 + \alpha(1-P)E_t\left[T \middle| T > M\right] - \alpha(1-P)E_c[C]$$

or

$$\alpha(1-P)I_0 + \alpha(1-P)\int_M^\infty t\,\frac{f(t)}{[1-F(M)]}\,dt - \alpha(1-P)E_c[vc \cdot (Time\ to\ Merger)]$$

or

$$\alpha(1-P)I_0+\alpha(1-P)\int_M^{\infty} t\,\frac{f(t)}{(1-F(M))}\,dt-\alpha(1-P)vc[E_c(TM)]$$

alternatively

$$\alpha(1-P)I_0+\alpha(1-P)\int_M^{\infty} t\,\frac{f(t)}{(1-F(M))}\,dt-\alpha(1-P)\frac{vc}{\lambda(1-F(M))}.$$

Finally, differentiating the expected value of SPAC management's share of the new firm $\alpha(1-P)I_0+\alpha(1-P)\left\{\int_M^{\infty} t\,\frac{f(t)}{(1-F(M))}\,dt-\frac{vc}{\lambda(1-F(M))}\right\}$

with respect to *M* yields

$$\alpha(1-P)\left[\left\{[-M\,f(M)][1-F(M)]-\left[\int_M^{\infty} tf(t)dt-\frac{vc}{\lambda}\right](-1)\frac{\partial F(M)}{\partial M}\right\}\left[\frac{1}{1-F(M)}\right]^2\right]$$

or

$$\alpha(1-P)\left[\left\{[-M\,f(M)][1-F(M)]-\left[\int_M^{\infty} tf(t)dt-\frac{vc}{\lambda}\right](-1)\frac{\partial\left[\int_0^M f(t)dt\right]}{\partial M}\right\}\left[\frac{1}{1-F(M)}\right]^2\right]$$

or

$$\alpha(1-P)\left[\left\{[-M\,f(M)][1-F(M)]-\left[\int_M^{\infty} tf(t)dt-\frac{vc}{\lambda}\right](-1)\,f(M)\right\}\left[\frac{1}{1-F(M)}\right]^2\right].$$

If we set the partial derivative of the expected value of the SPAC management's share of the new firm equal to zero, we have

$-M^*[1-F(M^*)]+\left[\int_{M^*}^{\infty} tf(t)dt-\frac{vc}{\lambda}\right]=0$ or, equivalently

$$\int_{M^*}^{\infty} tf(t)dt - \frac{vc}{\lambda} = \int_{M^*}^{\infty} M^* f(t)dt$$

or

$$\int_{M^*}^{\infty} (t - M^*) f(t)dt = \frac{vc}{\lambda}.$$

Given our ambitious objective function, the optimality condition for the minimum acceptable value of a merger target is surprisingly simple and convenient mathematically. However, the result can be written more intuitively[30]. Reconsider

$$\int_{M^*}^{\infty} (t - M^*) f(t)dt = \frac{vc}{\lambda}$$

as

$$\int_{M^*}^{\infty} tf(t)dt - \frac{vc}{\lambda} = \int_{M^*}^{\infty} M^* f(t)dt$$

or as

$$\int_{M^*}^{\infty} tf(t)dt - \frac{vc}{\lambda} = M^*\left[1 - F(M^*)\right]$$

or as

$$\int_{M^*}^{\infty} \frac{tf(t)dt}{[1 - F(M^*)]} - \frac{vc}{\lambda[1 - F(M^*)]} = M^*$$

or, finally, as

$$M^* = E[T \mid T > M^*] - vc \cdot E\left[TM\right].$$

[30] The computations in this section employ Leibnitz's results for taking the derivative of an integral whose limits are a function of the variable of differentiation.

When the optimality condition is written in this manner, the intuition for M^* is clear. The minimum acceptable value of a merger target is the difference in the conditional expected value of the acquired target and the expected total cost of running the SPAC until an acceptable business partner is found.

3. Comparative Static Behavior of the Expected Time to Merger

In order to explicate the predictive implications for our empirical analysis, we now present a comparative static analysis of the time to merger. Parametric changes have a direct and an indirect impact upon $E(TM^*)$ that we characterize in the following equation:

$$\frac{dE(TM^*)}{dq_i} = \frac{\partial E(TM^*)}{\partial q_i} + \frac{\partial E(TM^*)}{\partial M^*}\frac{dM^*}{dq_i} \qquad (i)$$

for q_i, alternatively, equal to "*vc*" the cost per unit of time of looking for a private firm to merge with, "σ_t" the standard deviation of the value of firms in the target industry, "μ" the mean value of private firms in the target industry and "λ" the rate of arrival of targets for the SPAC's consideration. Clearly, (*i*) documents the immediate impact of the change in q_i upon $E(TM^*)$. But the expression also acknowledges that the variation in q_i will occasion an adjustment of the firm's decision variable M^* and a consequent reaction in the expected time to merger.

3.1.The Impact of "vc" upon M and E(TM*)*

In order to find $\frac{dM^*}{dvc}$, $\frac{dM^*}{d\sigma_t}$, $\frac{dM^*}{d\mu}$, and $\frac{dM^*}{dvc}$ we use the implicit function theorem. Starting with $dFOC = \frac{\partial FOC}{\partial M^*}dM^* + \frac{\partial FOC}{\partial vc}dvc$, and setting $\frac{\partial FOC}{\partial M^*}dM^* + \frac{\partial FOC}{\partial vc}dvc = 0$, it follows that $-\frac{\frac{\partial FOC}{\partial vc}}{\frac{\partial FOC}{\partial M^*}} = \frac{dM^*}{dvc}$.

The $\frac{\partial FOC}{\partial vc}$ is simply $\frac{\partial[\int_{M^*}^{\infty}(t-M^*)f(t)dt - \frac{vc}{\lambda}]}{\partial vc}$ which is equal to $-\frac{1}{\lambda}$, a negative number, since $\lambda > 0$. To find $\frac{\partial FOC}{\partial M^*}$, which is $\frac{\partial[\int_{M^*}^{\infty}(t-M^*)f(t)dt - \frac{vc}{\lambda}]}{\partial M^*}$, we use Leibnitz's rule in order to explicitly consider the differentiation of the limits as well as the integrand[31].

We find that $\frac{\partial[\int_{M^*}^{\infty}(t-M^*)f(t)dt - \frac{vc}{\lambda}]}{\partial M^*} = 0 + 0 - \int_{M^*}^{\infty} f(t)dt = -\int_{M^*}^{\infty} f(t)dt$. So $\frac{\partial FOC}{\partial M^*} = -\int_{M^*}^{\infty} f(t)dt$, is a negative number. Therefore,

$$\frac{dM^*}{dvc} = -\frac{\frac{\partial FOC}{\partial vc}}{\frac{\partial FOC}{\partial M^*}} = -\frac{(-)}{(-)} < 0.$$

[31] Please see Appendix 2-1 for Leibnitz's Rule.

Our interpretation of this result would be that the higher the costs of looking for a merger target (per unit of time), the lower the optimal minimum value of the merger target. Furthermore,

$$\frac{dE[TM^*]}{dvc} = \frac{\partial E[TM^*]}{\partial vc} + \frac{\partial E[TM^*]}{\partial M^*}\frac{dM^*}{dvc}$$

$$\frac{dE[TM^*]}{dvc} = 0 + \frac{f(M^*)}{\lambda[1-F(M^*)]^2} \cdot \frac{-1}{\lambda[1-F(M^*)]}$$

$$\frac{dE[TM^*]}{dvc} < 0$$

Consequently, the greater the costs of maintaining the SPAC across time the shorter the expected time to merger.

3.2.The Impact of σ_t upon M and E(TM*)*

In order to find $\frac{dM^*}{d\sigma_t}$, we take $dFOC = \frac{\partial FOC}{\partial M^*} dM^* + \frac{\partial FOC}{\partial \sigma_t} d\sigma_t$ and we hold $dFOC = 0$ in order to obtain $-\frac{\frac{\partial FOC}{\partial \sigma_t}}{\frac{\partial FOC}{\partial M^*}} = \frac{dM^*}{d\sigma_t}$. If we assume that *T* (the true value of private firms in the target industry) is normally distributed, then

$$f(t) = \frac{1}{\sqrt{2\pi\sigma_t^2}} e^{-(t-\mu)^2/2\sigma_t^2}.$$

In order to find $\frac{\partial FOC}{\partial \sigma_t}$, which is $\frac{\partial[\int_{M^*}^{\infty}(t-M^*)f(t)dt - \frac{vc}{\lambda}]}{\partial \sigma_t}$, differentiation gives us

$$\frac{1}{\sigma_t^3}\left[\int_{M^*}^{\infty}(t-M^*)[t^2+\mu^2-2\mu t-\sigma_t^2]f(t)dt\right]$$

or

$$\frac{1}{\sigma_t^3}\left[\int_{M^*}^{\infty}t[t^2+\mu^2-2\mu t-\sigma_t^2]f(t)dt\right]-\frac{1}{\sigma_t^3}\left[\int_{M^*}^{\infty}M^*[t^2+\mu^2-2\mu t-\sigma_t^2]f(t)dt\right]$$

It can be shown for any normally distributed variate X that

$$\int_B^A xf(x)dx=\mu_x[F(A)-F(B)]-\sigma_x^2 f(A)+\sigma_x^2 f(B)$$

so

$$\int_{M^*}^{\infty}tf(t)dt=\mu[1-F(M^*)]+\sigma_t^2 f(M^*)\,.$$

It can be shown for $X\sim N(\mu_x,\sigma_x^2)$ that

$$\int_B^A x^2 f(x)dx=\sigma_x^2\int_B^A f(x)dx+\mu_x\int_B^A xf(x)dx-\sigma_x^2 xf(x)\,|_B^A$$

$$\int_B^A x^2 f(x)dx=\begin{cases}\sigma_x^2\big[F(A)-F(B)\big]+\mu_x\Big[\mu_x\big[F(A)-F(B)\big]-\sigma_x^2 f(A)+\sigma_x^2 f(B)\Big]\\-\sigma_x^2 Af(A)+\sigma_x^2 Bf(B)\end{cases}$$

so

$$\int_{M^*}^{\infty}t^2 f(t)dt=\sigma_t^2\big[1-F(M^*)\big]+\mu\Big[\mu\big[1-F(M^*)\big]+\sigma_t^2 f(M^*)\Big]+\sigma_t^2 M^* f(M^*)$$

In addition, for a normally distributed variate, it can be shown that

$$\int_B^A x^3 f(x)dx=2\sigma_x^2\int_B^A xf(x)dx+\mu_x\int_B^A x^2 f(x)dx-\sigma_x^2 x^2 f(x)\,|_B^A$$

so that

$$\int_{M^*}^{\infty} t^3 f(t)dt = 2\sigma_t^2\left[\int_{M^*}^{\infty} tf(t)dt\right] + \mu\int_{M^*}^{\infty} t^2 f(t)dt - \sigma_t^2 t^2 f(t)|_{M^*}^{\infty}$$

Given the results above, if we now go back to $\partial[FOC]/\partial\sigma_t^2$, then we have

$$\frac{1}{\sigma_t^3}\int_{M^*}^{\infty}\left[t^3 + \mu^2 t - 2\mu t^2 - \sigma^2 t\right]f(t)dt - \frac{1}{\sigma_t^3}\int_{M^*}^{\infty}(M^* t^2 + M^*\mu^2 - 2\mu t M^* - \sigma_t^2 M^*)f(t)dt$$

or we have

$$\frac{1}{\sigma_t^3}\int_{M^*}^{\infty}\left[t^3 f(t)dt - (2\mu + M^*)\int_{M^*}^{\infty} t^2 f(t)dt\right]$$

$$+\frac{1}{\sigma_t^3}\left[\mu^2 - \sigma_t^2 + 2\mu M^*\right]\int_{M^*}^{\infty} tf(t)dt - \frac{1}{\sigma_t^3}\left[M^*\mu^2 - \sigma_t^2 M^*\right]\int_{M^*}^{\infty} f(t)dt$$

so that

$$\frac{1}{\sigma_t^3}\left[2\sigma_t^2\int_{M^*}^{\infty} tf(t)dt + \mu\int_{M^*}^{\infty} t^2 f(t)dt - \sigma_t^2 t^2 f(t)|_{M^*}^{\infty}\right] - \frac{1}{\sigma_t^3}\left[2\mu + M^*\right]\int_{M^*}^{\infty} t^2 f(t)dt$$

$$+\frac{1}{\sigma_t^3}\left[\mu^2 - \sigma_t^2 + 2\mu M^*\right]\int_{M^*}^{\infty} tf(t)dt - \frac{1}{\sigma_t^3}\left[M^*\mu^2 - \sigma_t^2 M^*\right]\int_{M^*}^{\infty} f(t)dt$$

Cancelling yields:

$$\frac{1}{\sigma_t^3}\left[-\sigma_t^2 t^2 f(t)|_{M^*}^{\infty}\right] - \frac{1}{\sigma_t^3}\left[\mu + M^*\right]\int_{M^*}^{\infty} t^2 f(t)dt$$

$$+\frac{1}{\sigma_t^3}\left[\mu^2 + \sigma_t^2 + 2\mu M^*\right]\int_{M^*}^{\infty} tf(t)dt - \frac{1}{\sigma_t^3}\left[M^*\mu^2 - \sigma_t^2 M^*\right]\int_{M^*}^{\infty} f(t)dt$$

Further cancellation results in

$$-\frac{1}{\sigma_t^3}\left[-\sigma_t^2 M^*\right]\int_{M^*}^{\infty} f(t)dt - \frac{1}{\sigma_t^3}M^*\left[\sigma_t^2\left[1 - F(M^*)\right]\right] + \frac{\sigma_t^2}{\sigma_t^3}\left\{\sigma_t^2 f(M^*)\right\}$$

which, finally, yields

$$\frac{\sigma_t^2\sigma_t^2}{\sigma_t^3} f(M^*) \text{ or } \sigma_t f(M^*) = \sigma_t\frac{1}{\sqrt{2\pi\sigma_t^2}}e^{-(M^*-\mu)^2/2\sigma_t^2}$$

which is obviously a positive number.

So $\frac{\partial FOC}{\partial \sigma_t}$ is a positive number and we have already established that

$\frac{\partial FOC}{\partial M^*} = -\int_{M^*}^{\infty} f(t)dt$, a negative number. Hence, $-\frac{\frac{\partial FOC}{\partial \sigma_t}}{\frac{\partial FOC}{\partial M^*}} = (-)\frac{(+)}{(-)} = \frac{dM^*}{d\sigma_t} = (+)$.

In regard to the implications that this result has for the expected time to maturity, we have

$$\frac{dE[TM^*]}{d\sigma_t} = \frac{\partial E[TM^*]}{\partial \sigma_t} + \frac{\partial E[TM^*]}{\partial M^*}\frac{dM^*}{d\sigma_t}$$

$\frac{\partial E[TM^*]}{\partial M^*}$ was given earlier as $\frac{f(M^*)}{\lambda\left[1-F(M^*)\right]^2}$

$$\frac{dM^*}{d\sigma_t} = (-1)\frac{\frac{\partial FOC}{\partial \sigma_t}}{\frac{\partial FOC}{\partial M^*}} = \frac{\sigma_t f(M^*)}{-\int_{M^*}^{\infty} f(t)dt}(-1) = \frac{\sigma_t f(M^*)}{\int_{M^*}^{\infty} f(t)dt}$$

At this point, all we need is $\frac{\partial E[TM^*]}{\partial \sigma_t}$ where $E[TM^*] = \frac{1}{\lambda[1-F(M^*)]}$.

In order to simplify the analysis, let's rewrite *f(t)* in terms of *f(z)* the standardized normal variate so that $z = \frac{t-\mu}{\sigma_t}$ and $E[TM^*]$ can now be rewritten as

$$E[TM^*] = \frac{1}{\lambda\left[1-F_z(\frac{M^*-\mu}{\sigma_t})\right]}.$$

$$\frac{\partial E[TM^*]}{\partial \sigma_t} = \frac{[0][den] - [1]\left[-\lambda \frac{\partial F_z}{\partial \sigma_t}\left(\frac{M^* - \mu}{\sigma_t}\right)\right]}{\lambda^2\left[1 - F_z(\frac{M^* - \mu}{\sigma_t})\right]^2}$$

$$\frac{\partial F_z\left(\frac{M^* - \mu}{\sigma_t}\right)}{\partial \sigma_t} = \frac{\partial \int_{-\infty}^{\frac{M^* - \mu}{\sigma_t}} f(z)dz}{\partial \sigma_t} = -\frac{(M^* - \mu)}{\sigma_t^2} f_z\left(\frac{M^* - \mu}{\sigma_t}\right).$$

Putting it all together

$$\frac{dE[TM^*]}{d\sigma_t} = \frac{-\left(\frac{M^* - \mu}{\sigma_t^2}\right) f_z\left(\frac{M^* - \mu}{\sigma_t}\right)\lambda}{\lambda^2\left[1 - F_z\left(\frac{M^* - \mu}{\sigma_t}\right)\right]^2} + \left[\frac{f(M^*)}{\lambda[1 - F(M^*)]^2}\right]\left\{\sigma_t f(M^*)\right\}.$$

What is the relationship between $F_z\left(\frac{M^* - \mu}{\sigma_t}\right)$ and $F(M^*)$? They are obviously equal. But what about $f_z\left(\frac{M^* - \mu}{\sigma_t}\right)$ relative to $f(M^*)$?

