Does zero lower bound policy affect managerial risk-taking and executive compensation?

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Abstract

This study empirically examined whether the zero lower bound policy of 2008 promotes managerial risk-taking using samples of U.S. publicly traded firms. Based on the evidence documented in previous research, this policy can lead to a change in firms' managerial risk-taking and in turn result in a difference in executive compensation. By conducting empirical research, it was found that managerial risk taking increases significantly after the zero lower bound policy. In addition, firms' total executive compensation also increased significantly after the zero lower bound policy. Further analysis showed that the increase in executive compensation was caused by the partial mediation of managerial risk-taking. Moreover, robustness checks showed that the relation between zero lower bound policy and managerial risk-taking is less significant for S&P 500 firms. In addition, corporate governance moderates the relation between managerial risk-taking and executive compensation.

Keywords: *zero lower bound policy, managerial risk raking, executive compensation*

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Contents

1. Introduction

After the financial crisis of 2008, the U.S. Federal Reserve implemented a zero lower bound policy, which lowered the short-term nominal interest rate to nearly zero. The initial decision was followed by a series of announcements resulting in the zero lower bound policy being effective until the end of 2015. The U.S. Federal Reserve first announced lowering the interest rate to 0-0.25% on December 16th, 2008. Following this first announcement, a string of announcements were made to keep the nominal interest rate at the same level after every FOMC meeting. The Federal Reserve insists that the zero lower bound policy supports “continued progress toward maximum employment and price stability”, and that “the current 0 to 1/4 percent target range for the federal funds rate remains appropriate” (Board of Governors of FRS, 12/17/14).

On the other hand, researchers and policy makers have criticized the zero lower bound policy for squeezing corporate profit growth (Gross, 11/3/15), and that this policy can lead to a liquidity trap and leave central banks helpless to provide macroeconomic stimulus (McCallum, 2000; Orphanides and Wieland, 2000). Others in the media also hold the view that even though the economic growth rate is not particularly strong, the job market in the U.S is rather healthy. Therefore a rise in the interest rate is needed (Walker, 9/17/15). On December 17th, 2015, the Federal Reserve decided to increase the Fed’s target rate from the original 0-0.25% to a range of 0.25-0.50 percentage points (Reuters, 2015). This marked the end of a seven-year-long zero lower bound policy in the U.S. economy.

Since the implementation of the zero lower bound policy, it received broad attention from both researchers and practitioners. There is a string of literature focusing on examining the zero lower bound policy impact on banks and money funds. The documented results show that a lower monetary policy rate increases risk-taking in banks’ lending behavior by relaxing the bank capital constraint that is present due to moral hazard problems (Adrian and Shin, 2010). In addition, the zero lower bound policy also results in public pension funds allocating a larger proportion of their assets to risky investments (Boubaker et al., 2015).

However all of the previous literature focused on the zero lower bound policy's impact on financial institutions rather than general firms. Therefore there is a need to bring up the question of whether this policy also has a significant impact on firms of other industries. Based on documented results, companies besides banks and money funds will also pursue risky projects as a result of the zero lower bound policy. This study empirically examined the relation between zero lower bound policy and managerial risk-taking. Previous research on zero lower bound policy's effect on banks leads to a prediction that it also has a positive effect on corporate managerial risk-taking beyond the financial industry. Besides studying the relation between zero lower bound policy and managerial risk-taking, this study also investigated the relation between managerial risk-taking and executive compensation.

As previous research showed, even though shareholders and CEOs are both risk adverse, shareholders can turn into risk-neutral after diversifying away the idiosyncratic risk by investing in portfolios. Therefore, risk neutral shareholders will encourage CEOs to make risky investments for risky projects that may generate more profit for the firm (Jafri and Trabelsi, 2014). However, since managers cannot diversify away the risk, they have to make investment decisions that are best for their current as well as their future career. So they avoid investing in risky projects, even if the projects tend to enhance firm value (Hirshleifer and Thakor, 1992).