In detail, $\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left[\frac{M^* - \mu}{\sigma_t}\right]^2}$ relative to $\frac{1}{\sqrt{2\pi\sigma_t^2}} e^{-\frac{1}{2}\left[\frac{M^* - \mu}{\sigma_t}\right]^2}$

which clearly means

$$\frac{f_z(\cdot)}{\sigma_t} = f(M^*)$$

In conclusion,

$$\frac{dE[TM^*]}{d\sigma_t} = \frac{f(M^*)}{\lambda[1 - F(M^*)]^2}\left\{\left[\frac{\mu - M^*}{\sigma_t}\right](1) + \sigma_t f(M^*)\right\} \begin{matrix}\le \\ >\end{matrix} 0\,.$$

3.3.The Impact of μ upon M and E(TM*)*

In order to compute how M^* changes when the mean value (μ) of the firms in the target industry increase, $\frac{dM^*}{d\mu}$, we totally differentiate the first order condition $dFOC = \frac{\partial FOC}{\partial M^*} dM^* + \frac{\partial FOC}{\partial \mu} d\mu$ ** and since we hold *dFOC = 0,* we then have $-\frac{\frac{\partial FOC}{\partial \mu}}{\frac{\partial FOC}{\partial M^*}} = \frac{dM^*}{d\mu}$. The $\frac{\partial FOC}{\partial \mu} = \int_{M^*}^{\infty} (t - M^*) f(t) \left[\frac{-2(t-\mu)(-1)}{2\sigma_t^2} \right] dt$ because

$f(t) = \frac{1}{\sqrt{2\pi\sigma_t^2}} e^{-(t-\mu)^2/2\sigma_t^2}$. So

$$\frac{\partial \left[\int_{M^*}^{\infty} (t - M^*) f(t) dt - \frac{c}{\lambda} \right]}{\partial \mu} = \frac{1}{\sigma_t^2} \left[\int_{M^*}^{\infty} (t - M^*)(t - \mu) f(t) dt \right].$$

By expanding, we have

$$\frac{1}{\sigma_t^2} \left[\int_{M^*}^{\infty} t(t-\mu) f(t) dt - M^* \int_{M^*}^{\infty} (t-\mu) f(t) dt \right]$$

or

$$\frac{1}{\sigma_t^2} \left[\int_{M^*}^{\infty} t^2 f(t) dt - \mu \int_{M^*}^{\infty} t f(t) dt - M^* \int_{M^*}^{\infty} t f(t) dt + \mu M^* \int_{M^*}^{\infty} f(t) dt \right]$$

or

$$\frac{1}{\sigma_t^2} \left[\int_{M^*}^{\infty} t^2 f(t) dt + \mu M^* \int_{M^*}^{\infty} f(t) dt - (M^* + \mu) \int_{M^*}^{\infty} t f(t) dt \right].$$

For any variate *X* with $f(x) = \frac{1}{\sqrt{2\pi\sigma_x^2}} e^{-(x-\mu_x)^2/2\sigma_x^2}$, we have

$$\frac{df(x)}{dx} = f(x)\frac{-2(x-\mu_x)}{2\sigma_x^2} \text{ or}$$

$$\frac{df(x)}{dx} = f(x)\frac{(\mu_x - x)}{\sigma_x^2} \text{ or}$$

$$\sigma_x^2 \frac{df(x)}{dx} = \mu_x f(x) - xf(x) .$$

Rearranging and integrating yields

$$\int_B^A xf(x)dx = \mu_x \int_B^A f(x)dx - \sigma_x^2 f(x)|_B^A .$$

This means that the partial expectation of T can be written as

$$\int_{M^*}^{\infty} tf(t)dt = \mu \int_{M^*}^{\infty} f(t)dt - \sigma_t^2 f(t)|_{M^*}^{\infty}$$

or

$$\int_{M^*}^{\infty} tf(t)dt = \mu\left[1 - F(M^*)\right] + \sigma_t^2 f(M^*) .$$

So that we have for the $\left[\partial FOC / \partial \mu\right]$ the following expression

$$\frac{1}{\sigma_t^2}\left[\int_{M^*}^{\infty} t^2 f(t)dt + \mu M^*\left[1-F(M^*)\right] - (M^* + \mu)\left[\mu\left[1-F(M^*)\right] + \sigma_t^2 f(M^*)\right]\right]$$

or

$$\frac{1}{\sigma_t^2}\left[\int_{M^*}^{\infty} t^2 f(t)dt - \mu\left[\mu\left[1-F(M^*)\right]\right] - (M^* + \mu)\sigma_t^2 f(M^*)\right].$$

Taking the derivative of [x $f(x)$] with respect to x eventually yields

$$\int_B^A x^2 f(x)dx = \sigma_x^2 \int_B^A f(x)dx + \mu_x \int_B^A xf(x)dx - \sigma_x^2 x f(x)|_B^A$$

or

$$\int_B^A x^2 f(x)dx = \sigma_x^2 \int_B^A f(x)dx + \mu_x \left[\mu_x \int_B^A f(x)dx - \sigma_x^2 f_x(A) + \sigma_x^2 f_x(B) \right] - \sigma_x^2 x f(x) |_B^A .$$

For $\int_{M^*}^{\infty} t^2 f(t)dt$ this means that

$$\int_{M^*}^{\infty} t^2 f(t)dt = \sigma_t^2 \int_{M^*}^{\infty} f(t)dt + \mu \left[\mu \int_{M^*}^{\infty} f(t)dt + \sigma_t^2 f(M^*) \right] + \sigma_t^2 M^* f(M^*) .$$

Now we have for the $[\partial FOC / \partial \mu]$ the expression

$$\frac{1}{\sigma_t^2} \left[\sigma_t^2 \int_{M^*}^{\infty} f(t)dt + \mu \left[\mu \int_{M^*}^{\infty} f(t)dt + \sigma_t^2 f(M^*) \right] + \sigma_t^2 M^* f(M^*) \right]$$

$$- \mu[\mu[1 - F(M^*)] - M^* \sigma_t^2 f(M^*) - \mu \sigma_t^2 f(M^*)].$$

So the derivative $[\partial FOC / \partial \mu]$ reduces to

$\frac{\partial FOC}{\partial \mu} = \int_{M^*}^{\infty} f(t)dt$ which is greater than 0, consequently, we have

$$\frac{dM^*}{d\mu} = (-1) \frac{\frac{\partial FOC}{\partial \mu}}{\frac{\partial FOC}{\partial M^*}} = (-1) \frac{(+)}{(-)} > 0 ,$$

since we have already established that $\frac{\partial FOC}{\partial M^*}$ is a negative number[32].

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[32] The importance of the comparative static behavior of M^* is limited by the fact that the optimal value of M is not directly observable and, consequently, its behavior cannot be empirically ratified. However, the behavior of M^* can be documented by the impact that it has upon the expected to merger.

In regard to the impact of μ upon $E(TM^*)$, recall

$$\frac{\partial E\left[TM^*\right]}{\partial\mu}=\frac{\frac{\partial numer}{\partial\mu}[denom]-\frac{\partial denom}{\partial\mu}[numer]}{\lambda^2\left[1-F(M^*)\right]^2}$$

$$\frac{\partial E\left[TM^*\right]}{\partial\mu}=\frac{[0]-\frac{\partial\left[\lambda\left[1-F(M^*)\right]\right]}{\partial\mu}[1]}{\lambda^2\left[1-F(M^*)\right]^2}$$

$$\frac{\partial E\left[TM^*\right]}{\partial\mu}=\frac{\lambda\frac{\partial F(M^*)}{\partial\mu}}{\lambda^2\left[1-F(M^*)\right]^2}$$

since $\partial F(M^*)/\partial\mu$ can be written as

$$\frac{\partial}{\partial\mu}\left[\int_{-\infty}^{M^*}\frac{1}{\sqrt{2\pi\sigma_t^2}}e^{-(t-\mu)^2/2\sigma_t^2}dt\right]$$

which yields

$$\int_{-\infty}^{M^*}f(t)\frac{-2(t-\mu)(-1)}{2\sigma_t^2}dt \text{ or}$$

$$\int_{-\infty}^{M^*}f(t)\left[\frac{t-\mu}{\sigma_t^2}\right]dt \text{ or}$$

$$\frac{1}{\sigma_t^2}\left[\int_{-\infty}^{M^*}tf(t)dt-\mu F(M^*)\right].$$

$$E[TM^*]=\frac{1}{\lambda[1-F(\mathrm{M}^*)]}.$$

That is, as established above, changes in *vc*, λ, σ_t, and μ all change M^* and the unobserved changes in M^* are revealed in $E[TM^*]$.

Recall earlier in this manuscript we established that

$\int_{M^*}^{\infty} tf(t)dt = \mu F(M^*) - \sigma_t^2 f(M^*)$. This implies that the partial of $F(M^*)$ with respect to μ can be written as

$$\frac{\partial F(M^*)}{\partial \mu} = \frac{1}{\sigma_t^2}\left[\mu F(M^*) - \sigma_t^2 f(M^*) - \mu F(M^*)\right]$$

which yields

$$\frac{\partial F(M^*)}{\partial \mu} = -f(M^*) < 0 .$$

Now we have for $\partial E[TM^*]/\partial \mu$ the following

$$\frac{\partial E[TM^*]}{\partial \mu} = -\frac{\lambda\, f(M^*)}{\lambda^2\left[1 - F(M^*)\right]^2} = -\frac{f(M^*)}{\lambda\left[1 - F(M^*)\right]^2} < 0 .$$

However, we need to consider

$$\frac{dE[TM^*]}{d\mu} = \frac{\partial E[TM^*]}{\partial \mu} + \frac{\partial E[TM^*]}{\partial M^*}\frac{dM^*}{d\mu}$$

because the change in μ has both a direct and an indirect impact upon the expected time to merger. The indirect effect accounts for the reaction of M^* to the change in the mean value of the targets.

We have already computed $[dM^* / d\mu]$ and $[\partial E[TM^*]/\partial M^*]$ is obtained below.

$$E\left[TM^*\right] = \frac{1}{\lambda[1 - F(M^*)]}$$

$$\frac{\partial E[TM^*]}{\partial M^*} = \frac{\frac{\partial numer}{\partial M^*} den - \frac{\partial den}{\partial M^*}[numer]}{(den)^2} = \frac{[0]denom - \frac{\partial den}{\partial M^*}[1]}{\lambda^2[1 - F(M^*)]^2}$$

$$\frac{\partial den}{\partial M^*} = \frac{\partial\left[\lambda\left[1-F(M^*)\right]\right]}{\partial M^*} = \frac{-\lambda\,\partial F(M^*)}{\partial M^*} = -\lambda\, f(M^*)$$

substituting into $\frac{\partial E[TM^*]}{\partial M^*}$ yields

$$\frac{\partial E[TM^*]}{\partial M^*} = \frac{\lambda f(M^*)}{\lambda^2[1-F(M^*)]^2} = \frac{f(M^*)}{\lambda[1-F(M^*)]^2} > 0$$

At this point we need to combine our three sets of results to obtain

$$\frac{dE[TM^*]}{d\mu} = \frac{-f(M^*)}{\lambda[1-F(M^*)]^2} - \left[\frac{f(M^*)}{\lambda[1-F(M^*)]^2}\right]\left[\frac{(-1)\int_{M^*}^{\infty} f(t)dt}{\int_{M^*}^{\infty} f(t)dt}\right].$$

Clearly $\left[dE[TM^*]/d\mu\right]$ is zero.

3.4. The Impact of "λ" upon M and E(TM*)*

To find out how the optimal value of M^* changes with respect to changes in the rate λ at which merger targets appear to the SPAC, $\frac{dM^*}{d\lambda}$, we appeal to the implicit function theorem once again. Since $-\frac{\frac{\partial FOC}{\partial \lambda}}{\frac{\partial FOC}{\partial M^*}}$ equals $\frac{dM^*}{d\lambda}$, we need to find $\frac{\partial FOC}{\partial \lambda}$ and $\frac{\partial FOC}{\partial M^*}$. The $\frac{\partial FOC}{\partial \lambda}$ is $\frac{\partial\left[\int_{M^*}^{\infty}(t-M^*)f(t)dt - \frac{c}{\lambda}\right]}{\partial \lambda}$ or $\frac{c}{\lambda^2}$, which is a positive number. As we have computed earlier, $\frac{\partial FOC}{\partial M^*}$ is a negative number, so $\frac{dM^*}{d\lambda} > 0$, so as λ rises, then M^* will rise.

In regard to the impact of λ upon the expected time to merger, we need to consider: $\frac{dE[TM^*]}{d\lambda} = \frac{\partial E[TM^*]}{\partial \lambda} + \frac{\partial E[TM^*]}{\partial M^*}\frac{dM^*}{d\lambda}$

$$\frac{\partial E[TM^*]}{\partial \lambda} = \frac{-\left[1-F(M^*)\right]}{\lambda^2\left[1-F(M^*)\right]^2} + \frac{\partial E[TM^*]}{\partial M^*}\frac{dM^*}{d\lambda}$$

$$\frac{\partial E[TM^*]}{\partial \lambda} = \left\{\frac{-1}{\lambda^2\left[1-F(M^*)\right]} + \frac{f(M^*)}{\lambda\left[1-F(M^*)\right]^2}\cdot\frac{\frac{vc}{\lambda^2}}{\left[1-F(M^*)\right]}\right\} \gtrless 0 .$$

4. Introduction to Estimation

Early in this paper, we introduced a SPAC merger model (SMM). By maximizing the SPAC's expected profit function SPAC managers are able to find the optimal M^*, the minimum value of a target a SPAC would accept as a merger partner. Once M^* was found it was possible to solve for the expected time to merger E[TM^*].

The SPAC managerial team sets M^* by weighing the potential benefits of the target firm value "t" against the intertemporal input costs of waiting for the acceptable target to arrive. Each SPAC pays a cost per unit of time as the expiration date approaches. Once a merger is official, then the managers can officially begin the countdown to the date they can sell some of their equity and realize the profits from forming the SPAC. If a SPAC does not announce a merge, then the SPAC is liquidated and the managers are left with nothing.

We would like to know what factors influence a SPAC's decision to announce a pact during the merger window. With the announcement times in hand, we can use a statistical model that analyzes the "duration" to a well-defined event such as a SPAC alliance. Known as survival analysis, these models (often called "hazard models") use maximum likelihood estimation to determine the impact of RHS variables upon the time to merger announcement by a SPAC. Survival analysis takes into account the likelihood of a SPAC reporting a merger at a specific time in the merger window, along with the likelihood of the remaining SPACs *not* announcing a merger at this time. In other words, the inclusion of this additional information makes survival analysis the most appropriate econometric technique to study the SPAC merger announcements.

As an introduction to survival analysis consider the following simple example. Let T be non-negative random variable that represents the waiting time until a merger announcement by a SPAC. T is a continuous random variable with pdf $f(t)$ and cdf $F(t) = \Pr(T \leq t)$, which is the likelihood that a merger announcement has occurred by time t. The complement of the cdf is known as the "survival function" $S(t) = \Pr(T > t) = 1 - F(t) = \int_t^{\infty} f(x)dx$, which is the likelihood that a merger partner has not been found by time t. In other words, it is the probability that there is no merger announcement before t. The hazard function $h(t)$ is the probability that the event takes place in a given interval, conditional upon the SPAC having "survived" to the beginning of the interval, divided by dt. The hazard function can be defined as $h(t) = \lim_{dt \to 0} \frac{\Pr\{t < T \leq t + dt \mid T > t\}}{dt}$. By taking the limit as the interval dt goes to zero and rewriting, we get $h(t) = \frac{f(t)}{S(t)}$. If we know the hazard function, we can calculate $f(t)$ with the SPAC data sample of specific announcement times in conjunction with the survival function $S(t)$.

Having no predisposition towards the functional form for the hazard function, we can utilize a model first described by Cox (1972) known as a proportional hazard model, $h_j(t) = h_0(t)\exp(\beta_0 + X'_j\beta)$. The benefit with this approach is that we make no assumptions about the shape of the hazard over time. If we were to mistakenly select a particular parameterization of *h*(*t*), we might produce dubious results for β. The baseline hazard, $h_0(t)$ is the hazard subject *j* faces, modified by the explanatory variables $\exp(\beta_0 + X'_j\beta)$. The model is "proportional", such that the hazard firm *j* faces is multiplicatively proportional to the baseline hazard. If $X_j = 0$ then the hazard function of the *j*th SPAC is the baseline hazard function, or the hazard function in the absence of covariates.

Since we know the set of SPAC merger announcement dates t_i, we would like to find the best estimates of β that maximizes the likelihood of observing the data, given a set of covariates X_j. We offer the following example to demonstrate the likelihood function and the use of the Cox proportional model mentioned above.

SPAC	Time	Independent Variable (x_j, a single element in vector X_j)
1	3	4
2	4	1
3	6	3
4	12	2

There are four SPACs that each announces a merger at a specific time, t_i. There are also four separate probabilities of announcing a merger for each announcing SPAC. For example, we can find P_1, the probability at time 3 that firm 1 is the one that announces in a dataset with four firms, given that SPACs 2, 3, and 4 do not announce. We find the probability (P_2) at time 4 that SPAC 2 announces a merger in a dataset that contains firms 2, 3, and 4, given that SPACs 3 and 4 do not announce a merger. This continues as we find P_3 and P_4.

The likelihood function equals $L(\beta) = P_1 P_2 P_3 P_4$, where P_i, i = 1,…,4 is a conditional probability for each merger announcement time. At time = 12, given that one failure occurs, the probability that it is firm 4 is P_4 =1. Up to time 6, there are only two firms that have not announced a merger, SPAC 3 and SPAC 4. According to Bayes, the conditional probability that the announcement is by firm 3 at time 6 or

$P_3 = \Pr(\text{SPAC 3 announces} \mid \text{a SPAC announces at time6})$ is

$$P_3 = \frac{P(\text{event is experienced by 3 and not 4})}{P(\text{event is experienced by 3 and not 4}) + P(\text{event is experienced by 4 and not 3})}.$$

This can also be written as

$$P_3 = \frac{P(\text{event is experienced by 3}) \cdot P(\text{event is not experienced by 4})}{[P(\text{event is experienced by 3}) \cdot P(\text{event is not experienced by 4}) + P(\text{event is experienced by 4}) \cdot P(\text{event is not experienced by 3})]}.$$

Recall that $f(t_1 \mid \beta, X_1)$ is the likelihood of observing an announcement time given the value of X_1 and can be written as $S(t_1 \mid \beta, X_1) h(t_1 \mid \beta, X_1)$, due to the relationship between the hazard function and the survival function discussed earlier. The probability of not announcing past time t_1, given X_1 is $S(t_1 \mid \beta, X_1)$. We can rewrite P_3 as

$$\frac{f(t_3 \mid \beta, X_3) \cdot S(t_4 \mid \beta, X_4)}{f(t_3 \mid \beta, X_3) \cdot S(t_4 \mid \beta, X_4) + f(t_4 \mid \beta, X_4) \cdot S(t_3 \mid \beta, X_3)}.$$

Substituting $S(t_i \mid \beta, X_i)h(t_i \mid \beta, X_i)$ for $f(t_i \mid \beta, X_i)$ we now can write P_3 as $\frac{[S_3(6)h_3(6)]\cdot S_4(6)}{[S_3(6)h_3(6)]\cdot S_4(6)+[S_4(6)h_4(6)]\cdot S_3(6)}$. After cancellations $P_3 = \frac{h_3(6)}{h_3(6)+h_4(6)}$.

According to the Cox model, the hazard of announcing a merger is $h_j(6) = h_0(6)\exp(\beta_0 + x_j\beta)$ at time 6. So for SPAC 3 and SPAC 4 we have

$$h(\text{SPAC 3 at time 6}) = h_3(6) = h_0(6)\exp(\beta_0 + 3\beta)$$ and

$$h(\text{SPAC 4 at time 6}) = h_4(6) = h_0(6)\exp(\beta_0 + 2\beta).$$

Notice that in both of these equations the value of x_j is different for each firm's hazard function since x_3 is equal to 3 and x_4 is equal to 2, i.e., these are variables with firm-specific observations that do not vary with time. We can now substitute $h_0(t)\exp(\beta_0 + \mathrm{X}_j^{'}\beta)$ for each $h_j(t)$ listed above in P_3. As shown earlier, the probability that the announcement is by SPAC 3 at time 6 is

$$P_3 = \Pr(\text{SPAC 3 announces} \mid \text{a firm announces}) = \frac{h_3(6)}{h_3(6)+h_4(6)}$$

$$= \frac{h_0(6)\exp(\beta_0 + 3\beta)}{h_0(6)\exp(\beta_0 + 3\beta) + h_0(6)\exp(\beta_0 + 2\beta)}$$

and since exp(x + y) = exp(x)exp(y)

$$P_3 = \frac{h_0(6)\exp(\beta_0)\exp(3\beta)}{h_0(6)\exp(\beta_0)\exp(3\beta) + h_0(6)\exp(\beta_0)\exp(2\beta)}$$

Now the baseline hazard function $h_0(6)$ and $\exp(\beta_0)$ terms cancel, and we are left with

$$= \frac{\exp(3\beta)}{\exp(3\beta)+\exp(2\beta)}.$$

In like manner,

$$P_2 = \frac{\exp(1\beta)}{\exp(1\beta) + \exp(3\beta) + \exp(2\beta)}$$

And

$$P_1 = \frac{\exp(4\beta)}{\exp(4\beta) + \exp(1\beta) + \exp(3\beta) + \exp(2\beta)}.$$

$L(\beta) = P_1 P_2 P_3 P_4$ can also be written as $L(\beta) = \prod_{j=1}^{4} \frac{\exp(x_j \beta)}{\sum_{i \in R_j} \exp(x_j \beta)}$

where R_j is the set of SPACs at risk of announcing a merger at time t_j. Generally this is $L(\beta) = \prod_{j=1}^{k} \frac{\exp(X_j^{'} \beta)}{\sum_{i \in R_j} \exp(X_j^{'} \beta)}$ where we have k distinct observed announcement times. We will use this model to analyze the potential impact of various explanatory variables on the expected time to merger announcement for the SPAC firms in our sample. The ability of this function to incorporate the pdf of time to merger announcement along with the cdf (survival function) makes the use of a hazard model particularly appropriate for analysis of the SPAC merger times. We can maximize the likelihood function to find the regression coefficients that explain how the economic variables in our data set impact the expected time to merger for a SPAC. By using a statistical software package, we will be able to find the estimates of β using Newton-Raphson numerical iteration techniques that are standard in the non-linear maximization problems associated with survival analysis.

5. Empirical Analysis

5.1.Managerial Characteristics

Managers are essential to the success of any firm, big or small, private or public as are SPAC managers. They make all business decisions for SPACs[33, 34]. In detail, they set up SPAC firms, evaluate potential targets, and consummate acquisitions. They are in charge during the whole life span of a SPAC. As commanders of the SPACs, we believe that the magnitude of lambda is an artifact of a host of characteristics that document the impact of management.

5.1.1. Age

Yim (2013) in his investigation of executive post-acquisition compensation finds younger CEOs are more likely to make acquisitions since they expect to receive large, permanent increases in compensation earlier in their career. Yim's (2013) "career" hypothesis suggests that younger SPAC managers would work harder to develop more potential targets and, consequently, enhance the value of lambda (the rate of arrival of potential targets). On the other hand, it is easy to imagine that older SPAC managers would have years of experience in private equity as well as mergers and acquisitions. These men and women would likely have contacts and connections that far

[33] SPACs usually do not distinguish between managers and directors. The two words are used interchangeably and are inclusive of each other. In fact, most SPACs explicitly use "Our current directors and executive officers are listed below" to introduce their board of directors on prospectus. The board of directors is usually divided into three classes with only one class being elected in each year and each class serving a three-year term. The SPACs also identify some of the directors as "independent" directors as defined in Rule 10A-3 of the Securities Exchange Act of 1934, as amended, and as defined by the rules of the American Stock Exchange.

[34] Some SPACs hire external experts as "advisors", "senior advisors", or "special advisors". Advisors are expected to provide knowledge, experience, and general management advise to the SPACs. Some advisors are shareholders of the SPACs. These advisors act as external consultants, and they are not on the management team.

outnumber those of their younger counterparts and lead to a higher lambda. Given the contradiction, we believe that the ultimate determination of the effect of age upon the time to merger is an empirical matter. Due to the fact that each SPAC has multiple managers with varying ages, we use the average age of the managers as a RHS variable in our Cox regressions[35]

5.1.2. Number of SPACs Involved with

Field, Lowry, and Mkrtchyan (2013) study the role of "busy" directors in IPO firms and find that "busy" directors improve firm value by offering valuable experience that businesses could not gain from other sources.[36] If so, we would expect "busy" SPAC managers will enjoy a higher lambda. On the other hand, literature on "busy directors" generally supports the view that directors can negatively influence the value of a firm when they hold too many directorships at the same time. For example, Fich and Shivdasani (2006) find that "busy" board members are associated with weak governance and poor firm performance[37]. Ahn, Jiraporn and Kim (2010) document that the shareholders react negatively when the directors of an acquiring firm hold too many directorships. In our case, instead of shareholders reacting, it could be potential merger partners that perceive a manager as being over extended when he or she is involved in too many SPAC projects. Targets may feel that over extended SPAC managers have neither the time nor the motivation to complete a merger. In this case, lambda would

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[35] We also considered using the maximum and minimum executive age as RHS variables, but we recognize that the measures may pick up the effects of the outliers and dropped them from consideration.

[36] According to the authors, "busy" directors are independent directors who hold three or more directorships.

[37] According to the authors, "busy" board is defined as those in which a majority of independent directors hold three or more directorships.

fall and the expected time to merger would increase. We use the number of SPACs a manager is involved with to capture how "busy" an individual manager is. In our Cox regressions, we use the average and the maximum number of SPACs each manager is involved with to measure this effect upon the time to merger.

5.1.3. Total Managerial Ownership Percentage

Previous studies have provided support for the notion that stock ownership by management enhances executive effort. For example, Alavi, Pham, and Pham (2008) find that managerial ownership before an IPO incentivizes managers to exert more effort during the IPO process. The IPO process for a SPAC generally reduces the total managerial ownership from around 100% in pre-IPO period to a much lower level (about 20% on average) in post-IPO period. When managers expect a high lambda due to their pre-IPO efforts, we suspect they would retain a larger share of ownership in the post-IPO period. Conversely, managers would retain a lower level of post-IPO ownership if they expect a low lambda. In our model, we maintain lambda will be greater when the reduction in managerial ownership in the post-IPO period is smaller. Consequently, we expect the time to merger to be shortened. The reduction in percentage ownership is the difference between the pre- and the post-IPO ownership by management.

5.1.4. Ownership Dispersion

Given that there are between two and eleven members on the managerial team, the dispersion of ownership between managers may also influence SPAC effort and, consequently, the rate of arrival of target firms (lambda). For example, if there are 4 managers, and one owns 17% of the firm (the "majority owner"), while the other three own 1%, this would be considered *concentrated* ownership. If those same four managers own 5% each, this is considered *dispersed* ownership. In order for lambda to be larger for the firm with dispersed ownership, the increase in target development of the three managers that go from 1% to 5% ownership must be greater than the decrease in development activity of the majority owner when his ownership falls to 5%[38]. We expect lambda to increase as the ownership becomes more dispersed, hence the expected time to merger would be shortened. In support of our disposition, Eisenberg, Sundgren, and Wells (1998) document that in small firms where managerial ownership is concentrated, board size negatively impacts profitability. This implies that concentrated ownership could be value-destroying for small firms such as SPACs. We use the difference in percentage ownership of the manager holding the greatest share of the SPAC (post IPO) and the combined ownership of all other managers (*own_diff*) [39] as an independent variable. In addition, we employ a Herfindahl index to capture this ownership dispersion effect upon manager effort[40].

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[38] Although the SPAC posits in its prospectus that it has not targeted a specific firm or business to merge with, management states that they have advised a number of their contacts that a pool of capital is being raised for acquisitions and that they intend to seek a business partner after the consummation of the IPO. As managers advise their contacts, they indirectly augment the pool of potential partners, which in turn increases λ. The number of contacts made depends on the number of managers and the extent of their commitment. Both of these characteristics of the SPAC managers are artifacts of their ownership share.

[39] Own_diff is defined as the difference in percentage ownership between the first listed manager and the rest of the managers combined. Algebraically, own_diff = $own\_1^{st} - (own\_total - own\_1^{st}) = 2*own\_1^{st} - own\_total$.

[40] The Herfindahl index is calculated as 1 minus the sum of squared individual percentage ownership. For example, if a SPAC has 4 managers and each manager owns 25% of pre-IPO SPAC shares, the Herfindahl index is calculated as $1 - 4*(0.25)^2 = 0.75$. If three managers own 10% of the SPAC shares each and one manager owns 70% of the SPAC shares, the Herfindahl index becomes $1 - 3*(0.10)^2 - (0.70)^2 = 0.48$. The Herfinhal index is decreasing as the ownership becomes concentrated.

5.1.5. Managerial Ownership at the IPO Stage

All firms seeking an IPO, including SPACs, must file a Statement of Registration (Form S-1) with the SEC. It is common for there to be several amendments to this form prior to the final Form S-1 being filed. We believe that the number of Form S-1 filings and the time from the initial to the final filing could help document the managerial effort at the IPO stage. These two activities could also signal SPAC management effort to find a post-IPO merger partner. Lowry and Schwert (2002) find that the market learns important information about management during the registration period and that this information has implications for the IPO volume and the initial stock returns. In our case, the potential merger targets could track SPAC management efforts during the registration process and then react to that information. For example, potential targets may be encouraged by the S-1 filing efforts of SPAC managers. Elevated interest by targets would increase lambda and reduce the E(TM). We proxy these efforts by SPAC managers with two variables: the number of days a SPAC takes to file all S-1forms and the total number of S-1 forms a SPAC files. We use both variables in our investigation of the determinants of the time to SPAC mergers.

5.1.6. Working Hours

85 SPACs in our sample explicitly state the number of weekly working hours their executives are expected to spend on the SPAC related issues. For instance, Shine Media Acquisition Corp. mentions the following in its prospectus, "we expect each of [our managers] to devote a minimum of approximately ten hours per week to our business during the target identification stage, and close to fulltime during negotiations

of a business combination". We believe the number of hours is a direct measure of managerial effort, and we expect it to decrease the expected time to merger.

5.1.7. CEO Education

We believe education background could signal a manager's ability and financial literacy. In their study on acquisition decisions, Malmendier and Tate (2008, JFE) use CEO educational background as one dimension of executive characteristics. Following their measure, we create two dummy variables. One dummy variable documents if a CEO earned an MBA degree, as we believe an MBA degree not only provides a CEO with the relevant financial knowledge but also signals the ability the CEO possesses. The other dummy variable documents if a CEO earned a degree at master's level or higher (excluding MBAs).

5.1.8. Managerial Reputation

We use Factiva scores as a proxy for the level of awareness that the public has of SPAC executives. The Factiva score that we use as a RHS variable measures the number of news articles that contain each of the SPAC managers' names. The news sources include newspapers, official government publications, publications by nongovernmental organizations (NGO), company newswires and press release wires, official and unofficial company blogs, etc. Malmendier and Tate (2008) use Factiva scores as a measure of CEO overconfidence and conclude that arrogant CEOs make value-destroying mergers and acquisitions[41]. We believe that a higher Factiva score means greater media attention, which has the potential of gaining attention of possible merger targets. In other words, the more often a SPAC manager's name appears in the financial media, the greater the chance that potential targets would perceive the individual favorably. Consequently, we expect potential merger targets may emerge more rapidly for SPACs with highly recognized managers. Higher Factiva scores will improve lambda (the rate of arrival of targets) and shorten the time to merger. [42] Though Malmendier and Tate (2008) as well as Rajgopal, Shevlin, and Zamora (2006) exclusively focus on CEOs, we collected the number of news reports for each of the top five managers[43] of each SPAC because we believe any of the SPAC manager could draw the attention of potential targets. We collected the number of news reports during a one-year period prior to the prospectus filing date. We do so to measure the established managerial reputation prior to the SPAC's existence[44]. We then average across the five managers to get the average number of news reports for each SPAC's top five managers. We call this computation the average Factiva score, which we use as a quantitative measurement of managerial reputation.

5.1.9. Empirical Results

[41] Rajgopal, Shevlin, and Zamora (2006) use CEOs' exposure in the financial press (a similar measure to Factiva scores) to capture their external employment opportunities as the authors believe that the CEO talent is scarce in labor market.
[42] In the cases where an executive is listed with a middle initial, the search was performed both with and without the middle initial and the results were combined to obtain the variable value.
[43] We use the rankings on the SPAC prospectus to determine the top five managers.
[44] The cited papers use panel Factiva scores. In other words, the Factiva scores in those papers have time variations. However, the data we use are purely cross-sectional, hence our measure is not totally comparable to theirs.

Descriptive statistics of SPAC managerial characteristics are reported in Table 2-1. SPAC managers are in general very young with average age of 28. In a study of CEOs in S&P 1500 firms, Yim (2013) reports the average age of CEOs is 55.2 years old. Although the difference in the average age is large, it is also clear that managing an S&P 1500 firm requires a different skill set than managing a SPAC firm. The majority of SPAC managers are involved in only a single SPAC project, however, it is possible to document managers involved in as many as 5 SPAC projects[45]. In a study of "busy directors", Fich and Shivdasani (2006) report on average each outside director in a Fortune 500 company holds 3.11 directorships. The combined holdings of all other managers exceed the SPAC ownership of the 1st listed manager by 10%. The ownership Herfindahl index is 0.795 which indicates a thoroughly dispersed ownership. It takes just over 5 months for a SPAC to complete its S-1 filings. During the process, the average SPAC would file the S-1 and the amended S-1 forms 6 times. We found interestingly that the first listed manager on a SPAC has a much higher Factiva score than the rest of the managers (226 for 1st listed managers versus 125 for all managers[46]).

[Insert Table 2-1 about here]

We initially run the Cox regressions with just one of the independent variables discussed above, we then successively replace each RHS variable with another for each new regression. At the end of this process, if we have more than one variable that is statistically significant, we combine them, and run a multivariate Cox regression. The

[45] At this stage, we are unable to identify if the SPAC projects they involved in are simultaneous or sequential.

[46] The 1st listed manager typically is the largest owner, but this is not always the case.

results of the Cox regressions for the managerial characteristics as determinants of the time to merger are reported in Table 2-2.

[Insert Table 2-2 about here]

We first focus on the variables that measure managerial experience. The average age of SPAC managers is a statistically significant variable in the determination of the time to merger. Clearly the coefficients reported above are not directly very intuitive. However, for a quantitative variable like "age_avg", we can use the transformation $100*(e^{-0.0172616} - 1)$ which gives us the percentage change in the expected time to merger for a single unit increase in average age of the SPAC managers. Thus, we have 100*(0.9828865279 - 1) = -1.71134721%. According to our model, then, an increase in the average age of our SPAC managers reduces the expected time to merger by 1.71134721%[47]. The older the average age of the SPAC managers, the shorter the time to a merger. Our results contrast with prior literature which documents younger CEOs outperforming older ones. The 1.711% reduction in the dependent variable documents the superior reservoir of contacts and connections that accrue to older SPAC managers with experience in the business of mergers and acquisitions. The other two measures of

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[47] AA_0 = average age originally

$$\frac{e^{\hat{\beta}_{0j}+\hat{\beta}_{1j}(AA_0+1)+\hat{\beta}_{2j}x_2}}{e^{\hat{\beta}_{0j}+\hat{\beta}_{1j}(AA_0)+\hat{\beta}_{2j}x_2}} \quad \leftarrow \text{jth SPAC}$$

Rewriting,

$$e^{[\hat{\beta}_{0j}+\hat{\beta}_{1j}(AA_0+1)+\hat{\beta}_{2j}x_2]-[e^{\hat{\beta}_{0j}+\hat{\beta}_{1j}(AA_0)+\hat{\beta}_{2j}x_2}]}$$

Ceteris paribus (X_2 is unchanged)

$$e^{\hat{\beta}_{1j}(AA_0+1)-\hat{\beta}_{1j}(AA_0)} = e^{\hat{\beta}_{1j}} \text{ where } \hat{\beta}_{1j} = -0.0172616$$

managerial experience, the average and the maximum number of SPACs a manager is involved with are not statistically significant.

We then investigate the impact of managerial incentives in the determination of the SPAC's time to merger. Unfortunately, none of these three measures (i.e. total ownership, difference in ownership, and the Herfindahl index on ownership) provide significant estimates. In a similar fashion, we find the measurements of managerial effort, including the number of days filing S-1 and the total S-1 filings, are statistically insignificant in explaining the time to merger. Finally, the effects of managerial reputation, as measured by the average and the first listed manager's Factiva scores, do not have a statistically significant impact upon the time to merger. In conclusion, we found that the only significant RHS variable is the average age of SPAC managers. An increase in the average age of SPAC management reduces the time to merger.

5.2.Investor Characteristics

SPAC investors have a stake in the successful merger of their firm. In fact, Lewellen (2009) reports that the monthly buy-and-hold excess returns to shareholders are around 2.40% for SPACs that have announced a target. Therefore, investors have an incentive to monitor the effort of SPAC managers in regard to achieving a successful merger. Consequently, we believe that various investor characteristics and their associated behavior could affect the magnitude of lambda.

5.2.1. Number of Large Investors per SPAC

Large investors, especially institutional investors are key monitors of corporations. They monitor the behavior of management through several channels. For example, Carleton, Nelson, and Weisbach (1998) argue that institutional investors have greater access to management hence they use private negotiations to monitor firms. Cheng, Huang, Li, and Lobo (2010) provide evidence that securities litigation[48] is another effective monitoring tool for institutional investors. We suspect monitoring forces SPAC managers to exert a higher level of effort in the development of potential targets. We expect the greater the number of institutional investors in a given SPAC, the larger the rate of arrival of potential merger targets (lambda) and the shorter the time to merger. Empirically, we hand collected number of investors who file 13G and 13D Schedules with the SEC to document their purchase and sell offs of the SPAC units at hand and we used that as a measurement of the number of large investors. (A detailed discussion on 13G and 13D filings is presented in section 5.2.3.)

5.2.2. Number of SPACs Each Large Investor Involved With

If a large investor is involved in multiple SPACs, they could gain experience in dealing with SPACs and become more effective in monitoring the performance of the SPACs' managers. Alternatively, there might be a dilution in the time to monitor as the number of SPACs involved with increases, which makes the large investors less effective monitors[49]. Consequently, we let the resolution of the effect of multiple SPAC holdings to be an empirical matter. The total number and the average number of SPACs

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[48] In detail, the paper investigates the impact of using securities class action lawsuits on monitoring defendant firms. The plaintiffs are shareholders of the defendant firm and are usually lead by an investor with the largest stake (usually an institution).

[49] At present, we do not know whether the large investors involve with SPACs sequentially (good monitors) or simultaneously (poor monitors).

held by institutional investors were used in our Cox regressions. The measurements are constructed as follows. First, we collect investor names for each SPAC from 13D and 13G filings. Subsequently, we count the number of SPACs each investor is involved with. To be counted as an "involvement" with a SPAC, the investor has to file at least one 13D or 13G forms for the SPAC. Finally, we calculate the average and the total number of SPAC involvement across all investors for each SPAC.

5.2.3. Number of Schedule 13G or 13D Filings

Edmans, Fang, and Zur (2013) study blockholder governance and point out that blockholders who intend to engage in intervention must file a 13D, while those who intend to remain passive have the option of filing a 13G instead. In other words, 13D and 13G could be proxies for active and passive investors, respectively[50]. Klein and Zur (2009) document the similarities and differences among different types of investors who file 13D. They find that all filers enjoy positive returns around the initial 13D filings. In addition, large shareholders, even passive ones, could impact SPAC manager performance. If blockholders are more effective monitors, the lambda should increase as the number of large investors increase. On the other hand, the 13D and 13G forms filed by investors may just reflect their sell offs. In particular, investors may sell their SPAC shares when they perceive that a merger is unlikely to occur. If this is true, the number of both 13D and 13G forms should be negatively associated with lambda. Given the contradictory predictions, we have decided to treat the impact of the number of 13D/G filings upon the time to merger as an empirical matter. We use the total

[50] Edmans, Fang, and Zur (2013) also find that a 13G filing is following by positive market reaction, a positive holding period return, and an improvement in firm performance.

number of all 13D/G filings and the number of each type of filings to capture the effect of effective monitors.

5.2.4. Empirical Results

Descriptive statistics of investor characteristics are reported in Table 2-3. An average SPAC has 11.11 blockholders who file 13D or 13G forms to SEC. On average, the blockholders file 10.22 13G forms, 12.68 13G amended forms, 1.79 13D forms, and 2.40 13D amended forms for each SPAC. The average blockholder is involved with 32 SPACs.

[Insert Table 2-3 about here]

Identical to our procedure in the previous sections, we first run Cox regressions with each one of the independent variables discussed above, we then replace that variate with each new regression. At the end of the process, if there is more than one significant variable, we combine them on the right hand side, and run a multivariate Cox regression. The results of the bivariate Cox regressions with investor characteristics as determinants of the time to merger are reported in Table 2-4.

We first estimate the impact of the number of blockholders per SPAC upon the time to merger. The number of SPAC owners who file a 13D or 13G form is a significant RHS variable. According to our model, one more 13D/G filer is associated with 100*(1.0510 - 1) = 5.10% increase in the expected time to merger. This result is contrary to what we anticipated but it could be that most of our documented filings are sell-offs. Investors decide that the SPAC's lambda is lower than they originally thought and they sell off. In fact, Edmans, Fang, and Zur (2013) suggest that passive shareholders intervene only through exiting (selling the shares). Our descriptive statistics show that the number of passive blockholders (13G filers) exceeds that of active blockholders (13D filers). Hence our unexpected results may be mainly driven by the inactive monitoring provided by passive shareholders.

We then investigate the impact of large investors' involvement in SPACs upon the expected time to merger. Empirically, we use two measurements to capture the effect: the total and the average number of SPACs that the 13D/G filer at hand is involved with. We find that only the second of the two RHS variables is statistically significant and its impact is intuitive. In particular, as the average number of SPAC involved with increases by 1, the expected time to merger is reduced by 2.77% (that is 100*(0.9723 – 1)). This result supports the notion that large investors become more effective monitors as they become involved with more SPACs.

Next we estimate the impact of the number of 13D and 13G filings for each SPAC. We break down the effect into four measurements: the total number of 13D, 13D/A, 13G, and 13G/A filings, respectively. The forms 13D/A and 13G/A are the amended version of forms 13D and 13G. Except for the number of 13G/A filings, we find strong positive results for all other variates at 1% significance level. In detail, we find an additional 13G, 13D, and 13D/A filing is associated with an increase in the expected time to merger by 3.86%, 11.42%, and 7.00%, respectively. The results contradict our '*a priori*' notion that the filings would increase the rate of arrival of potential targets (lambda) and reduce the time to merger. Again, we argue that the increase in the independent variable at hand is associated with sell offs. The 13D and

13G filings document sell offs as well as purchases. That is, it is possible that investors have made downward revisions in their assessment of lambda.

[Insert Table 2-4 about here]

We now run Cox regressions with multiple independent variables that capture the investor characteristics. We do so by collecting and combining the variables that produce significant results in the bivariate Cox regressions. The results of the two steps are reported in Table 2-5.