When CEOs are encouraged to take more risk, they tend to protect themselves by generating excess compensation (Jafri and Trabelsi, 2014). Therefore, one can predict that when managerial risk increases, there is also an increase in executive compensation. In the setting of this study, one then predicts that since zero lower bound policy promotes managerial risk-taking, it will also result in an increase in executive compensation. Managerial risk-taking is the mediator in this relation.

To test these hypotheses, the study used a sample of U.S. publicly traded companies and their executives' compensation for two periods, before and after the zero lower bound policy. Firm managerial risk taking was proxied by using investment, R&D expenditure and capital expenditure (Bargeron et al., 2010). Executive compensation was estimated as the average executive total compensation documented in the Execucomp database. There was control for the effects of other variables, such as firm size, total debt, sales growth, earnings before interest and tax, and market to book ratio, which are believed to have an impact on the relations (Bargeron et al., 2010).

Results of this study showed that there is a significant relation between zero lower bound policy and managerial risk taking. In turn, it leads to an increase in executive compensation. The empirical analysis revealed that after zero lower bound policy was implemented after 2008, there was an increase both in firms' managerial risk taking and executive total compensation. There were also tests to show that the increase in executive compensation was caused by the partial mediation effect of managerial risk-taking. At the same time, zero lower bound policy can have a direct impact on executive total compensation.

This study contributes to current literature that examines the micro-impact of zero lower bound policy on companies. This analysis consisted of three parts: the relation between zero lower bound policy and managerial risk-taking; the relation between managerial risk-taking and executive compensation after zero lower bound policy; and the mediation effect of managerial risk-taking. This study is an extension to the Di Maggio and Kacperczyk (2014) study and further analyzed zero lower bound policy's impact on managerial risk-taking variation and even executive compensation.

The study results can also be of use to practitioners. This study is not only important to the U.S. market but is also important to the world economy. Zero lower bound policy was also implemented by other economies such as the Eurozone, U.K., and Japan. A negative interest rate policy of -0.1% was imposed in Japan on February 16, 2016. Before Japan, the Eurozone already had a negative interest rate. Still, this is a first for the world's third-largest economy. The Bank of Japan stated "the Bank of Japan will cut interest rates further into negative territory if judged as necessary". The intention of this negative interest rate policy is to achieve an inflation target of 2% (BBC News, 1/29/16).

With the large-scale implementation of zero lower bound policy, the study results provided insights of its influence on general firms and should be considered by policy makers when they evaluate the impact of zero lower bound policy on the economy. For possible future studies concerning the negative interest rate policy, the study results can also provide guidance. The study can also be of importance to investors and boards of directors so they can better understand executive's risk-taking behavior after zero lower bound policy.

This remainder of this document is organized as follows. Section 2 presents a discussion of related literature and the hypotheses development. Section 3 describes the methodology, sample, and data used for empirical tests. Section 4 contains the results of the relations between zero lower bound policy, managerial risk-taking and executive compensation. Section 5 provides robustness tests to support the main hypotheses. Section 6 concludes and provides possible future extensions.

2. Related literature and hypotheses development

This section reviews the literature on managerial risk-taking and executive compensation and then develops the hypotheses concerning their relations with zero lower bound policy.

2.1 Zero lower bound policy and managerial risk-taking

It is widely proved by various streams of literature that external policies can have an impact on firms' risk-taking. For example, Defond et al. (2014) suggest that IFRS adoption affects firm level "crash risk", which is the frequency of extreme negative stock returns. Academics and policy makers have always supported the idea to introduce a complementary macro-prudential framework to make sure of financial stability (Hanson, Kashyap and Stein, 2010). In addition, Vazquez and Federico (2015) find that country-specific macroeconomic environment plays an important role in the likelihood of bank failure. They also prove that monetary conditions are also related with the likelihood of bank failure. Therefore, introducing the impact of macro policy on firms when studying risk-taking is a must based on prior literature.

Zero lower bound policy is a decision that the U.S. Federal Reserve made that aimed to lower the short-term nominal interest rates to zero after the financial crisis of 2007-2008. The initial announcement of zero lower bound policy was made in December 2008. Even though it was proposed as a short-term policy, a series of later announcements were made stating that this short-term rate would stay near zero for a longer time period. This policy was in effect until December 2015.