When we combine the 5 significant variables from the bivariate regressions, we find that only two measures remain significant. The average number of SPACs that a 13D/G filer is involved with continue to produce hazard ratios below one. In particular, an additional SPAC that a 13D/G filer is involved with reduces the expected time to merger by 1.98% (that is 100*(0.9802 -1)). Moreover, the total number of 13D/A filings continue to increase the expected time to merger by 5.40% (that is 100*(1.0540 – 1)). The remaining RHS variables become insignificant in this setting.

[Insert Table 2-5 about here]

In summary, from the bivariate analyses we find at least one RHS variable under each of the three categories of investor characteristics is statistically significant in the determination of the expected time to merger. In the multivariate Cox regression, two measures (the average number of SPACs that a 13D/G filer is involved with and the total number of 13D/A filings) continue to provide a statistically meaningful explanation of the expected time to merger.

5.3.Macroeconomic Conditions

We argue that a surge in aggregate demand usually accounts for an increase in GDP or GDP growth. To accommodate this increase in demand, often firms are forced to increase their capacity. For private firms, obtaining funds can be difficult in either debt or equity markets (IPO). Consequently, more private firms may use SPACs as an alternative funding source. If this is true, we expect the arrival rate of potential targets (lambda) to be greater when the economy heats up.

5.3.1. Real GDP and Real GDP Growth

Real GDP is the price adjusted total of final goods and services produced in the US economy in a year's time. We use real GDP and its percentage change as RHS in the determination of the SPAC's time to merger[51].

5.3.2. Empirical Results

The conventional Cox model is only capable of handling cross-sectional variations rather than variations within a SPAC unit over time. Our macroeconomic conditions variables, however, are time varying hence cannot be estimated with conventional Cox regressions. Following prior literature in statistics,[52] we modify the conventional Cox model to allow for time varying variables. Specifically, we enter the SPAC observations as follows. We first enter each SPAC into multiple rows, where the number of rows is equal to the number of quarters during which the SPAC has available

[51] Jeng and Wells (2000) use real GDP to proxy for the activity level of venture capitalists. Lowry (2003) real GDP growth as a proxy of private firms' capital demands in a study of IPO activities. Lowry(2003) points out that the capital demands of private targets are high when the overall economy grows quickly.
[52] For example, Martinussen and Scheike (2006).

data. For each row of entry, we keep the time invariant variables the same and update the time varying variables from one quarter to the next. The procedure allows us to estimate the impact of time varying variables with Cox regressions.

We then run bivariate and, if necessary, a multivariate Cox regressions as we have done in previous sections. The regression results are reported in Table 2-6.

[Insert Table 2-6 about here]

When we include GDP growth as a single RHS variable in a Cox regression, we find it increases the expected time to merger. Specifically, we find that one percentage point increase in the GDP growth rate is associated with 7.71% (that is, (1.077177 – 1)*100% = 7.7177%) increase in the time to merger. A increase in the level of GDP by one trillion dollars increases the expected time to merger by 69.11% (that is (1.691166 – 1)*100%). Both results are contradictory to our predictions.

Since both the growth rate and the level of GDP produce significant estimates in the bivariate regressions, we include both in a multivariate Cox regression. The growth rate of GDP remains statistically significant. Results show that a one percentage point increase in GDP growth is associated with 7.03% (that is (1.07329 – 1)*100%) increase in the expected time to merger. In this context, the level of GDP becomes statistically insignificant in the determination of the time to merger.

The unexpected signs on our two MC variables points to the fact that running Cox regression solely on real macroeconomic variables is myopic. All three equations are probably misspecified. That is, we may have excluded some meaningful intermediate variables. For instance, if real GDP and real GDP growth have both increased (putting pressure on firm capacity) then it is possible that IPOs have increased which “crowds out” SPACs as a way to finance desired capital expenditures by private firms. Or perhaps the surge in aggregate economic activity is an artifact of expansionary open market operations by the Fed. With expanded bank reserves, capital expansion by private firms can be accomplished by borrowing from banks, eliminating the need for SPAC as an investment vehicle. By omitting these variables from our empirical analysis, our Cox regressions have produced counterfeit results.

5.4.Underwriter Characteristics

5.4.1. Lead Underwriter, the Number of Underwriters, and IPO Allocation

When preparing for IPO, a SPAC usually hires a group of underwriters. Among them, one serves as the representative (lead) underwriter. We record the names of the representative underwriters and count their appearances. We then create a dummy variable for those which serve as the lead underwriter for at least 20 SPACs. As a result, we identify two underwriters that satisfy the criteria, namely Citigroup Global Markets and EarlyBird Capital. We use these two dummy variables to investigate if the representative underwriter has any effect on the expected time to merger.

We also believe that the number of underwriters per SPAC speaks to the view the market has for the SPAC in terms of riskiness. Having fewer underwriters means that each underwriter is willing to shoulder a larger portion of the risk associated with the SPAC. We hypothesize that an underwriter is willing to accept large share allocation in IPO only when the underwriter believes that the SPAC is likely to complete a merger successfully. When an underwriter finds the IPO of a SPAC too risky, the underwriter seeks to share the risk with other underwriters. Empirically, we use two variables to capture this effect: the total number of underwriters per SPAC and the percentage of shares allocated to the first listed underwriter. We expect lambda to decrease as the number of underwriters increases (or as the percentage of allocation to the first listed underwriter decreases).

5.4.2. Underwriter Experience

The number of SPACs each underwriter is involved with speaks to the overall experience of the underwriter with regard to SPACs. Underwriters who are involved with multiple SPACs may be uniquely placed to offer assistance beyond simply providing the shares in the IPO[53]. Megginson and Weiss (1991) find that the certification role provided by venture capitalists helps to reduce the total costs of going public through IPOs. Krishnan, Ivanov, Masulis, and Singh (2011) find that the venture capitalist's experience in VC backed IPOs is positively associated with the long-run performance of the public firms. We argue that the underwriters' previous experience with SPAC IPOs should enhance the likelihood of SPACs completing a merger. Our empirical measurement of underwriter experience includes the average number of SPAC IPOs that each underwriter is involved with and that the first underwriter is involved with. We expect the more experience the underwriters have, the larger the lambda and the shorter the expected time to a merger.

5.4.3. Purchase Options

[53] Most underwriters provide "firm commitment" to an IPO. Specifically, the underwriter (or the syndicated underwriters) will purchase all new issuing shares from the offering firm at a discount. The underwriter(s) then will sell the shares to the public. The underwriter(s) will bear the risk of not being able to sell all the shares since the offering firm has already been paid then the shares are bought by the underwriter(s).

The purchase option is an option to purchase stock granted to the underwriter(s) as part of their compensation. This is separate from the overallotment amount which is explained in the next subsection. We argue underwriters ask for more options if they believe both the value of lambda and the likelihood of a SPAC merger is high. Empirically, we measure the purchase options in millions of shares.

5.4.4. Overallotment

We compare (A) the number of issues the SPAC intends to offer from the prospectus and (B) the number of shares outstanding from the first Form 8-K filing. If (A) is less than (B), the difference is the overallotment used. The amount of the overallotment used indicates the level of enthusiasm the market has for the IPO. If more of the overallotment is used, then the SPAC is facing a more enthusiastic market and management should have an easier time finding a suitable acquisition target. We hypothesize that the lambda is larger when the overallotment is high. Empirically, we measure the overallotment for each SPAC in millions of shares.

5.4.5. Offer Discount

Empirically we measure offer discount as the difference between the IPO price and the first recorded closing price, scaled by the IPO price. We argue that SPAC with high perceived value of lambda would experience larger price increase in the first few days of trading. So we expect lambda to be bigger when the offer discount variable is more negative.

5.4.6. Underwriter Compensation

Thompson (2010) reports that on average underwriters receive about 7% of proceeds as compensation at offering. He further reports that some underwriters choose to defer part of the compensation until the successful consummation of the initial merger. The more compensation an underwriter receives upfront, the less proceeds will be deposited into the trust. Therefore, we expect an increase in underwriter compensation will increase the expected time to merger. On the other hand, when an underwriter chooses to defer its compensation until the initial merger completes, the shareholders are better protected because they will be entitled to receive the deferred underwriter compensation in case the SPAC fails to finish a merger. Thus the expected time to merger should fall in the case of deferred compensation. Empirically, we measure the underwriter compensation as a percentage of total proceeds. We use a dummy variable to document if the compensation is deferred.

5.4.7. Empirical Results

Descriptive statistics of underwriter characteristics are presented in Table 2-7. Each SPAC uses 3.45 underwriters to help with their IPO issuance. The first listed underwriter receives about 66% of all IPO shares. On average, each underwriter has dealt with SPAC IPO issuance for 36 times, while the first listed underwriter has involved with 28 SPAC IPO issuances. The offer discount, measured as the percentage difference between the IPO price and the first recorded closing price, is around 8%.

[Insert Table 2-7 about here]

Following our procedures laid out in previous sections, we first run Cox regressions with each one of the independent variables discussed above, we then replace that variate in each new regression. At the end of the process, if there is more than one significant variable, we combine them on the right hand side, and run a multivariate Cox regression. The results of the bivariate Cox regressions with underwriter characteristics as determinants of the time to merger are reported in Table 2-8.

The Cox regressions suggest that underwriter's options and overallotment are significant in the determination of the SPACs' time to merger. Specifically, every 1,000,000 shares increase in underwriter options is associated with 47.01% (= 100*[1.4701 – 1]) increase in the time to merger, and every 1,000,000 shares increase in overallotment is associated with 0.0001% (= 100*[0.9999 – 1]) decrease in the expected time to merger. The latter result supports our view that the overallotment speaks to the market's enthusiasm about a SPAC's merger prospects. The former result is contradictory to our hypothesis which states that the higher the options, the lower the expected time to merger. We attribute the reason to be that underwriters attempt to "fool" the market about a SPAC's quality by increasing the number of its options. We also find that when SPACs use Citigroup Global Markets as the representative underwriter, their expected time to merger decreases by 43.67% [100*(1-0.5633)]. Last but not least, the results on underwriter compensation are consistent with our predictions. Specifically, we find that a 1 percentage point increase in underwriter compensation (relative to total proceeds) is associated with a 13.51% [100%*(1.1351 – 1)] increase in expected time to merger. In addition, when an underwriter chooses to defer part of the compensation until the completion of the initial merger, the expected time to merger falls by 29.25% [100%*(1-0.7075)].

[Insert Table 2-8 about here]

Since underwriter options and overallotment, a dummy variable for Citigroup, and two underwriter compensation variables produce significant estimates in the bivariate case, we include them in a multivariate Cox regression. The results are reported in Table 2-9. We find only two variables remain statistically significant. In particular, both the compensation to underwriters as a percentage of total proceeds and the number of underwriter options increase the expected time to merger.

[Insert Table 2-9 about here]

5.5.Financial Conditions

5.5.1. Interest Rates

Without publicly traded equity, private firms often use bank loans as a primary financing source. As the interest rate goes up, firms face higher borrowing costs and, consequently, may consider a SPAC merger to get access to public equity market. In addition, periods with high interest rates often witness high systematic risks which discourage banks, especially small ones, from lending to private firms due to their opaque financial conditions. On the other hand, at depressed rates of interest, SPACs are able to acquire more debt, at low cost, and become more attractive to cash hungry private firms. Given this contradiction, the impact of interest rates on the expected time to merger is an empirical issue. We use the London Interbank Offered Rate (LIBOR) and the domestic prime rate to document fluctuations in interest rates. The interest rate data are collected from the St. Louis Federal Reserve Economic Database (FRED) on a monthly basis.

5.5.2. State of IPO Markets

Although there are distinct differences between SPAC mergers and mergers in general, they have enough in common to believe that they could go through similar patterns of behavior. If SPACs and mergers have similar cyclical characteristics, then the relation that SPACs have with IPOs, a priori, may be compared to the relationship that mergers have with IPOs. For example, Rau and Stouraitis (2011 JFQA) find that IPO waves typically start first, then merger waves begin shortly thereafter and continue after the end of the IPO wave. In another example of the link between mergers and IPOs, Brau and Fawcett (JF, 2006), using the results of a survey of 336 CFOs, argue that firms decide to go public in order to facilitate future takeover transactions. On the basis of these citations, and if SPACs have the same relationship with IPOs as mergers do, then a sluggish IPO market means a sluggish SPAC merger (lambda is down) and a surge in an IPO market means a surge in the SPAC market (lambda is up).

If the IPO market is stagnant, then more private firms may choose to go public via a SPAC and lambda will rise. Of course this assumes that SPAC reverse mergers and IPOs are substitutes as Gleason, Rosenthal, and Wiggins III (JCF 2005) maintain. Furthermore, casual empiricism indicates that the SPAC market began to grow in 2002 as the IPO market reached its nadir; this suggests that IPOs and SPAC-based reverse mergers are indeed substitutes. In summary, the discussion here generates conflicting predispositions, consequently the resolution of the impact of IPO success upon the magnitude of lambda, and indirectly, the time to a SPAC merger is an empirical matter.

5.5.3. Empirical Results

The RHS entries for our Cox regressions include the number of gross IPOs and the number of net IPOs to capture the IPO market activity. The quarterly number of IPO issues is obtained from Jay Ritter's website. Based on Jay Ritter's definition, gross IPOs include the issuance of penny stocks, units, and close-end funds, which are excluded by net IPO counts. The results are reported in the tables below.

[Insert Table 2-10 about here]

When we use each variate as a single RHS variable in our Cox regressions, all of the results produce statistically significant estimates. Specifically, the LIBOR and the prime rates significantly increase the expected time to merger by 23.5% and 25.2% respectively, which suggests that SPACs facing higher borrowing costs find it difficult to attract cash hungry target firms. The number of IPOs also lengthens the expected time to merger, although the increase of 1% in expected time to merger represents a much smaller impact. This result supports the view that SPACs and IPOs are indeed substitutes.

[Insert Table 2-11 about here]

When we combine all four variables on the RHS of a multivariate Cox regression, the prime rate is the only variable that remains statistically significant. The multivariate results suggest that a one percent increase in the prime rate could approximately double (100.69% = (2.0069 – 1)*100%) the expected time to merger.

The multivariate results again suggest that higher borrowing costs make SPACs less attractive to private firms.

5.6.First Mover as A Right-Hand-Side Variable

If a SPAC is the first firm (a "first mover") in a target industry to attempt to find a partner, then the rate of arrival of potential merger partners λ could be higher than that of SPACs that are faced with competing SPACs in their target industry [54]. Harford (2005) describes the first-mover advantage in corporate mergers from the buyer's perspective and finds that the earliest participants in a sector find the best-performing targets. The stock returns are higher for these earliest participants. Other buyers, with late entry into those sectors, suffer from lower (or even negative) stock returns from merger and acquisition activities.[55] Tufano (2003), in a discussion of financial innovation, predicts that first-movers in new securities should generate excess profits until competition (other investors) arrives to the marketplace. In a similar setting, Herrera and Schroth (2011) study the underwriting fees charged by investment banks who enter the market at different stages. The innovating banks (or first movers) who develop new corporate securities possess "superior expertise" that allows them to recoup the R&D costs even without patent protection. Other investment banks, though equally competitive, set lower fees than innovating banks mainly because they are considered as "imitators" and hence are not thought to possess "superior skills".

[54] It is fair to presume that the first SPAC to arrive in an industry will have no competition from other SPACs for at least part of the time during its search process.

[55] Herding is when investors mimic other successful market participants; also known as "jumping on the bandwagon." Influential papers on herding include Wermers (1999), Graham (1999), and Grinblatt, Titman, and Wermers (1995).

On the other hand, “first mover” SPACs may be thought to be exotic in the sense that they bring some uniqueness to the marketplace that cannot be easily deciphered by market participants. In particular, potential targets may not be familiar with the newly innovated SPACs. Their lack of knowledge about SPACs may actually discourage their arrival of as a potential partner and precipitate a fall in λ.

Empirically, we consider two kinds of first movers. First, we pool all SPACs together and sort them based on the SPAC IPO date. We then define first movers as the SPACs that went public earliest in time. To make the measure more robust, we use three different numerical cutoffs. In particular we, alternatively, create a dummy variable for a SPAC if it belongs to the first 10%, or 25%, or 50% to be partnered during the legal existence of SPACs. Second, we also consider industry-based first movers. Specifically, we categorize our SPACs into four groups: China-oriented, Western-oriented, single-industry-oriented, and multiple-industry-oriented. Within each of the four categories, we defined group-based first movers as the first 10%, 25%, and 50% SPACs that ever exist in each group. Our Cox regression results are reported in Table 2-12.

[Insert Table 2-12 about here]

The empirical results suggest that the expected time to merger of the pooled first movers is longer than others. For example, the first 50% of SPACs take significantly longer time (58%, or (1.58 – 1)*100%) to complete a merger. If we look into grouped SPACs, we find that being a first mover is to the detriment to the expected time to merger for SPACs whose targets are in a single industry. The expected time to merger for the first 50% of SPACs with single-industry targets is 69% (or (1.69-1)*100%) longer.

The results seem to suggest that the first movers in SPACs did not carry advantages and, in fact, being a first mover could be a disadvantage. One possible explanation is that potential targets are suspicious of the financial and managerial configuration of these Special Purpose Acquisition Corporations. The private merger targets may need more time to understand these abstruse corporate innovations and, as a consequence, the λ available to first mover SPACs actually falls.

5.7.SPAC Characteristics

Although SPACs may look similar as a particular kind of public firm, there are distinguishing aspects between them. In this section, we investigate how different SPAC characteristics influence the expected time to merger. In particular, we analyze the impact of the following factors, namely, debt level, time to expiration, the SPAC's stock exchange listing, the number of SPAC offering units, the number of managers, warrant characteristics, SPAC IPO proceeds, the waiting period before common shares and warrants are traded separately, the number of series of common shares, and the characteristics of the SPAC's auditors.

5.7.1. SPAC Debt Level

Bharadwaj and Shivdasani (2003 JFE) point out, receiving a bank loan "certifies" the trustworthiness of an acquirer to the capital market, which may aid in their ability to find a suitable target. We believe the "certification effect" extends to

SPACs as well – having debt in capital structure signals the trustworthiness of a SPAC and hence makes it more attractive to private targets. However, having too much debt would not be an enhancement of the SPAC's financial profile. Private firms could consider excessive fixed claims held against the SPAC a burden to a new firm created by a merger. Ultimately, we believe that the effect of a SPAC's debt level on its expected time to merger is an empirical issue. We use both the total and net debt level of SPACs provided by Capital IQ on a quarterly basis. These two variables are often time varying over the life of a SPAC.

5.7.2. SPAC's Time to Expiration

SPACs have a set amount of time in which to complete an acquisition before they are required to liquidate themselves and return the IPO funds that have not been spent on the SPAC's operating expenses. This time to expiration ranges from 12 to over 24 months. We believe that the managers of SPACs with a shorter time to maturity will be more active in searching for targets that is have a larger lambda than those with longer expiry. We use dummy variables to represent the following epochs: 12-18 months, 18-24 months and over 24 months. The acquirers' time to termination information is hand collected from each SPAC's prospectus.

5.7.3. Listed Stock Exchanges

When preparing for an IPO, SPACs can choose to be listed on AMEX, NASDAQ, NYSE, or OTC. We believe each exchange provides SPACs with different levels of liquidity and investor attention, which may impact their ability to find a suitable acquisition target. For instance, Anderson and Dyl (2008 FM) study the SEC Rule 144 which regulates the sale of restricted stocks. They find that firms choose NASDAQ as opposed to NYSE to reduce the effect of limits on selling restricted stocks. Furthermore, Kahl, Liu, and Longstaff (2003, JFE) find that the economic costs of such liquidity restrictions to the firm can be sizeable. Finally, Kadlec and McConnell (1994 JF) find that firms earn 5% in abnormal return in response to the announcement of listing in NYSE. The exchange chosen by each SPAC for its "listing" was hand collected from the SPAC's prospectus. Dummy variables were used to represent the selection with AMEX serving as the base group.

5.7.4. Number of Units in Offering

The vast majority of SPACs issue their shares at a price that does not vary much from $7 per unit. Therefore, the number of units offered in the IPO is related to the total proceeds the SPAC is able to raise during the offering[56]. We believe there are two reasons that the number of units offered leads to bigger lambda and shorter expected time to merger. First, given that a SPAC is required to spend a specified amount of their initial proceeds on a single acquisition, typically 80%, the number of units may significantly impact their ability to find a suitable acquisition target. More specifically, given the 80% constraint, if there are more large private firms seeking public partners, then the lambda would be larger for SPACs with large proceeds. Second, larger SPACs

56 Previous studies focus on the characteristics of firms which choose to issue units instead of shares. Schultz (1993 JFE) finds that unit offerings reduce the agency cost of management spending free cash flows wastefully.