Since this policy was implemented, there has been an intense debate on whether it has positive or negative effects on the national economy. The Federal Reserve insists that this policy has made continuing progress toward maximum employment and price stability. Thus, zero lower bound policy should still be effective until employment and price goals are reached. There is evidence showing that the zero lower bound policy can help central banks to reduce average inflation rates (McCallum, 2000). But at the same time, a similar action in Japan failed to prevent a prolonged macroeconomic slump because of the near-zero nominal interest rate, which provides support to the critics of zero lower bound policy.

Critics believe that because the nominal interest rate is approximately zero, the central banks are helpless to provide macroeconomic stimulus (McCallum, 2000). Goodfriend (2000) held the position that nominal interest rates can be negative occasionally and temporarily when needed, but not for a long time. Because if zero lower bound policy is in effect for long, it can cause liquidity trap and limit the capacity that the central bank has to stimulate economic growth.

Defond et al. (2014) find that crash risk decreases among non-financial firms after they adopt IFRS, while crash risk does not change for financial institutions. This suggests a possible difference of reaction to external policies. Therefore, this study believes that there is a need to analyze the impact of zero lower bound policy even if there is evidence based on financial industry documented in previous research.

2.1.1 Possible positive impact of zero lower bound policy on risk-taking

Before the zero lower bound policy, there was already a stream of literature studying monetary policy's impact on managerial risk taking. Most recently, Jiménez G et al. (2014) studied the issue using Spanish bank data and found that a low overnight interest rate can lead to risker lending. This result was found by comparing banks' lending volume, borrowers' ex-ante risk, and loans' chance of default. In conclusion, this stream of research reached the conclusion that monetary policy drives banks risk-taking (Jiménez et al., 2014).

Even though it was shown that there is a strong relation between monetary policy and risk-taking, most research addressed this issue using banks and little has been done using firms in other industries besides financial institutions. Thus, this study focused on firms that were outside the financial industry and studied their risk-taking behavior due to monetary policy interest rate change. Following Di Maggio and Kacperczyk (2014), this study found that the U.S. zero lower bound policy is an optimal situation to solve the problems at hand.

Di Maggio and Kacperczyk (2014) empirically examined the zero lower bound policy's impact on U.S. money funds. They found that money funds tend to invest in risker assets in response to the zero lower bound policy's initial announcement and the following announcements, which declared the zero interest rates would be maintained. Similarly, Kim and Olivan (2015) also suggest that low interest rate is associated with excessive risk taking for mutual funds. Mutual funds take higher risk for they want to attract new money and more investors. But as empirical results show, the cost of high returns in fact offset the profit. Therefore, this increased risk-taking does not benefit investors. They all support a strong interaction between unconventional low interest rate policy and mutual funds' risk-taking behavior (Chodorow-Reich, 2014).

Besides the study of this policy's impact on the money fund industry, previous studies examined its impact on the banking industry. The results were consistent. They all found that as a result of low interest rates, banks will increase risk-taking in lending and less-capitalized banks even lend to riskier firms (Adrian and Shin, 2010; Jiménez et al., 2014; Maddaloni and Peydró, 2011).

As a result of banks' softening their lending standards, firms that didn't have capital resources due to high firm risk could now have access to more capital and thus invest in risky portfolios. Besides the case for risky firms, Maddaloni and Peydró (2011) confirmed that in general, lower short-term interest rates would soften banks' lending standards for retail and corporate loans, resulting in more available capital resources for firms. With banks' lower interest rates and relaxed lending standards, companies are expected to invest more in risky portfolios, hoping to generate higher returns.

In addition, since zero lower bound policy results in a decrease in bank profit, bank owners will seek to compensate for the utility loss from this capital regulation by increasing bank risk (Laeven and Levine, 2009). Evidence documented in previous research showed that this same rule also applies to companies in other industries. Buser et al. (1981) found that owners might compensate for the loss of utility due to more stringent capital requirements by selecting a risker investment portfolio. Therefore, when companies' profits are reduced because of the zero lower bound policy, management may seek to invest in risky assets to compensate for their losses.

Altunbas et al. (2009) find that unusually low interest rates over an extended period of time cause an increase in banks' risk taking. They believe that the low interest rate can affect banks in three ways. Firstly, it can affect cash flows and incomes, and in turn impact how bank measure risk (Adrian and Shin, 2009). Secondly, since low interest rate can lead to low returns on investment, managers will take more risk to meet the target nominal return (Brunnermeier, 2001). Thirdly, it can also induce a decrease in risk aversion by banks and other investors. Changes in risk perception and risk tolerance due to monetary policy are studied by Borio and Zhu (2012).

Looking at the evidence documented in previous research, there is sufficient reason to believe that zero lower bound policy has an impact on firms' managerial risk-taking. But since all prior studies focused on the banking and money fund industries, this study used firm samples not limited to those industries. As a result, this study contributes to this stream of literature by adding further evidence of zero lower bound policy's impact on managerial risk-taking across all industries.

This study has the following first hypothesis:

H1a: There is an increase in managerial risk-taking after the implementation of zero lower bound policy.

2.1.2 Possible negative impact of zero lower bound policy on risk-taking

With all the evidence supporting the positive impact of zero lower bound policy on firms' managerial risk-taking, there is also the possibility that the impact can be negative. There are two possible reasons as to why zero lower bound policy might result in a decrease in firms' managerial risk-taking. This relationship is illustrated in this section.

On one hand, public saving goes down as a result of low nominal interest rates, and therefore banks lack funds to lend to companies. Thus, companies cannot get many loans from banks and do not invest in risky projects due to inadequate cash flow. It was already shown that when banks are unable to raise enough funds to continue lending, their loan supply would decease and in turn affect their bank-dependent borrowing (Kishan and Opiela, 2000). Gambacorta and Mistrulli (2004) studied the difference in response of lending to monetary policy due to differences in capital ratios. They found that well-capitalized banks are less affected by monetary policy because they have better access to non-deposit fund-raising.

In other words, banks' funding is affected by interest rate change, even though the impact degree can differ based on their access to non-deposit funds. Gambacorta and Mistrulli (2004) also point out that when studying regulations, it is necessary to consider the macroeconomic consequences on banks. As a result of banks loosing deposit funds, there is a possibility that firms couldn't borrow enough money from banks and decrease their risk-taking.

On the other hand, since zero lower bound policy is squeezing banks' profit growth (Gross, 11/3/15), banks are less willing to lend to companies. According to Giulioni (2015), when a policy announces a decrease in interest rate, it implies a reduction of interest rate charged on corporate loans. In turn, banks' average rate of return will shrink. Since corporate loans cannot generate the desired profit for banks, they become less willing to provide loans. This causal relationship was discussed in detail by Goyal and McKinnon (2003) using Japanese sample firms.

Japan was the first nation that started to use zero lower bound policy in modern times. Therefore, studying the consequences of Japanese zero lower bound policy can provide guidance to the U.S. market. The result of implementing zero lower bound policy is pushing the lending interest rates towards zero and thus squeezing banks' profit margins. When banks earn less profit from lending, it becomes impossible for them to write off previous bad loans using current profit. This implies that Japanese banks cannot earn enough profit to cover the losses they generate from past and current loans. In order to solve this problem, banks have the intention to raise lending rates.

However they are not able to raise interest rates significantly due to two possible reasons. They might lose credit-worthy clients as a result of raising lending rates. Another possibility is that small and medium companies, banks' primary clients, would raise their risk of default if banks raise lending rates because these companies are already heavily indebted. Therefore, this only leaves banks with one option to maximize their profit and minimize their loss: decrease commercial lending and getting more low-transaction-cost government bonds (Goyal and McKinnon, 2003). From the companies' point of view, banks are reluctant to make new loans so firms are not getting enough funds from banks. Finally, companies aren't able to make risky investments due to insufficient funding.