(with greater cash) could generate more interest among potential targets which are liquidity starved, hence their lambda would be bigger than their smaller counterparts. We expect either phenomenon could shorten the expected time to merger. We collected this information from the SPACs' prospectus manually.

5.7.5. Number of Managers per SPAC

The number of managers each SPAC has may substantially impact the probability of and the time to a successful SPAC merger. On one hand, having more managers means a SPAC has more people who can actively search for a suitable acquisition target enhancing the magnitude of lambda. This disposition follows Haleblian and Finkelstein (1993, Academy of Management Journal), who find that firms with a large managerial team perform better, especially in a turbulent environment. On the other hand, having more managers may lead to a "free-rider" problem where each manager puts forth less effort than they would have otherwise and hopes other managers will do more than their fair share. We treat the "net" effect of the number of managers upon the time to merger as an empirical matter. The number of managers a SPAC has is manually collected data from the SPAC's prospectus.

5.7.6. Warrant Characteristics

Like an option on a stock, the typical warrant on a SPAC entitles its holder to purchase one share of the SPAC common stock at a pre-specified price. Usually a warrant will become exercisable on the either the consummation of the SPAC's initial business combination[57] or one year after the SPAC IPO, whichever takes longer to transpire. We have two views with respect to the effect of warrant conversions on the expected time to merger. On one hand, the number of warrant conversions signals the confidence of warrant holders about the prospect of a successful merger. On the other hand, as Miller (2008, Financier Worldwide) and Lakicevic, Shachmurove, and Vulanovic (2013, SSRN) point out, SPAC shareholders may face high dilution when a substantial proportion of warrant holders have chosen to exercise their conversion rights, thus the shareholders may exert less monitoring power on the SPAC managers. Consequently, the dilution may negatively impact the prospect of a merger. We believe the "net" effect of warrants upon the expected time to merger is an empirical issue. We collect the following variables from SPAC prospectus to measure its warrant characteristics, namely, the number of warrants per unit, warrant exercise price, the ratio of warrant value relative to common stock value, whether the warrant is only exercisable after a successful merger, and the threshold of exercising the conversion right.

5.7.7. The Characteristics of the SPAC's IPO

We employ two empirical variables to capture the impact of the characteristics of a SPAC's IPO proceeds upon the expected time to merger: the percentage of total proceeds deposited into a trust and the percentage of total proceeds invested by insiders (mostly managers).

[57] A SPAC may make several mergers during its life time. In such cases, the warrants will become exercisable upon the completion of the first merger.

We believe the first variable speaks to shareholder protection. As Berger (2008, JACF) points out, a SPAC liquidates its proceeds in trust and returns them to the investors on a pro rata basis when it fails to consummate a business combination with the required time frame. Thus, the higher the percentage of proceeds deposited in the trust, the better the shareholders are protected, which should positively impact the merger outcome.

The second variable relates to not only the managerial incentive but also the "warrant overhang" problem mentioned in the previous section. Insiders usually purchase the SPAC warrants prior to its IPO in a private placement transaction with their personal funds. The insider investment is then combined with the proceeds from the IPO and deposited into the trust. We believe the insider investment directly ties the managers' financial well-being with the SPAC's future performance. If the SPAC can consummate a business merger successfully, the managers could profit by converting their warrants to common shares. In addition, Lakicivic et. al (2013, SSRN) also claim that the insider purchase of warrants can effectively alleviate the "warrant overhang" problem. Therefore, we expect the insider investment to have a positive effect on the merger outcomes.

5.7.8. Separate Trading of Warrants and Common Shares

Hale (2007, JCAF) documents an important feature with respect to the trading of SPACs. Although a SPAC is issued and initially traded in units, its warrants can be traded separately from the common stocks after a waiting period. We measure the waiting period as the number of days after IPO.

5.7.9. Series of Common Shares

Seven SPACs in our sample of 194 choose to issue their common shares in two distinct series, A and B. The holders of series A shares face higher risks than those of series B holders. In particular, purchasers of series A units bear the expenses of underwriting discount and commissions relating to the sale of both series A units and series B units. Holders of series A units cannot vote. More importantly, holders of series A units are paid after those of series B units in the event of liquidation. Therefore, we believe the structure of separate series may create agency problems in which the managers and series B holders take advantage of series A holders by failing to complete a merger since the loss are mostly taken by the series A holders. We use a dummy variable to distinguish SPACs with such a structure.

5.7.10. Auditors

The financial statements included in prospectus of a SPAC have to be audited by an independent auditor. We record the auditor names for all SPACs and find that some auditors show up more often than others. To document their effect on the expected time to merger, we create a dummy variable for each auditing firm which participants in more the 20 SPACs' audition. These auditing firms are Rothstein Kass, Goldstein Golub Kessler, Marcum, and BDO Seidman. We also create a dummy variable for SPACs whose financial statements are audited by the Big Four (KPMG, Deloittle, PwC, and Ernst & Young).

5.7.11. Empirical Results

We start by running Cox regressions with each of the SPAC characteristics as the only RHS variable, subsequently, we combine all the significant features and run a multivariate Cox regression. The results are shown in the tables below.

[Insert Table 2-13 about here]

The univariate Cox regressions produce eleven statistically significant variables. Specifically, a SPAC's total debt level is positively associated with the expected time to merger. A $1 million increase in total debt would increase the expected time to merger by 61.99% ((1.6199 – 1)*100%). This result seems to suggest that private targets are concerned about the fixed claims held against the SPAC becoming a burden of the new firm after the merger. Comparing SPACs with less than 18 months to expiration, SPACs with 18 – 24 months of life span experience a dramatic reduction in expected time to merger, which is about 43.45% ((0.5655-1)*100%). Comparing to AMEX, listings in NASDAQ, NYSE, and OTC tends to increase the expected time to merger by 83.99%, 95.27%, and 46.63%. This result suggests that AMEX offers the SPACs the best exposure to potential private targets. Both the number of offering units and the number of managers reduce the expected time to merger, suggesting that higher offering proceeds and more managers facilitate the merger process. The results on the number of unit offering support the idea that higher proceeds increase lambda either because higher proceeds are attractive to cash starved private firms or because there are many large private firms which require higher proceeds in merger payments. The results on the number of managers indicate the benefits of having additional managers on board outweigh the cost of a possible free-rider problem.

With respect to the warrant characteristics, we find the expected time to merger increases with the decrease in exercise price and increase in the warrant value relative to the common share value. A $1 decrease in exercise price increases the expected time to merger by 8.61% [= 100%*(1-0.9139)]. A 1 percentage point increase in the warrant value relative to the common share value is associated with a 0.60% [=100%*(1.0060-1)] increase in the expected time to merger. The results are consistent with our "warrant overhang" story. Specifically, dilution occurs when warrants are converted into common shares, which is more likely when the exercise price is low and when the warrants value is high relative to common shares.

We also find that a 1 percentage point increase in the proceeds deposited in a trust decreases the expected time to merger by 6.0% [=100%*(1-0.9400)]. Last but not least, SPACs audited by the Big Four enjoy a shorter time to merger.

[Insert Table 2-14 about here]

When we run a multivariate regression with the individually significant variables combined on the RHS, we find only three variables remain statistically significant. The expected time to merger will decrease when the number of offering units goes up, when the total debt level goes down, and when the proceeds deposited in trust goes up. The result on the number of unit offering indicates that higher offering proceeds provide a SPAC with larger financial capacity to acquire target firms. The results also confirm our hypothesis that higher proceeds deposited in trust provide better protection to the shareholders and hence improves the merger outcome.

6. Conclusions

This paper used a simple target acquisition model to guide an empirical investigation of the determinants of the time to a successful merger between a SPAC and a private firm. We considered seven sources of independent variables including SPAC managerial characteristics, investor characteristics, underwriter characteristics, macroeconomic conditions, financial conditions, the "first mover" phenomenon, and the SPAC characteristics. Survival analysis established that these sources provided over twenty right hand side variables as being statistically significant in the determination of the time to merger.

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Appendix 2-1

Leibnitz's Rule:

$$y = \int_{g(x)}^{h(x)} f(x)dx$$

$$\frac{\partial y}{\partial x} = \int_{g(x)}^{h(x)} f'(x)dx + \frac{\partial h(x)}{\partial x} \cdot f(h(x)) - \frac{\partial g(x)}{\partial x} \cdot f(g(x))$$

Appendix 2-2

Does $\int_0^\infty f(x)dx = 1$

where $f(x) = \lambda e^{-\lambda x}$?

We have $\int_0^\infty \lambda e^{-\lambda x} dx = -e^{-\lambda x}\Big|_0^\infty = e^{-\lambda(0)} = 1$

so $\lambda e^{-\lambda x}$ for $0 \leq x \leq \infty$ makes sense as a pdf for the time for a merger target to become within the "purview" (consideration) of the SPAC.

Appendix 2-3

The mean of this process is easily obtained from

$$\int_0^{\infty} xf(x)dx = \int_0^{\infty} \lambda \; xe^{-\lambda x} dx$$

where, recall, *x* is the time to when a target is taken into consideration by the SPAC.

Given any two continuous variables *u* and *v* we have

$$d(uv) = udv + vdu$$

$$uv\Big|_b^a = \int_b^a udv + \int_b^a vdu$$

$$uv\Big|_b^a - \int_b^a udv = \int_b^a vdu$$

$$du = \lambda e^{-\lambda x} dx$$

$$u = -e^{-\lambda x}$$

$$v = x$$

$$dv = dx$$

and integrating by parts yields:

$$-e^{-\lambda x} x\Big|_b^a + \int_b^a e^{-\lambda x} dx$$

$$-e^{-\lambda x} x\Big|_0^{\infty} + \int_0^{\infty} e^{-\lambda x} dx$$

$$0 + \frac{-1}{\lambda} e^{-\lambda x}\Big|_0^{\infty} = \frac{1}{\lambda}.$$

So that $\int_0^{\infty} xf(x)dx = \frac{1}{\lambda}$.

Appendix 2-4

Does

$$e^{\lambda\tau F(M^*)} = 1 + \lambda\tau F(M^*) + \frac{1}{2}\left(\lambda\tau F(M^*)\right)^2 + \frac{1}{2\cdot 3}\left(\lambda\tau F(M^*)\right)^3 + \ldots \text{ ?}$$

Let's say $z = -\lambda\tau F(M^*)$ so does

$$e^z = 1 + z + \frac{1}{2}z^2 + \frac{1}{2\cdot 3}z^3 + \frac{1}{2\cdot 3\cdot 4}z^4 + \ldots + \ldots \text{ ?}$$

Let's evaluate e^z using a Taylor expansion with z=0 as our point of evaluation

$$e^z = e^z\big|_{z=0} + \frac{\partial e^z}{\partial z}\Big|_{z=0} dz + \frac{1}{2}\frac{\partial^2 e^z}{\partial z \partial z}\Big|_{z=0}(dz)^2 + \frac{1}{2\cdot 3}\frac{\partial^3 e^z}{(\partial z)^3}\Big|_{z=0}(dz)^3 + \ldots + \ldots$$

$$e^z = 1 + 1(dz) + \frac{1}{2}(1)(dz)^2 + \frac{1}{2\cdot 3}(1)(dz)^3 + \ldots + \ldots$$

$$e^z = 1 + z + \frac{1}{2}z^2 + \frac{1}{2\cdot 3}z^3 + .. + \ldots$$

but recall $z = \lambda\tau F(M^*)$ and, consequently, we have

$$e^{\lambda\tau F(M^*)} = 1 + \lambda\tau F(M^*) + \frac{1}{2}\lambda^2\tau^2\left[F(M^*)\right]^2 + \frac{1}{2\cdot 3}\left[\lambda\tau F(M^*)\right]^3 + \ldots \quad .$$

Appendix 2-5

If $P(X \le \tau) = 1 - e^{-\lambda\tau\left(1-F\left(M^*\right)\right)}$

and $P(X \le \tau) \equiv \int_0^\tau f(x)dx$

then $\int_0^\tau f(x)dx = 1 - e^{-\lambda\tau\left(1-F\left(M^*\right)\right)}$.

So $F(\tau) - F(0) = 1 - e^{-\lambda\tau\left(1-F\left(M^*\right)\right)}$

or $F(\tau) = 1 - e^{-\lambda\tau\left(1-F\left(M^*\right)\right)}$

Consequently

$$\frac{\partial F(\tau)}{\partial \tau} = \lambda\left(1-F\left(M^*\right)\right)e^{-\lambda\tau\left(1-F\left(M^*\right)\right)} = f(\tau).$$

So that $f(x) = \lambda\left(1 - F\left(M^*\right)\right)e^{-\lambda x\left(1-F\left(M^*\right)\right)}$ and $\lambda\left(1 - F\left(M^*\right)\right)e^{-\lambda x\left(1-F\left(M^*\right)\right)}$ is, by inspection, the probability density function of an exponentially distributed variable.

Appendix 2-6

Does $\int_0^\infty \lambda\left(1-F\left(M^*\right)\right)e^{-\lambda x\left(1-F\left(M^*\right)\right)}dx = 1$?

Does $-e^{-\lambda x\left(1-F\left(M^*\right)\right)}\Big|_0^\infty = 1$?

Does $e^0 = 1$?

The mean of this process is easily obtained from

$$\int_0^\infty x f(x)dx = \int_0^\infty x\lambda\left(1-F\left(M^*\right)\right)e^{-\lambda x\left(1-F\left(M^*\right)\right)}dx\,.$$

where *x* is the time to when a target becomes acquired by the SPAC.

Given any two continuous variables *u* and *v* we have

$$d(uv) = udv + vdu$$

$$uv\Big|_b^a = \int_b^a u\,dv + \int_b^a v\,du$$

$$uv\Big|_b^a - \int_b^a u\,dv = \int_b^a v\,du$$

$$du = \lambda\left(1-F\left(M^*\right)\right)e^{-\lambda\left(1-F\left(M^*\right)\right)x}dx$$

$$u = -e^{-\lambda\left(1-F\left(M^*\right)\right)x}$$

$$v = x$$

$$dv = dx$$

and integrating by parts yields

$$-xe^{-\lambda\left(1-F\left(M^*\right)\right)x}\Big|_0^\infty + \int_0^\infty e^{-\lambda\left(1-F\left(M^*\right)\right)x}dx$$

or

$$\int_0^{\infty} e^{-\lambda\left(1-F\left(M^*\right)\right)x}\,dx$$

or

$$\left.\frac{-1}{\lambda\left(1-F\left(M^*\right)\right)} e^{-\lambda\left(1-F\left(M^*\right)\right)x}\right|_0^{\infty}$$

and, finally, $\frac{1}{\lambda\left(1-F\left(M^*\right)\right)}$.

Appendix 2-7

Consider the evaluation of $\int_B^A xf(x)dx$ where $f(x)=\dfrac{1}{\sqrt{2\pi\sigma_x^2}}e^{-(x-\mu_x)^2/2\sigma_x^2}$.

The $\dfrac{\partial f(x)}{\partial x}=-f(x)\left(\dfrac{x-\mu_x}{\sigma_x^2}\right)$.

Rearranging, we have

$$-\sigma_x^2\frac{\partial f(x)}{\partial x}=xf(x)-\mu_x f(x).$$

Integrating yields

$$-\sigma_x^2 f(x)\Big|_B^A=\int_B^A xf(x)dx-\mu_x\int_B^A f(x)dx$$

or finally, we have

$$\int_B^A xf(x)dx=\mu_x\left[F(A)-F(B)\right]-\sigma_x^2 f(A)+\sigma_x^2 f(B).$$

Appendix 2-8

Consider the evaluation of $\int_B^A x^2 f(x)dx$ where $f(x) = \frac{1}{\sqrt{2\pi\sigma_x^2}} e^{-(x-\mu_x)^2/2\sigma_x^2}$.

The $\frac{d(xf(x))}{dx} = f(x)\left[1 - \frac{x^2}{\sigma_x^2} + \frac{\mu_x x}{\sigma_x^2}\right]$.

Alternatively, we have

$$x^2 f(x) = \sigma_x^2 f(x) + f(x)\mu_x x - \sigma_x^2 \frac{d(xf(x))}{dx}.$$

Integrating the expression above yields

$$\int_B^A x^2 f(x)dx = \sigma_x^2 \int_B^A f(x)dx + \mu_x \int_B^A xf(x) - \sigma_x^2 xf(x)\Big|_B^A \ .$$

Equivalently,

$$\int_B^A x^2 f(x)dx = \sigma_x^2[F(A) - F(B)] + \mu_x[\mu_x(F(A) - F(B)) - \sigma_x^2 f(A) + \sigma_x^2 f(B)]$$
$$- \sigma_x^2 Af(A) + \sigma_x^2 Bf(B)$$

Appendix 2-9

Consider the evaluation of $\int_B^A x^3 f(x)dx$ where $f(x) = \frac{1}{\sqrt{2\pi\sigma_x^2}} e^{-(x-\mu_x)^2/2\sigma_x^2}$.

The $\frac{d\left[x^2 \frac{1}{\sqrt{2\pi\sigma_x^2}} e^{-(x-\mu_x)^2/2\sigma_x^2}\right]}{dx}$ equals

$$\frac{1}{\sqrt{2\pi\sigma_x^2}}\left\{2xe^{-(x-\mu_x)^2/2\sigma_x^2} + x^2 e^{-(x-\mu_x)^2/2\sigma_x^2} \cdot \frac{-x+\mu_x}{\sigma_x^2}\right\}$$

Rearranging

$$x^3 f(x) = f(x)\left[2x\sigma_x^2 + x^2\mu_x\right] - \sigma_x^2 \frac{d\left(x^2 f(x)\right)}{dx}.$$

Integrating

$$\int_B^A x^3 f(x)dx = 2\sigma_x^2 \int_B^A xf(x)dx + \mu_x \int_B^A x^2 f(x)dx - \sigma_x^2\left[x^2 f(x)\Big|_B^A\right].$$

Finally, we have

$$\int_B^A x^3 f(x)dx = 2\sigma_x^2\left[\mu_x\left(F(A)-F(B)\right) - \sigma_x^2 f(A) + \sigma_x^2 f(B)\right] + \mu_x\left[\sigma_x^2\left(F(A)-F(B)\right)\right] +$$

$$\mu_x^2\left[\mu_x\left(F(A)-F(B)\right) - \sigma_x^2 f(A) + \sigma_x^2 f(B)\right] - \mu_x\left[\sigma_x^2 A\cdot f(A) - \sigma_x^2 B \cdot f(B)\right]$$
$$-\sigma_x^2 A^2 f(A) + \sigma_x^2 B^2 f(B)$$.

Appendix 2-10: Are First Movers Smaller?

Small buyers could have a difficult time acquiring large targets. In the SPAC setting, we posit that size could be one of the explanations as to why it takes longer for first mover SPACs to find a merger partner. In particular, small SPACs may not be able to catch the attention of many potential targets. Here we conduct difference in means test (t-test) to examine if first mover SPACs are relatively small comparing to "slow" mover SPACs. Our variable of interest, *size*, is measured as the ratio of total proceeds of a particular SPAC from its IPO to the median proceeds among all SPACs in our sample.

We use three measures to characterize first mover SPACs, namely the first 10%, 25%, and 50% of all SPACs, respectively. The table below shows first mover SPACs are indeed much smaller than other SPACs. The results are robust to all three first mover measures and confirm our argument that first movers SPACs are unattractive to potential merger partners partially due to their size.

Group 1	Group 2	Mean Group1	Mean Group2	p-value
First 10% of all SPACs	The rest 90% of all SPACs	0.73	2.09	0.0018
First 25% of all SPACs	The rest 75% of all SPACs	1.06	2.22	0.0007
First 50% of all SPACs	The rest 50% of all SPACs	1.30	2.57	0.0000

Appendix 2-11: Sample of First Mover Dummy Variables

The table below provides a sample on how the first mover dummy variables are entered into our data spreadsheet.

SPAC ID (cik #)	IPO Date	First 10% of All SPACs	First 25% of All SPACs	First 50% of All SPACs
1310817	2/24/2005	1	1	1
1327012	9/14/2005	0	1	1
1337749	3/14/2007	0	0	1
1436612	8/15/2008	0	0	0

Appendix 2-13 Tables

Table 2-1: Descriptive Statistics on Managerial Characteristics

variable	mean	sd	min	p25	p50	p75	max	N
age_avg	28.244	11.041	0	21.636	27.364	34.636	54.909	3476
avg_spac	1.239	0.481	0.8	1	1	1.29	3.75	3476
max_spac	1.522	0.857	1	1	1	2	5	3476
ot	0.885	0.243	0	0.872	0.977	1	1.667	3476
diffo	-0.1	0.465	-0.986	-0.44	-0.158	0.1	1	3476
herf	0.795	0.29	0	0.767	0.882	0.954	1.891	3476
s1days	166.923	147.388	6	85	112	203	1040	3476
s1filings	6.183	2.366	2	5	6	8	15	3476
factiva_avg	125.601	241.741	0	11.8	37.4	130.8	2410.25	3571
factiva1	226.031	594.57	0	3	13	92	3978	3571
mgr working hours	12.55	6.16	10	10	10	10	50	1471
MBA degree	0.361	0.48	0	0	0	1	1	3571
Other master's or PhD degree	0.11	0.313	0	0	0	0	1	3571

Table 2-2: Cox Regressions on Managerial Characteristics

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
age_avg	0.9829	0.0067	-2.53	0.011	0.9699	0.9961
avg spacs a mgr involves with	1.0712	0.1572	0.47	0.64	0.8034	1.4283
max spacs a mgr involves with	1.0347	0.0878	0.4	0.687	0.8762	1.2219
total ownership	0.7806	0.2346	-0.82	0.41	0.4331	1.4068
own_diff	1.2305	0.1950	1.31	0.191	0.9019	1.6788
herfindahl	0.9494	0.2412	-0.2	0.838	0.5770	1.5620
total days filling S1	0.9997	0.0006	-0.59	0.553	0.9986	1.0008
number of S1 filings	0.9990	0.0349	-0.03	0.976	0.9329	1.0697
factiva_avg	1.0003	0.0003	0.86	0.39	0.9996	1.0009
factiva of 1st mgr	0.9999	0.0002	-0.91	0.364	0.9996	1.0002
mgr working hours per week	0.9999	0.0190	0.00	0.996	0.9633	1.0380

Table 2-3: Descriptive Statistics on Investor Characteristics

variable	mean	sd	min	p25	p50	p75	max	N
# owners who file 13D/G	11.1160	4.7304	3	7	10	13	28	3533
total # SPACs that 13D/G filers involved with	329.342	141.6349	22	208	344	437	729	3533
avg # SPACs that 13D/G filers involved with	32.0085	12.6104	4.28	21.7	34.79	41.6	61	3533
total 13G filings	10.2224	4.6114	1	7	9	12	29	3533
total 13G/A filings	12.6810	9.0959	0	7	11	15	53	3533
total 13D filings	1.7973	2.4546	0	0	1	2	13	3533
total 13D/A filings	2.4053	4.7176	0	0	0	3	41	3533

Table 2-4: Cox Regressions on Investor Characteristics

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
# owners who file 13D/G	1.0510	0.0159	3.29	0.001	1.0203	1.0827
total # SPACs that 13D/G filers involved with	0.9991	0.0005	-1.58	0.113	0.9980	1.0002
avg # SPACs that 13D/G filers involved with	0.9723	0.0061	-4.44	< 0.001	0.9604	0.9844
total 13G filings	1.0386	0.0149	2.64	0.008	1.0098	1.0682
total 13G/A filings	1.0120	0.0076	1.57	0.116	0.9970	1.0272
total 13D filings	1.1142	0.0297	4.06	< 0.001	1.0575	1.1740
total 13D/A filings	1.0700	0.0129	5.61	< 0.001	1.0450	1.0956

Table 2-5: Cox Regressions on Investor Characteristics (Multivariate)

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
# owners who file	0.9992	0.0431	-0.02	0.985	0.9180	1.0875
avg # SPACs that 13D/G filers involved with	0.9802	0.0075	-2.61	0.009	0.9656	0.9950
total 13G filings	1.0104	0.0359	0.29	0.77	0.9423	1.0835
total 13D filings	0.9962	0.0523	-0.07	0.943	0.8987	1.1044
total 13D/A filings	1.0540	0.0174	3.18	0.001	1.0203	1.0888

Table 2-6: Cox Regressions on Macroeconomic Conditions (Bivariate & Multivariate)

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
gdp_growth	1.0772	0.0262	3.06	0.002	1.0270	1.1298
gdp_level	1.6912	0.4219	2.11	0.035	1.0372	2.7575
gdp_growth	1.0703	0.0266	2.73	0.006	1.0194	1.1238
gdp_level	1.4353	0.3601	1.44	0.15	0.8779	2.3469

Table 2-7: Descriptive Statistics of Underwriter Characteristics

variable	mean	sd	min	p25	p50	p75	max	N
# underwriters	3.45	1.85	1	2	3	4	10	3571
pct of allocation the 1st underwriter receives	0.66	0.2	0.225	0.5	0.7	0.8	1	3571
avg # SPACs underwriters involved with	36.45	16.7	1	25	36.75	45.67	93	3571
# SPACs the 1st underwriters involved with	28.67	25.95	1	12	21	45	93	3571
underwriter's option in 1,000,000 shares	0.3	0.37	0	0	0.25	0.475	2.5	3571
overallotment amount in 1,000,000 shares	2283.04	2625.65	0	750	1474.5	2343.75	13500	3571
offer dicount	0.08	0.1	-0.48	0.07	0.09	0.1	0.59	2150
underwriter Citi	0.17	0.37	0	0	0	0	1	3571
underwriter EarlyBird	0.15	0.35	0	0	0	0	1	3571
underwriter comp as pct to proceeds	6.5	1.62	2	6	7	7	10	3571
underwriter defer comp	0.78	0.41	0	1	1	1	1	3571

Table 2-8: Cox Regressions on Underwriter Characteristics

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
# underwriters	1.0552	0.0426	1.33	0.183	0.9750	1.1420
pct of allocation the 1st underwriter receives	0.9233	0.3625	-0.2	0.839	0.4277	1.9929
avg # SPACs underwriters involved with	0.9985	0.0048	-0.3	0.761	0.9892	1.0080
# SPACs the 1st underwriters involved with	1.0024	0.0030	0.8	0.424	0.9966	1.0082
underwriter's option in 1,000,000 shares	1.4701	0.2360	2.4	0.016	1.0733	2.0138
overallotment amount in 1,000,000 shares	0.9999	0.0000	-2.43	0.015	0.9998	1.0000
offer discount	0.9090	0.9978	-0.09	0.931	0.1057	7.8155
underwriter citi	0.5633	0.1342	-2.41	0.016	0.3532	0.8984
underwriter earlybird	1.1850	0.2438	0.82	0.409	0.7918	1.7734
compensation to underwriter as a pct of total proceeds	1.1342	0.0616	2.32	0.021	1.0196	1.2616
part of underwriter comp is only available after merger	0.7076	0.1286	-1.9	0.057	0.4955	1.0105

Table 2-9: Cox Regressions on Underwriter Characteristics (Multivariate)

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
underwriter's option in 1,000,000 shares	1.3700	0.2549	1.69	0.091	0.9513	1.9729
overallotment amount in 1,000,000 shares	0.9999	0.0000	-1.33	0.182	0.9999	1.0000
compensation to underwriter as a pct of total proceeds	1.1174	0.0583	2.13	0.033	1.0088	1.2377
part of underwriter comp is only available after merger	0.8706	0.1644	-0.73	0.463	0.6013	1.2605
underwriter_citi	0.7232	0.1959	-1.2	0.232	0.4253	1.2298

Table 2-10: Cox Regressions on Financial Conditions

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
libor	1.2352	0.0514	5.08	< 0.001	1.1384	1.3402
prime_rate	1.2522	0.0531	5.3	< 0.001	1.1522	1.3608
grossipo	1.0117	0.0034	3.42	0.001	1.0050	1.0185
netipo	1.0171	0.0046	3.75	< 0.001	1.0081	1.0262

Table 2-11: Cox Regressions on Financial Conditions (Multivariate)

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
libor	0.6394	0.2534	-1.13	0.259	0.2941	1.3903
prime_rate	2.0070	0.8378	1.67	0.095	0.8856	4.5483
grossipo	1.0016	0.0099	0.16	0.875	0.9823	1.0212
netipo	0.9977	0.0140	-0.16	0.87	0.9706	1.0256

Table 2-12: Cox Regressions on First Movers

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
first 10% of all SPACs	1.9881	0.4354	3.14	0.002	1.2943	3.0539
first 25% of all SPACs	2.3718	0.4208	4.87	<0.001	1.6752	3.3580
first 50% of all SPACs	1.5802	0.2442	2.96	0.003	1.1673	2.1391
first 10% of SPACs with Chinese Target	1.1181	0.6825	0.18	0.855	0.3380	3.6988
Chinese Target	1.0066	0.2152	0.03	0.976	0.6619	1.5306
first 25% of SPACs with Chinese Target	1.2069	0.5021	0.45	0.651	0.5340	2.7277
Chinese Target	0.9696	0.2272	-0.13	0.895	0.6126	1.5347
first 50% of SPACs with Chinese Target	0.8202	0.3052	-0.53	0.594	0.3955	1.7010
Chinese Target	1.1331	0.3182	0.45	0.656	0.6535	1.9649
first 10% of SPACs with Western Target	1.8093	1.2125	0.88	0.376	0.4865	6.7291
Western Target	0.8286	0.2840	-0.55	0.583	0.4232	1.6221
first 25% of SPACs with Western Target	2.2015	1.2958	1.34	0.18	0.6946	6.9778
Western Target	0.7209	0.2785	-0.85	0.397	0.3381	1.5373
first 50% of SPACs with Western Target	0.6575	0.4041	-0.68	0.495	0.1971	2.1929
Western Target	1.2569	0.6389	0.45	0.653	0.4641	3.4040
first 10% of SPACs with a single Target	3.2511	1.1301	3.39	0.001	1.6450	6.4256
Single Target	0.8582	0.1357	-0.97	0.334	0.6294	1.1701
first 25% of SPACs with a single Target	1.8905	0.4595	2.62	0.009	1.1740	3.0443
Single Target	0.8030	0.1359	-1.3	0.195	0.5762	1.1190
first 50% of SPACs with a single Target	1.6951	0.3780	2.37	0.018	1.0950	2.6243
Single Target	0.7234	0.1421	-1.65	0.099	0.4922	1.0631
first 10% of SPACs with multiple Targets	1.1191	0.5428	0.23	0.817	0.4326	2.8954
Multiple Targets	0.8453	0.1706	-0.83	0.405	0.5691	1.2555
first 25% of SPACs with multiple Targets	2.0238	0.7284	1.96	0.05	0.9996	4.0977
Multiple Targets	0.7091	0.1601	-1.52	0.128	0.4555	1.1039
first 50% of SPACs with multiple Targets	1.2073	0.4174	0.54	0.586	0.6131	2.3775
Multiple Targets	0.7700	0.2163	-0.93	0.352	0.4441	1.3353

Table 2-13: Cox Regressions on Underwriter Characteristics

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
total debt	1.6200	0.3706	2.11	0.035	1.0347	2.5364
net debt	1.0778	0.0894	0.9	0.367	0.9161	1.2680
dummy: 18-24 months life	0.5655	0.0919	-3.51	< 0.001	0.4112	0.7777
dummy: 24+ months life	0.2796	0.2817	-1.26	0.206	0.0388	2.0142
exchg_otc	1.4664	0.2614	2.15	0.032	1.0340	2.0795
exchg_nasdaq	1.8399	0.4325	2.59	0.009	1.1607	2.9167
exchg_nyse	1.9528	0.7439	1.76	0.079	0.9255	4.1200
# units	0.9861	0.0056	-2.47	0.014	0.9752	0.9971
# managers	0.9277	0.0311	-2.24	0.025	0.8687	0.9907
# warrants in a unit	1.0832	0.0659	1.31	0.189	0.9614	1.2205
warrant strike price	0.9139	0.0412	-2	0.046	0.8367	0.9983
warrant value/common share value	1.0060	0.0018	3.29	0.001	1.0024	1.0096
warrant only exercisable after merger	2.2397	1.3126	1.38	0.169	0.7101	7.0640
threshold of exercise conversion right	0.5830	0.2359	-1.33	0.182	0.2638	1.2884
pct of insider investment in the SPAC	13.9812	76.1926	0.48	0.628	0.0003	608545.3000
pct proceeds in trust	0.9400	0.0147	-3.95	<0.001	0.9115	0.9693
waiting period before separate trading	1.0034	0.0022	1.52	0.129	0.9990	1.0078
the SPAC has two separate series of common shares	1.2346	0.4780	0.54	0.586	0.5781	2.6370
auditing_rothstein	0.6859	0.1590	-1.63	0.104	0.4354	1.0803
auditing_goldstein	1.1136	0.2222	0.54	0.59	0.7532	1.6466
auditing_marcum	0.7780	0.2278	-0.86	0.391	0.4383	1.3810
auditing_bdo seidman	0.8599	0.2349	-0.55	0.581	0.5034	1.4688
audting_big4	0.5393	0.1952	-1.71	0.088	0.2652	1.0963

Table 2-14: Cox Regressions on Underwriter Characteristics (Multivariate)

	Haz. Ratio	Std. Err	z	P>|z|	[95% Conf.	Interval]
total debt	1.9279	0.5104	2.48	0.013	1.1475	3.2390
dummy: 18-24 months life	0.8078	0.2214	-0.78	0.436	0.4721	1.3821
exchg_otc	0.8298	0.2580	-0.6	0.548	0.4512	1.5262
exchg_nasdaq	1.3201	0.5106	0.72	0.473	0.6186	2.8174
exchg_nyse	1.0090	0.5851	0.02	0.988	0.3239	3.1440
# units	0.9776	0.0122	-1.82	0.069	0.9541	1.0017
# managers	1.0417	0.0631	0.68	0.5	0.9252	1.1729
warrant strike price	0.9405	0.0719	-0.8	0.423	0.8096	1.0926
warrant value/common share value	0.9971	0.0035	-0.83	0.408	0.9904	1.0039
pct proceeds in trust	0.9255	0.0329	-2.18	0.029	0.8630	0.9923
audit_big4	1.1328	0.6306	0.22	0.823	0.3805	3.3730

Chapter 3: Media Exposure and Executive Compensation: An Analysis of Turnover Events[58]

1. Introduction

In recent years the role of the media has emerged as one of the key factors affecting corporate policies. For example, it has been shown that the media could help to reverse the violations in corporate governance and to detecting accounting fraud (Dyck, Volchkova, and Zingales [2008], Miller [2006]). However, there is limited understanding on the role of media on executive pay. In this paper, we study how incoming CEOs' media exposure influences the changes in compensation relative to their predecessors' during turnover events.

Media coverage can influence executive compensation through two channels. On one hand, the media may play as a "watchdog" which provides external monitoring power to the firms. If so, higher media exposure would translate into more careful scrutiny over boards determining the compensation packages of the CEOs. Therefore, highly visible CEOs will not receive higher compensation offers while having higher pay-for-performance in their compensation packages (Media scrutiny hypothesis).

On the other hand, the media may act as a "cheerleader" which selectively reports positive news on the subjects. When a CEO persistently receives positive news coverage, recruiting firms tend to label the CEO with positively biased image. Consequently, the recruiting firms would be willing to pay more to hire the "star" CEOs. Furthermore, "star" CEOs can shop around and apply for several positions with

[58] This chapter is based on collaborative work with Vahap B. Uysal.

multiple firms because of their high visibilities in the news. They could then pick the most favorable compensation packages from several firms – those with higher total pay and lower pay-for-performance sensitivity. (Media hype hypothesis).

To test these hypotheses, we focus on executive turnover events which provide the board of directors with unique opportunities to restructure the executive compensation package. In absence of the turnover, it is difficult to negotiate with an incumbent CEO and change the existing compensation package. Rather, the negotiation with the incoming CEO can go easier, especially when the successor is young and less entrenched. We measure the incoming CEO's media exposure with the number of news reports, excluding firm-originated newswires and press release wires, during the 12 months prior to the appointment. While media's "watchdog" role lines up with the board's interest of limiting total pay and increasing incentives, its "cheerleader" role inflates the value of the incoming CEOs and enables them to exact more rents from the firm. We hypothesize that when media scrutiny (hype) effect dominates, incoming CEOs with higher media exposures receives more (fewer) incentives such as stock and option grants, higher pay-for-performance sensitivities, and lower (higher) total pay. We use OLS regressions to examine the effect of media on the change in composition and level of CEO compensation.

Our findings reveal strong association between media exposure and composition of executive compensation. Specifically, we find that having a media exposure affects the composition of the compensation package. However, it does not does not influence total compensation to a CEO. Highly visible CEOs are offered with more stock and option awards which lead to higher *deltas*. In general, CEOs are compensated more effectively when their media exposure is high. Collectively, these findings are consistent with the media scrutiny hypothesis.

We also consider the endogeneity of media exposure. Most notably, having media exposure is related to a firm's size, industry, previous stock performance, growth opportunity, and board characteristics. In addition to controlling for these factors in our analyses, we take further steps to disentangle the effect on executive pay of having media exposure. Specifically, we implement propensity score matching and replicate the analysis. To a large extent, the propensity score approach reduces the possibility that the firms hiring low-visibility CEOs are fundamentally different from firms hiring high-visibility CEOs. The results from the propensity score matching approach support our findings from the OLS regressions that the media provides scrutiny and monitoring power over boards determining the compensation packages to the incoming CEOs.

This study is related to the monitoring role of the media in corporate policies. Dyck et al (2008) present evidence that the media helps to reverse corporate governance violations. Joe et al (2009) document that the media coverage on board ineffectiveness forces the target to take corrective actions and leads to enhanced shareholder wealth. Miller (2006) points out that the press helps in the discovery of accounting fraud by rebroadcasting and conducting original investigations. This study extends the existing literature by exploring the influence of the media monitoring power on executive compensation contracts.

The paper also contributes to the literature on how executive turnover events influence executive compensation and future firm performance. Elsaid and Davidson III (2009) address the issue by concentrating on the negotiating power between the boards and the newly appointed CEOs. When the board has dominating bargaining power, incoming CEOs have a greater proportion of pay-at-risk and smaller proportion of salary. Murphy (2002) compares the pay to inside and outside incoming CEOs and finds outside replacements are usually paid more than inside replacements. Blackwell et al. (2007) document that future firm performance is positively related to the proportion of stock grants to the new CEOs. In an attempt to explain the changes in executive compensation surrounding turnover events, our paper extends the investigation by incorporating CEO media exposure into consideration.

The rest of the paper is organized as follows. Section 2 discusses the theoretical framework as well as the development of hypotheses. Data and empirical issues are discussed in Section 3. In section 4, we report univariate and multivariate analyses on how executive media coverage impacts executive compensation. We conduct a number of robustness checks, which are reported in Section 5. Section 6 concludes the paper.

2. Related Literature and Hypotheses Development

While media coverage receives great attention in asset pricing research, existing literature on the relation between media coverage and corporate policies is limited (Zingales [2000]). The research that does exist presents contrasting findings. Some literature suggests that the press serves as “watchdogs” which provide external monitoring power. On the other hand, media may act as “cheerleaders” providing systematically positively biased information. The following subsections provide more detailed discussion on the conflicting findings.

2.1.Media Hypes

When media behaves as “cheerleaders”, it hypes individuals and firms by selectively presenting positive information. As a result, audience perceives the individuals and firms with disproportionally positive images. There are several reasons media may produce hypes.

First, the subjects of media stories demand less unfavorable reports about themselves. Often the subjects are also the advertisers who the media has to rely on and hence cater to. Reuter and Zitzewitz (2006) document that personal finance publications are more likely to recommend mutual funds of their advertisers, but national newspapers do not present the pattern. Gurun and Butler (2012) show local newspapers use fewer negative words on local companies. Moreover, the local bias is more evident for firms with higher advertising expenditures. The adverting income pressurizes media to hype the subjects.

Second, firms are more likely to be hyped when board members are connected with mass media. Gurun (2011) finds that firms with a media expert on board receive 40% more news coverage and the news reports contain 25% fewer negative words.

Third, the demand for news services results in media sensationalism. Jensen (1979) argues that most demand for news services derives not from a demand for information, but from a demand for entertainment. Consequently, media tend to sensationalize stories to attract audience. Similarly, Gurun and Butler (2012) argue that local media are more likely to reproduce the qualitative content of company news releases, which are like to be positive in tone.