Based on these two possible reasons, the following hypothesis is stated:

H1b: There is a decrease in managerial risk-taking after the implementation of zero lower bound policy.

2.2 Zero lower bound, managerial risk-taking, and executive compensation

Choi and Kronlund (2014) find that when funds change their investment portfolio to reach for yield, they experience increased cash flow. This indicates that investor react positively to funds' higher risk-taking behavior. Similar conclusions are drawn by Rajan (2013) and Borio and Zhu (2012). They all indicate low interest rate policy promotes investors to reach for yield and take higher risk. As a result, theses funds generate higher return (Choi and Kronlund, 2014). Even though it is also suggested that the superior performance can be explained by risk-taking rather than better skill, investors do invest more money in theses high-risk-taking funds. This suggests that investors approve of high risk-taking of money funds and believe that higher risk can provide them higher return.

Theoretically, executive compensation should reflect executives' managerial skill, firm performance, their ability to maximize shareholder value, etc. Practically, most firms form compensation committees to ensure the rationality of executive compensation plans. The final decisions concerning levels and structures of executive pay are often made by outsider directors who are aware of the conflicts of interests between shareholders and executives. Therefore, if shareholders believe that the investment decisions made by the executives can help them generate high profit, they will recognize the effort made by executives and compensate more for their better performance. But at the same time, one cannot deny that CEOs and top managers can have at least some influence over both their compensation levels and compensation structure (Murphy, 1999).

Based on agency theory, we know that shareholders and managers have agency problems for their goals and desires are different. The underlying problem is the separation of ownership and control of the corporation (Garen, 1994). Therefore, even though the manager should be acting in the best interests of the shareholders, the manager may not be acting this way in reality.

Among the many conflicts of interests between shareholders and executives, the difference in risk preference is one factor that may influence executive pay. Agency theory suggests that managers tend to be more risk adverse than shareholders (Eisenhardt, 1989). Even though both shareholders and executives are risk adverse, shareholders can diversify away the idiosyncratic risk by investing in different stocks and forming portfolios. On the other hand, executives have much of their economic wealth as well as their reputation tied to the firm. Thus, they cannot diversify away the risk because bad investments may cause them big losses (Milgrom and Roberts, 1992).

Therefore, only executives remain risk adverse with respect to firm performance. Core et al. (2003) came up with a theory that risk and return go hand-in-hand and one cannot generate high returns without taking high risks. As a result, the main goal for shareholders is to maximize their returns. Since high returns are often generated by investments with high risks, shareholders tend to favor high-risk investment choices.

But at the same time, executives are not willing to make risky decisions due to two reasons. First, their wealth portfolios cannot be diversified as shareholders can because their stock options are within the firms. Second, they will receive market penalties if the risky investments they choose fail to generate high returns in the end. Market penalties may include a devaluation of the executives' reputations, leading to a negative impact on their future careers in the labor market.

Principal-agent theory suggests that companies design executive compensation contracts with the intention to yield optimal incentives, thereby motivating the executives to maximize shareholder wealth. In the process of designing the contracts, shareholders are aware that executives are risk adverse. Thus, they impose more incentives that will generate more compensation for agents for increased risk (Conyon, 2006).

Since executives are encouraged to take higher risks, agency theory suggests that they would protect themselves by obtaining excess compensation (Jafri and Trabelsi, 2014). They may gain excess compensation directly or indirectly. Aboody and Kaszinik (2000) suggested that executives might manipulate the company's stock price to show shareholders that the company has good performance and thereby gain excess compensation. Executives may also raise the fixed component of their pay and reduce the variable portion to gain excess compensation directly (Aggarwal and Samwick, 1998). Either way, they want to make up for the potential in their compensation and future career losses generated by taking higher risks. In conclusion, it was shown in previous research that there is a positive relation between managers' risk-taking and executive compensation level.