There are at least two channels through which the media hype could positively affect executive compensation. First, media hype inflates a firm's evaluation on a CEO talent. A firm evaluates a CEO candidate based on the information set it gathers. The press serves as an extremely important and trustworthy source of information. If the press consistently provides positively biased information about the CEO candidate, the firm would perceive that the candidate possesses superior talent. As a result, the firm would spend more than it needs to hire the CEO with media hypes. Second, "star" CEOs receive more attention and hence are presented with more job opportunities. Consequently, "star" CEOs can shop around and choose the most favorable compensation package. Under both cases, firms tend to pay more in total compensation and set a lower pay-for-performance sensitivity.

H1.A**:** *When media hype effect dominates, incoming CEOs with higher media exposures earn more total pay than those with lower media exposures.*

H1.B**:** *The compensation package provides the incoming CEO with fewer incentives and lower pay-for-performance sensitivities when media hypes the incoming CEOs.*

2.2.Media Scrutiny

The press could act as "watchdogs" if it can discover information from various sources, such as employees and customers, and report negative news before the news is disclosed by firms. In other words, the asymmetry in information disclosure may cause media to publish information with negative tones. Miller (2006) empirically investigates the role of media in detecting accounting fraud, and he finds that media provides the public with the information about accounting fraud. Dyck et al (2008) examine the role of media in monitoring corporate governance violations in Russia during 1999 to 2002. The news coverage in Western media increases the chance that a corporate governance violation is reversed. Farrell and Whidbee (2002) show that media scrutiny of poor firm performance increases the likelihood of forced CEO turnover.

When the media plays as a “watchdog”, it could negative impact the executive compensation for the following reasons. First, negative media exposure hurt executive reputations. Fama and Jensen (1983) point out that the value of managers’ human capital depends on the signals about the managers’ performance as corporate decision makers. CEOs with high media exposure understand that their compensation packages are likely to be studied by the media carefully; hence they have incentives to keep the total pay low enough to avoid media attention. To offset the loss in total pay, they would ask for higher pay-for-performance sensitivities which increase the compensation as firm performance improves. Second, the board of directors understands that media exposure translates into external monitoring power which reduces the CEO rent-extracting activities. Together, we predict that

H2.A**:** *When media scrutiny effect dominates, incoming CEOs with higher media exposures earn less total pay than those with lower media exposures.*

H2.B: *The compensation package provides the incoming CEO with higher incentives when media acts as an external monitor.*

3. Data Source, Sample Selection, and Empirical Design

3.1. Data Source

The annual data on managerial compensation and executive characteristics comes from Standard & Poor's *ExecuComp*. *ExecuComp* contains data from annual proxy statements for at least five top executives for S&P 1500 firms since 1992. Variables to be included in my analysis include executive cash pay, bonus, stock grants, option grants, income in other forms, CEO tenure, etc. In terms of identifying executive turnover events, *ExecuComp* provides two key variables of interest: the date on which an executive leaves office and the date on which an executive becomes CEO. A turnover is identified if a firm *i* has a predecessor CEO *p* who left the firm in the same calendar year in which a successor CEO *s* took office. We construct a pair of CEOs, a predecessor *p* and a successor *s*, by matching on calendar year and firm ID. Next we construct the measures of the changes in compensation between the successor CEO and the predecessor CEO. The relative change in total compensation is measured as the difference in total compensation to the successor CEO in the event year *t* and that to the predecessor CEO in the prior year, scaled by the total compensation to the predecessor CEO in the prior year.

$$\frac{Tot_t^s - Tot_{t-1}^p}{Tot_{t-1}^p}$$

The change in component pay is measure as:

$$\frac{Comp_t^s}{Tot_t^s} - \frac{Comp_{t-1}^p}{Tot_{t-1}^p}$$

in which superscripts *s* and *p* stand for successor and predecessor respectively. *Tot* measures the annual total compensation paid to executives and *Comp* stands for a certain component of the executive compensations, such as salary, bonus, stock awards, etc. We use the predecessor compensation in the prior year because the predecessor CEO may receive other compensation (such as golden parachutes) that is pertinent to the turnover events.

We have two other measures of incentive - *delta* and *vega* – generated from the compensation package[59]. Both *delta* and *vega* measure the sensitivity of executive compensation to firm stock performance. More specifically, *delta* measures the executive compensation sensitivity to the change in stock price, while *vega* measures that to the change in stock volatility. The *delta* and *vega* measures could capture the incentives generated from the compensation packages.

We use Factiva to obtain CEO news coverage information. We look at the number of news reports that involve the incoming CEO's full name 12 months prior to the appointment. To eliminate the noise, we exclude news wires and press releases that are generated by the firm. To determine the type of turnover, we search the *Factiva* for the reasons of the turnovers. We will classify a turnover as "voluntary" if the turnover relates to retirement, death, illness, etc. Following Parrino (1997), we use the age of 60 to be the normal retirement age for CEOs.

Data on firm characteristics, financial performance and other firm-specific information are collected from COMPUSTAT annual files. Information on board of directors is obtained from the *RiskMetrics*. My final sample contains 815 executive turnover events and covers from 1996 to 2006.

[59] Coles et al. (2006) finds that higher delta leads to riskier policy choices, including more investment in R&D, less investment in tangible assets, and higher leverage.

All variables are winsorized at the 2^{nd} the 98^{th} percentiles. See Appendix 3-1 for detailed variable definitions. Descriptive statistics are reported in Table 3-1. On average, the incoming CEOs earn $5.25 million less than their predecessors each year. An average incoming CEO has 127 pieces of news reports during the one year period prior to the announcement of their appointment.

[Insert Table 3-1 about here]

3.2. Regression Models

To test for the difference in compensations for outgoing and incoming CEOs (hypothesis #1 & #2), we plan to conduct both univariate t-tests and multivariate regressions. If the change in compensation is positively (negatively) related to the news coverage, cheerleader (watchdog) hypothesis is supported.

We use the following regression models:

$$chg = News * \alpha + Board * \beta + CEO * \gamma + Ctrl * \eta + \varepsilon$$

The dependent variable *chg* measures the relative difference in total compensation or the change in component pay between the incoming and the outgoing CEOs. *Board*, *CEO*, and *Ctrl* are matrices that capture the effects of board, CEO, and firm characteristics. The key variable of interest would be *News*, which captures CEOs' media visibility. We have two measure of the *News*. In Table 3-3 we measure it as the natural log of the number of news reports involving the incoming CEO during the 1 year period prior to the appointment. In Table 3-4 we measure it with a vector of three dummy variables which equal to 1 for CEOs belonging to the 2^{nd}, 3^{rd}, and 4^{th} quartiles in news exposure, respectively.

3.3. Propensity Score Matching

The analysis so far suffers from endogeneity issues. Specifically, firms that hire high visibility CEOs may be fundamentally different from firms that hire low visibility CEOs. One way to address the issue is to implement the propensity score matching to estimate the average treatment effect (ATE) of the CEO visibility on the change in compensations.

The first step of the propensity score matching procedure is to perform a Probit estimation of the probability of being in the treatment group (i.e., of hiring highly visible CEOs) based on firm characteristics. Next, we use the estimated probability to form matched pairs of observations with similar estimated probabilities but different realizations of the treatment (i.e., similar in firm characteristics but hiring CEOs with different media visibility). Finally, we calculated the ATE of the treated CEOs (i.e., those with the highest media exposure) for the change in total compensation and the changes in each component.

4. Empirical Results

4.1. Univariate Analysis

In this subsection, we compare the changes in each component of executive compensation between CEOs with different media visibility. To do this, we first sort all incoming CEOs into quartiles based on the number of news reports during the 12-month period prior to their appointment. Second, we perform t-tests to detect whether the means of each compensation component is equal between the CEOs in the lowest quartile and those in the highest quartile. Table 3-2 displays the results of the univariate analysis. Regardless of media exposure, incoming CEOs in all quartiles earn less in total compensation than their predecessors. The decrease in total compensation is larger among CEOs with higher media coverage, which is surprising. Highly visible CEOs, however, have higher *deltas* from their compensation package. These CEOs also have more bonuses and stocks relative to the total compensation. In summary, when successor CEOs are more visible in media reports, they are offered with more effective compensation packages, signaled by lower total pay and higher incentives.

[Insert Table 3-2 about here]

4.2. Regression Analysis

Table 3-3 reports the results from regression analyses. We run each dependent variable against our key variable of interest and three sets of control variables. The CEO media exposure, our key variable of interest is measured as the natural logarithm of the number of news reports during the 12 months prior to the appointment. The first set of control variables focus on firm characteristics. We use the market-book ratio, firm size, and previous stock returns as the controls. The second set of control variables include board size, average tenure, and percentage of outside directors and outside compensation committee members, which control for board quality. We also control for CEO age. All regressions are performed via OLS with White standard errors to correct for possible heteroscedasticity.

[Insert Table 3-3 about here]

Table 3-3 shows that the change in the weight of stock awards and that of option awards are positively associated with higher media coverage. A 1% increase in the number of news reports leads to 1.2 percentage point increase in the proportion of stock awards relative to total compensation. The increase is equivalent to over 7% increase in the average weight of stock awards. Similarly, the proportion of option awards to new CEOs also increases as their news coverage increases. In terms of the pay-performance sensitivity measure of *delta*, CEOs with higher media attention are associated with higher *delta* from their compensation packages. It implies that the compensation to more visible CEOs is more closely tied to future firm performance. The results are statistically significant at 1% level.

The effect of CEO media exposure on the relative change in total compensation is statistically insignificant (it has a p-value of 0.108), although the estimated coefficient is positive. In other words, CEO media visibility does not have a strong impact on the level of total compensation. We do not find CEO media exposure has significant impacts on the changes in the weight of salary, bonus, and compensation in other forms. To sum up, when incoming CEOs are more visible under media coverage, their compensation packages tend to be more effective. Without being paid more in total, the incoming CEOs have higher stock and option awards as well as higher *delta*. Consequently, their compensation packages provide higher incentives to improve firm performance. The firms are able to better align the incoming CEOs' interest with shareholders. More importantly, the goal is achieved without raise the level of total pay.

We notice that the measure of CEO news exposure – the natural logarithm of the number of news reports – is highly positively skewed. We are concerned that the statistical significance we reported in Table 3-3 is mainly driven by the outliers on the right tail. To address the issue, we run the regressions again with a different measure of news coverage – a dummy variable which equals to 1 for CEOs in the 4^{th} (top) quartile of news exposure and 0 otherwise. Using the dummy variable instead of the continuous variable, we get rid of the outliers and we reserve the qualitative difference in CEO news coverage. The results are reported in Table 3-4

[Insert Table 3-4 about here]

Table 3-4 shows that the overall results from Table 3-3 are largely retained. Specifically, CEOs in the top quartile receive more options grants in compensation. In other words, more visible CEOs in the media are compensated more with option grants. High option pay, in turn, leads to high *delta*, which indicates that more visible CEOs are compensated with higher pay-for-performance sensitivities and their wealth is more closely linked to future firm performance. We do not find the media coverage plays an important role in affecting the stock grants and total pay.

To sum up, our evidences in Table 3-4 are largely consistent with those in Table 3-3. The empirical results suggest that CEO news exposure is an important determinant in the relative change in option awards and in *delta*, which lead to higher incentives and pay-for-performance sensitivities. These changes are achieved without paying significantly more in total to the incoming CEOs. Our findings support the media scrutiny hypothesis that the media provides external monitoring and helps in designing more effective compensation contracts to incoming CEOs.

4.3.Propensity Score Matching

[Insert Table 3-5 about here]

Table 3-5 presents the results from the propensity score matching procedures, which addresses the concern of endogeneity. We first estimate the propensity of a firm which chooses to hire a CEO with high media exposure. The high media exposure is proxied by a dummy variable which equals to 1 if the CEO belongs to the top quartile of news coverage and 0 otherwise. The propensity score is estimated via a probit model based on a series of firm and board characteristics. The results from the probit model are reported in Table C1. We then match firms that hire CEOs in the top quartile of media exposure with firms that fire CEOs in the lowest quartile of media exposure based on the propensity scores. We apply the Kernel matching algorithm which uses the weighted average of all cases in the control group to estimate artificial outcomes. The weight is calculated by the propensity score distance between a treatment case and all control cases. The Kernel matching allows us to assign higher weight to the closest control groups. Lastly, we estimate the average treatment effects (ATE) of hiring a highly visible CEO among firms with similar propensity scores. Table 3-5 reports the ATE estimates. In detail, it reports the average treatment effect (ATE) on the changes in various components of compensation, where the treatment is defined as CEOs being in the top quartile of media coverage. Our results show that after matching firm and board characteristics, CEO media exposure exerts effects on some components of the total compensation package, namely stock awards, option awards, *delta*, and other income. The results from the propensity score matching procedure are consistent with the results from regression analysis. Although incoming CEOs do not experience significant changes in total compensation, they receive more stock and option grants which tie their compensation closely to firm performance. More important, the propensity score matching approach allows us to at least partially address the endogeneity. In other words, it helps to eliminate the possibility that firms hiring less visible CEOs are fundamentally different from firms hiring highly visible CEOs.

4.4. Univariate Test across Firm Size Quartiles

Table 3-6 compares the difference in the means of executive compensation variables across firm size quartiles. We first sort all observations into quartiles based on firm size, which is measured as the natural logarithm of total firm assets at the event year. For observations in the top and bottom quartile, we then conduct difference of means tests for each executive compensation variable. The bottom of Table 3-6 reports the t-statistics and p-values of the tests.

[Insert Table 3-6 about here]

With the exceptions of the changes in the weight of stock awards and bonus, the tests generally indicate that the executive compensation variables do not exhibit large variations across firm size quartiles. Therefore we argue that firm size is not heavily related with the measures of executive compensation. The link between the changes in the components of compensation and CEO news exposure is not affected by firm characteristics.

5. Robustness Checks

5.1. Alternative Dependent Variables

In our previous regression models, we define the dependent variable *chg* as the change in the weights of compensation components between the successor CEOs and the predecessor CEOs. This definition directly measures how the board modifies the compensation contract with the incoming CEO based on the contract to the outgoing executive. Most newly appointed CEOs, however, were employed by the firms of which they become CEOs later. We believe the board is interested in modifying the compensation contract to the new CEOs after the appointment. In other words, an individual's employee contract would differ from his/her CEO contract in terms of component pays and total pay. We define the *chg* variable as the change in the weights of compensation components for the same individual before and after he/she becomes CEO. Mathematically, the change in component pay and total pay are defined as

$$\frac{Comp_t^s}{Tot_t^s} - \frac{Comp_{t-1}^s}{Tot_{t-1}^s} \text{ and } \frac{Tot_t^s - Tot_{t-1}^s}{Tot_{t-1}^s},$$

where *s*, *comp*, and *tot* stand for successor CEO, component pay, and total compensation, respectively. Unreported summary statistics show that the weights in stock awards, option awards, salary, and bonus increase for individual who become CEO. Other compensation and total compensation, however, decrease after the event. Table 3-7 presents the results from replicating the regression model in Table 3-3 with alternative dependent variables.

[Insert Table 3-7 about here]

Table 3-7 shows that only the change in the weight of stock awards is marginally significantly related to CEO news coverage. However, the negative correlation is surprising. We don't have a good explanation for the sign. The weights in other components are not significantly related to the CEO news coverage. Based on the findings, we argue that the board uses the outgoing CEO's compensation as a benchmark when making decisions on the incoming CEO's compensation. The incoming CEO's compensation history is not a significant factor in the process.

5.2. Internal versus External Hire

Naveen (2006) points out that it becomes quite common that firms make plans to respond to future CEO turnovers by recruiting potential future CEO candidate as an top executive (but not CEO) several years prior to the turnover. Our observation is consistent with the argument. Specially, most successor CEOs were employed by the firm of which they become CEOs later. We believe that the source of hiring could play an important role in the compensation negotiations. Realizing most recruitment is conducted internally, we define an internal hire as a dummy variable which is equal to 1 when the incoming CEO worked in the firm 2 years prior to the CEO appointment. Table 3-8 reports the results from regressions with the internal hire variable included.

[Insert Table 3-8 about here]

In general, our main results hold. The weights in stock awards and option awards are still positive and significantly related to the executive news exposure. CEOs with higher media exposure tend to have higher delta, which is also consistent with our prior results. Internal hire decreases the weight in stock awards and in bonuses.

6. Conclusions

We examine the role of the media in affecting executive compensation by studying how incoming CEOs' media exposure is associated with the changes in compensation relative to their predecessors during turnover events. We find that the successor CEOs do not earn more in total than their predecessors. However, the proportion of stocks and options relative to the total pay are significantly higher among CEOs with higher media exposures. Moreover, the compensation packages provide high *delta* to more visible CEOs.

Our findings imply that the media acts an external monitor who helps the firms set up effective compensation schemes with executives by increasing the incentive components and tying the executive's wealth with future firm performance. Our paper also implies that the executive turnover events are great opportunities for the firm to better align executive's interest with shareholders' at low cost. Our paper does not answer the question of the relation between media exposure and future firm performance. We leave the topic for future research.

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Appendix 3-1: Variable Definitions

Variables	Detailed Definitions
Market-Book	Number of common shares outstanding * Closing price of the fiscal year/book value of equity
Log(Assets)	The natural logarithm of (1 + total assets)
Board Size	The total number of members on the board of directors, including the chair
Compensation Committee Size	The total number of members on the Compensation Committee
Pct of Outside Directors	The percentage of outside directors on board. Outsiders are defined as those who are not former employees, not interlocked with the firm's CEO, and not related by business relationships
Pct of Outside Comp Cmt Members	The percentage of outside directors on the compensation committee. Outsiders are defined as those who are not former employees, not interlocked with the firm's CEO, and not related by business relationships
CEO age	The age of the CEO of the year
log(Total Comp)	the natural logarithm of (1 + total compensation)
Weight of Salary	Salary for CEO i in year t divided by the total compensation for CEO i in year t
Weight of Bonus	Bonus for CEO i in year t divided by the total compensation for CEO i in year t
Weight of Stock Awards	Stock grants for CEO i in year t divided by the total compensation for CEO i in year t
Weight of Option Awards	Option grants for CEO i in year t divided by the total compensation for CEO i in year t
Weight of Other Income	Other income for CEO i in year t divided by the total compensation for CEO i in year t
Relative Chg in Total Compensation	The difference in total compensation for the incoming CEO in year t and for the outgoing CEO in year t-1, scaled by the total compensation for the outgoing CEO in year t-1
Chg in Weight of Salary	The difference between the weight in salary for the incoming CEO in year t and that for the outgoing CEO in year t-1
Chg in Weight of Bonus	The difference between the weight in bonus for the incoming CEO in year t and that for the outgoing CEO in year t-1
Chg in Weight of Stock Awards	The difference between the weight in stock grants for the incoming CEO in year t and that for the outgoing CEO in year t-1

Chg in Weight of Option Awards	The difference between the weight in option grants for the incoming CEO in year t and that for the outgoing CEO in year t-1
Chg in Weight of Other Income	The difference between the weight in other income for the incoming CEO in year t and that for the outgoing CEO in year t-1
Delta	The dollar change in CEO wealth in response to a 1% change in firm stock price. See Coles et al (2006) for detailed calculation procedures.
Vega	The dollar change in CEO wealth in response to a 1% change in firm stock volatility. See Coles et al (2006) for detailed calculation procedures.
log(# News Reports)	The natural logarithm of (1+the number of news reports involving the incoming CEO during the 12 months prior to the appointment)
News_qt	A dummy variable which equals to 1 if the incoming CEO belongs to the top quartile in terms of news coverage and 0 otherwise.

Appendix 3-2: Tables

Table 3-1: Descriptive Statistics

The sample consists of 815 CEO turnover events during 1996 – 2006. Data come from Compustat, ExecuComp, RiskMetrics, and Factiva. See Appendix A for detailed variable definitions. All variables are winsorized at 2nd and 98th percentile. We report the mean, standard deviation, minimum, 25% percentile, median, 75% percentile, maximum, and the number of observations for each variable.

	Mean	Std Dev	Min	25%	50%	75%	Max	N
Market-Book	3.22	2.61	0.08	1.47	2.21	4.05	12.22	815
Log(Assets)	7.87	1.66	4.86	6.54	7.78	9.01	11.79	815
Board Size	10.01	3.03	4	8	10	12	25	815
Compensation Committee Size	8.42	4.55	0	7	9	11	25	815
Pct of Outside Directors	63.00	16.44	0	52.17	66.67	75.00	93.33	815
Pct of Outside Comp Cmt Members	33.11	13.55	0	25.00	33.33	40.00	0.83	690
CEO age	51.87	6.69	32	47	52	56	79	769
log(Total Comp)	7.53	1.27	0.00	6.75	7.53	8.34	11.67	815
Weight of Salary	0.35	0.27	0.00	0.14	0.28	0.51	1.00	814
Weight of Bonus	0.23	0.20	0.00	0.04	0.19	0.36	0.89	814
Weight of Stock Awards	0.14	0.25	0.00	0.00	0.00	0.21	0.99	814
Weight of Option Awards	0.21	0.30	0.00	0.00	0.00	0.37	0.99	814
Weight of Other Income	0.07	0.12	0.00	0.01	0.02	0.07	0.94	814
Relative Chg in Total Compensation	0.01	0.98	-0.94	-0.66	-0.31	0.33	2.86	814
Chg in Weight of Salary	0.05	0.30	-0.98	-0.06	0.04	0.20	0.96	813
Chg in Weight of Bonus	0.09	0.22	-0.67	0.00	0.03	0.19	0.85	813
Chg in Weight of Stock Awards	0.10	0.24	-0.71	0.00	0.00	0.06	0.99	813
Chg in Weight of Option Awards	3.45	15.93	-38.90	0.20	0.82	2.13	181.06	798
Chg in Weight of Other Income	-0.09	-0.09	-0.98	-0.09	0.00	0.01	0.93	813
Delta	6958.38	34566.29	0.00	0.00	15.81	2832.00	554696.90	815
Vega	0.00	0.02	0.00	0.00	0.00	0.00	0.27	815
CEO news exposure	127.55	279.25	0	8	26	103	1528	813

Table 3-2: Univariate Analysis

We compare CEOs in the lowest news exposure quartile to CEOs in the highest news exposure quartile across different categories. The first 4 rows of Table 2 report the mean of each quartile. The last 3 rows of Table 2 report the t-test on the difference of means between the top and the bottom quartile. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively.

		N	Relative Chg in Total Comp	Chg in Weight of Salary	Chg in Weight of Bonus	Chg in Weight of Stock Awards	Chg in Weight of Option Awards	Chg in Weight of other income	Delta	Vega
News Quartile	1	217	0.0001	0.036	0.0462	0.0627	2.9017	-0.0678	2387.501	3.80E-03
	2	194	-0.0091	0.0521	0.0995	0.1281	1.9174	-0.1193	1418.67	9.55E-37
	3	199	0.0000	0.0533	0.128	0.1099	2.2077	-0.0631	8258.69	0.0000
	4	203	0.0257	0.0613	0.1018	0.1126	6.628	-0.1082	15913.02	0.00E+00
	Diff (1-4)		-0.0256	-0.0252	-0.0556	-0.0499	-3.7264	0.0404	-13525.52	3.80E-03
	t-stat		-0.266	-0.8104	-2.6044	-2.2083	-1.9025	1.5418	-3.0481	1.7401
	p-value		0.7904	0.4182	0.0096**	0.0279*	0.0582+	0.1239	0.0026**	0.0833+

Table 3-1: Regression Analysis

The table presents results of pooled OLS regressions with White standard errors of the following model:

$$chg = News * \alpha + Board * \beta + CEO * \gamma + Ctrl * \eta + \varepsilon$$

chg stands for the relative change in total compensation or the change in the weight of each component (i.e., salary, bonus, etc.); *News* is the natural logarithm of the number of news reports. *Board* stands for board characteristics, including board size, average director age, so on. *CEO* stands for CEO age. *Ctrl* standards for control variables at firm level, including market-book, firm size, ect. Numbers in parenthesis are the p-values of the estimates above them. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively.

Table 3-3: Regression Analysis - *Continued*

	Chg in Weight of Stock Awards	Chg in Weight of Option Awards	Delta	Relative Chg in Total Comp	Chg in Weight of Salary	Chg in Weight of Bonus	Chg in Weight of other income
log(# News Reports)	0.012*	0.983**	1858.729**	0.034	-0.003	-0.004	0.001
	-0.027	-0.007	0	-0.108	-0.71	-0.522	-0.887
Market-Book	-0.015**	0.375*	724.796+	-0.037*	0.006	0.006+	0.010**
	0	-0.043	-0.064	-0.013	-0.116	-0.062	-0.002
log(Assets)	0.003	0.202	189.698	0.002	0.005	0.011	-0.009
	-0.751	-0.528	-0.836	-0.958	-0.636	-0.116	-0.272
Previous Stock Return	-0.009	-1.582*	-4064.352**	-0.051	0.021+	0.015	0.002
	-0.373	-0.013	0	-0.243	-0.096	-0.118	-0.832
Board Size	0.001	-0.872**	-1016.784*	-0.002	0.001	-0.009*	0.003
	-0.797	-0.007	-0.049	-0.893	-0.908	-0.015	-0.45
Pct of Outside Directors	0.124+	-14.872*	-31243.658**	0.092	-0.139	0.198**	-0.111
	-0.088	-0.013	0	-0.764	-0.153	-0.004	-0.154
Avg. Director Tenure	0.001	-0.742**	-1420.715**	0.016	-0.015**	-0.006*	0.005
	-0.805	-0.002	0	-0.206	0	-0.022	-0.131
Pct of Outside Comp Cmt Members	0.159+	-11.279*	2577.568	0.677+	-0.234+	-0.224**	0.065
	-0.1	-0.047	-0.639	-0.087	-0.058	-0.001	-0.521
Executive's Age	-0.003*	0.314*	0.969	-0.016**	0.005**	-0.004**	-0.001
	-0.025	-0.011	-0.995	-0.005	-0.006	-0.004	-0.616
Constant	0.118	9.043	37246.288**	0.415	0.004	0.277**	-0.017
	-0.25	-0.121	-0.001	-0.336	-0.975	-0.003	-0.89
Observations	658	646	660	659	658	658	658
R-squared	0.055	0.089	0.13	0.037	0.054	0.057	0.025
F	5.376	1.77	5.722	2.668	3.169	4.843	2.927

Table 3-2: Regression Analysis

The table presents results of pooled OLS regressions with White standard errors of the following model:

$$chg = News\_qt * \alpha + Board * \beta + CEO * \gamma + Ctrl * \eta + \varepsilon$$

Chg stands for the relative change in total compensation or the change in the weight of each component (i.e., salary, bonus, etc.); *News_qt* is a dummy variable which equals to 1 for CEOs in the top (4^{th}) quartile of news exposure, respectively. *Board* stands for board characteristics, including board size, average director age, so on. *CEO* stands for CEO age. *Ctrl* standards for control variables at firm level, including market-book, firm size, ect. Numbers in parenthesis are the p-values of the estimates above them. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively.

Table 3-4: Regression Analysis - ***Continued***

	Chg in Weight of Stock Awards	Chg in Weight of Option Awards	Delta	Relative Chg in Total Comp	Chg in Weight of Salary	Chg in Weight of Bonus	Chg in Weight of other income
News_qt	0.014	5.558**	7811.874**	0.086	-0.011	-0.022	0.007
	-0.522	-0.004	-0.002	-0.34	-0.733	-0.306	-0.763
Market-Book	-0.014**	0.360*	739.033+	-0.036*	0.006	0.006+	0.010**
	0	-0.045	-0.059	-0.015	-0.114	-0.06	-0.003
log(Assets)	0.005	-0.011	40.565	0.004	0.005	0.012+	-0.01
	-0.549	-0.968	-0.963	-0.896	-0.635	-0.089	-0.257
Previous Stock Return	-0.008	-1.760*	-4277.710**	-0.051	0.022+	0.016+	0.002
	-0.432	-0.01	0	-0.238	-0.097	-0.099	-0.861
Board Size	0.001	-0.788**	-944.282+	-0.002	0.001	-0.009*	0.003
	-0.875	-0.009	-0.059	-0.891	-0.92	-0.012	-0.433
Pct of Outside Directors	0.123+	-14.517*	-30700.905**	0.094	-0.139	0.196**	-0.11
	-0.089	-0.013	0	-0.759	-0.153	-0.004	-0.158
Avg. Director Tenure	0	-0.784**	-1496.024**	0.015	-0.014**	-0.006*	0.005
	-0.887	-0.002	0	-0.24	0	-0.027	-0.14
Pct of Outside Comp Cmt Members	0.15	-11.965*	1028.511	0.650+	-0.232+	-0.220**	0.064
	-0.117	-0.039	-0.854	-0.1	-0.062	-0.001	-0.524
Executive's Age	-0.003*	0.295*	-30.113	-0.017**	0.005**	-0.004**	-0.001
	-0.018	-0.012	-0.83	-0.004	-0.006	-0.005	-0.607
Constant	0.154	13.218*	44496.490**	0.535	-0.007	0.262**	-0.013
	-0.115	-0.023	0	-0.194	-0.956	-0.005	-0.915
Observations	658	646	660	659	658	658	658
R-squared	0.05	0.099	0.132	0.035	0.053	0.058	0.025
F	4.345	1.818	5.585	2.699	3.231	4.961	3.065

Table 3-5: Average Treatment Effect (ATE) on Changes in Compensation for CEO media Exposure

The table presents the results of the propensity score matching procedures. Specifically, it presents the average treatment effect (ATE) on changes in CEO compensation for CEOs with high media exposures. Kernel matching method is applied to each variable. Each t-statistics is estimated with bootstrapping method for 1000 repetitions. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively. See Appendix 3-1 for detailed variable definitions.

	ATE	t-stat
Change in Weight of Stock Awards (High Media Exposure CEOs vs. Low)	0.076	3.564**
Change in Weight of Option Awards (High Media Exposure CEOs vs. Low)	5.121	2.753**
Delta (High Media Exposure CEOs vs. Low)	14087.873	3.290**
Relative Change in Total Compensation (High Media Exposure CEOs vs. Low)	0.158	1.171
Vega (High Media Exposure CEOs vs. Low)	-0.002	-1.728+
Change in Weight of Salary (High Media Exposure CEOs vs. Low)	0.02	0.512
Change in Weight of Bonus (High Media Exposure CEOs vs. Low)	0.005	0.118
Change in Weight of Other Income (High Media Exposure CEOs vs. Low)	-0.08	-2.715**

Table 3-6: Univariate Analysis Based on Firm Size and Market-Book Ratio

Firm size is measured as the natural logarithm of total assets. Both total assets and market-book ratio are winsorized at the 2^{nd} and the 98^{th} percentiles. We compare CEOs in the lowest quartile to CEOs in the highest quartile across different categories. The first 4 rows of each table report the mean of each quartile. The last 3 rows of each table report the t-test on the difference of means between the top and the bottom quartile. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively.

		N	Relative Chg in Total Comp	Chg in Weight of Salary	Chg in Weight of Bonus	Chg in Weight of Stock Awards	Chg in Weight of Option Awards	Chg in Weight of other income	Delta	Vega
Size Quartile	**1**	206	0.0607	0.0288	0.0614	0.0994	4.2923	-0.1011	5685.823	9.00E-37
	2	202	-0.0679	0.0639	0.0895	0.0629	5.8984	-0.0526	8607.338	4.08E-03
	3	204	0.1003	0.0438	0.0969	0.0999	1.1895	-0.1043	5084.137	8.09E-22
	4	203	-0.0653	0.0635	0.1152	0.146	2.3189	-0.0961	8492.391	0.00E+00
	Diff (1-4)		0.126	-0.0347	-0.0538	-0.0466	1.9733	-0.0049	-2806.57	9.00E-37
	t-stat		1.3273	-1.1111	-2.4255	-1.7256	1.5854	-0.1755	-0.6529	1
	p-value		0.1852	0.2672	0.0157*	0.0852+	0.114	0.8608	0.5144	0.3185

Table 3-3: Robustness Check on Dependent Variables

This table replicates the regression model in Table 3. The model is specified as the following:

$$chg = News * \alpha + Board * \beta + CEO * \gamma + Ctrl * \eta + \varepsilon$$

News is the natural logarithm of the number of news reports. *Board* stands for board characteristics, including board size, average director age, so on. *CEO* stands for CEO age. *Ctrl* standards for control variables at firm level, including market-book, firm size, ect. *Chg* stands for the relative change in total compensation or the change in the weight of each component (i.e., salary, bonus, etc.). Unlike Table 3, in which we measure the *chg* by comparing the difference in the compensation to the successors and the predecessor, here we compare the compensation to the successors only. More specifically, we compare the compensation to the successors in year t to that in year t-1. Mathematically, the change in component pay is defined as $\frac{Comp_t^s}{Tot_t^s} - \frac{Comp_{t-1}^s}{Tot_{t-1}^s}$ and $\frac{Tot_t^s - Tot_{t-1}^s}{Tot_{t-1}^s}$, where *s*, *comp*, and *tot* stand for successor CEO, component pay, and total compensation, respectively.

Numbers in parenthesis are the p-values of the estimates above them. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively.

Table 3-7: Robustness Check on the Dependent Variables – ***Continued***

	Chg in Weight of Stock Awards	Chg in Weight of Option Awards	Relative Chg in Total Comp	Chg in Weight of Salary	Chg in Weight of Bonus	Chg in Weight of other income
log(# News Reports)	-0.025+	0.131	-0.005	0.004	-0.006	-0.011
	(0.097)	(0.612)	(0.926)	(0.728)	(0.507)	(0.129)
Market-Book	-0.017	-0.133	0.012	-0.002	0.015**	0.001
	(0.120)	(0.536)	(0.699)	(0.757)	(0.009)	(0.746)
log(Assets)	-0.021	-0.388	0.048	0.001	0.033**	-0.007
	(0.398)	(0.378)	(0.440)	(0.963)	(0.004)	(0.610)
Previous Stock Return	0.010	0.452	0.165	-0.022	0.047**	0.008
	(0.691)	(0.478)	(0.101)	(0.325)	(0.008)	(0.684)
Board Size	-0.004	-0.657	-0.012	0.015	-0.006	0.015
	(0.814)	(0.203)	(0.783)	(0.178)	(0.288)	(0.135)
Pct of Outside Directors	0.004	3.109	0.214	-0.071	0.336*	-0.002
	(0.987)	(0.687)	(0.715)	(0.741)	(0.018)	(0.982)
Avg. Director Tenure	-0.007	-0.317	-0.006	0.005	-0.005	-0.007
	(0.349)	(0.303)	(0.783)	(0.472)	(0.498)	(0.411)
Pct of Outside Comp Cmt Members	0.227	-12.748	-0.226	0.156	-0.071	-0.000
	(0.248)	(0.349)	(0.753)	(0.590)	(0.568)	(0.999)
Executive's Age	-0.002	-0.110	-0.005	0.002	-0.001	-0.003
	(0.683)	(0.402)	(0.716)	(0.579)	(0.639)	(0.410)
Constant	0.442+	21.335	-0.114	-0.238	-0.242	0.139
	(0.069)	(0.233)	(0.901)	(0.501)	(0.138)	(0.628)
Observations	220	208	220	220	220	220
R-squared	0.049	0.040	0.016	0.022	0.122	0.033
F	1.299	0.774	0.617	0.495	3.319	0.774

Table 3-4: Robustness Check on Internal Hire

The table presents results of pooled OLS regressions with White standard errors of the following model:

$$chg = News * \alpha + Board * \beta + CEO * \gamma + Ctrl * \eta + \varepsilon$$

Chg stands for the relative change in total compensation or the change in the weight of each component (i.e., salary, bonus, etc.); *News* is the natural logarithm of the number of news reports. *Board* stands for board characteristics, including board size, average director age, so on. *CEO* stands for CEO age. *Ctrl* standards for control variables at firm level, including market-book, firm size, ect. *Internal Hire* is a dummy variable which is equal to 1 if the successor CEO was employed more than 2 years prior to the CEO appointment and 0 otherwise.

Numbers in parenthesis are the p-values of the estimates above them. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively.

Table 3-8: Robustness Check on Internal Hire – *Continued*

	Chg in Weight of Stock Awards	Chg in Weight of Option Awards	Delta	Relative Chg in Total Comp	Chg in Weight of Salary	Chg in Weight of Bonus	Chg in Weight of other income
log(# News Reports)	0.011*	0.978**	1847.881**	0.035	-0.003	-0.004	0.001
	(0.036)	(0.008)	(0.000)	(0.106)	(0.742)	(0.455)	(0.919)
Market-Book	-0.013**	0.387*	749.706+	0.000	0.005	0.007*	0.010**
	(0.000)	(0.033)	(0.057)	(0.013)	(0.175)	(0.031)	(0.001)
log(Assets)	0.005	0.217	225.192	0.000	0.004	0.013+	-0.009
	(0.526)	(0.492)	(0.814)	(0.992)	(0.705)	(0.071)	(0.319)
Previous Stock Return	-0.006	-1.562*	-4022.971**	-0.053	0.020	0.017+	0.003
	(0.563)	(0.016)	(0.000)	(0.230)	(0.117)	(0.070)	(0.761)
Board Size	0.003	-0.861*	-993.586*	-0.003	-0.000	-0.008*	0.004
	(0.503)	(0.010)	(0.048)	(0.852)	(0.976)	(0.028)	(0.388)
Pct of Outside Directors	0.100	-15.051*	-31588.971**	0.106	-0.127	0.183**	-0.118
	(0.171)	(0.011)	(0.000)	(0.730)	(0.191)	(0.007)	(0.126)
Avg. Director Tenure	0.001	-0.740**	-1416.055**	0.016	-0.015**	-0.006*	0.005
	(0.722)	(0.002)	(0.000)	(0.213)	(0.000)	(0.026)	(0.125)
Pct of Outside Comp Cmt Members	0.165+	-11.250*	2668.401	0.673+	-0.237+	-0.220**	0.067
	(0.090)	(0.049)	(0.624)	(0.089)	(0.057)	(0.001)	(0.513)
Executive's Age	-0.003*	0.317**	7.271	-0.017**	0.005**	-0.003**	-0.001
	(0.047)	(0.010)	(0.960)	(0.006)	(0.009)	(0.007)	(0.667)
Internal Hire	-0.109**	-0.713	-1537.380	0.062	0.050	-0.066*	-0.033
	(0.001)	(0.545)	(0.546)	(0.537)	(0.174)	(0.013)	(0.244)
Constant	0.155	9.293	37779.540**	0.394	-0.013	0.300**	-0.006
	(0.126)	(0.101)	(0.000)	(0.355)	(0.915)	(0.001)	(0.963)
Observations	658	646	660	659	658	658	658
R-squared	0.081	0.089	0.131	0.038	0.057	0.069	0.027
F	6.092	2.706	5.735	2.401	3.002	5.081	2.891

Table C 1: Probit Estimates of the Propensity Score Matching

The table presents results from the first stage of the propensity score matching. The estimated coefficients from the probit model are reported in the first column. The p-values corresponding to the estimates are reported in the parentheses under the coefficients. The sample means of the variable for firms with CEOs from the top and bottom news coverage quartiles are reported in the 2nd and 3rd columns, and p-values from t-tests are presented in the 4th column. +, *, ** indicate two-tail statistical significance at 10%, 5%, and 1% levels, respectively. See Appendix 3-1 for detailed variable definitions.

	Dep. = 1 if incoming CEO in top exposure quartile	**Treatment Sample Mean**	**Control Sample Mean**	**Pr(diff)**
Market-Book	-0.020	3.55	2.89	0.0101*
	(0.515)			
log(Assets)	0.250**	8.42	7.28	0.0001**
	(0.000)			
Stock Return	0.144+	0.15	0.01	0.1048
	(0.082)			
Stock Volatility	0.207	0.76	0.74	0.4974
	(0.259)			
log(Captial Expenditures)	0.186**	4.64	3.67	0.0001**
	(0.000)			
log(PPE)	-0.178**	6.32	5.61	0.0010**
	(0.001)			
log(Ad. Expenditures)	0.191**	2.26	0.80	0.0001**
	(0.000)			
log(R&D)	0.051	2.86	2.03	0.0007**
	(0.112)			
Compensation Committee Size	0.029	9.39	7.65	0.0001**
	(0.196)			
Pct of Outside Directors	-0.189	0.63	0.62	0.6550
	(0.684)			
Avg. Director Tenure	-0.020	7.70	7.42	0.5124
	(0.315)			
Constant	-2.161**			
	(0.000)			
# Treated (top media exposure quartile)	203			
# Untreated (bottom media exposure quartile)	217			