As mentioned in Section 2.1, the implementation of zero lower bound policy may have a positive impact on managerial risk-taking. Sufficient evidence was documented in previous research supporting the positive relation between managerial risk-taking and executive compensation (Chen et al., 2006; Rajgopal and Shevlin, 2002). Therefore, this study proposed that after the implementation of zero lower bound policy, there is an increase in executive compensation. Since this policy shouldn't have a direct impact on executive compensation, this positive relation should only exist because of the mediation effect of managerial risk-taking.

This leads to the following hypothesis:

H2: The implementation of zero lower bound policy leads to an increase in managerial risk-taking, which in turn leads to an increase in executive compensation.

3. Research design

This section explains the methodology used to test the hypotheses in this study. By defining the independent and dependent variables, it also introduces the samples used and data sources.

3.1 Sample

The empirical tests aimed to identify the impact of zero lower bound policy on firms' managerial risk-taking and executive compensation. The sample consisted of 1,480 U.S. publicly traded companies for which sufficient data exists in the Compustat and Execucomp databases. The sample firms exclude those firms from financial sectors according to Fama and French (1997). These firms represent all companies those databases for which there exists consistent data before and after the implementation of zero lower bound policy. Specifically, the study required the following variables to be available during the 2004-2014 period for companies to be included in the sample: capital expenditure, executive total compensation, firms' book value of asset and firms' market value of asset. Since data on R&D expenditure is small, the study treated missing values of R&D expenditures as zero when performing regression analysis.

3.2 Data

The fundamental accounting data for sample companies was collected from the Compustat database. For every firm in the period of 2004-2014, the following accounting data was collected: R&D expenditures, capital expenditures, sale of property plant and equipment, total assets, total debt, book value of assets, market value of assets, earnings before interest and tax, and sales. The internal governance measure, B-Index, was defined according to Baber et al. (2012). It focused mainly on the role of director independence. The variables were defined as indicated in Appendix I.

Executive compensation data was collected from the Execucomp database. For every firm in the period of 2004-2014, the following compensation data was collected: total compensation and S&P Index. The study defined the variable TDC as Total Compensation (including Salary, Bonus, Other Annual, Total Value of Restricted Stock Granted, Total Value of Stock Options Granted (using Black-Scholes, 1973), Long-Term Incentive Payouts, and All Other Total).

There are several traditional measures of risk-taking used in previous research. Abnormal stock return volatility and standard deviation of abnormal stock returns is a set of risk-taking measures based on market performance (Kravet, 2014; Bova et al., 2014). Based on stock returns, Cole et al. (2006) also use the logarithm of the variance of daily stock returns over a certain period of time to measure risk. This measure is commonly found in executive compensation literature. In addition, idiosyncratic risk is also a risk-taking measure that is commonly used in accounting research (Barber et al., 2013). It represents the risk associated with firm's investment portfolios. There is also an accounting measure of risk-taking, which is developed by John et al. (2008), that is based on firms' earnings.

Previous literature also uses research and development expense (R&D) and capital expenditure (CAPEX) as risk taking proxies. Evidence documented in prior research consistently shows that research and development expense is positively associated with firms' risk taking, while capital expenditure is shown to be both positively (Bargeron et al., 2010; Cohen et al., 2013) and negatively (Coles et al., 2006) related to firms' risk-taking. Following this stream of literature, we decide to use the sum of research and development expense and capital expenditure, defined as investment, R&D, and CAPEX to be our proxies for firms' risk-taking.

Laeven and Levine (2009) imply when banks have different corporate governance structures, the same regulation can have different effects on their risk taking. John et al., (2008) suggest that ownership structure can have an impact on corporate risk taking. In addition, Agrawal and Mandelker (1987) find that there is a negative relation between the degree of managerial control and firms' risk taking. Based on the evidence documented in previous literature, the study controlled for governance structure, b-index, in its models.

4. Empirical results

This section presents the main empirical results. First, the positive relation between the implementation of zero lower bound policy is shown. Next, it looks at the mediation effect of managerial risk on the relation between the implementation of zero lower bound policy and executive compensation.

To test whether managerial risk-taking and executive compensation for publicly traded U.S. companies increased significantly after the zero lower bound policy, both correlation analysis and multivariate regression analysis were performed. Each analysis is discussed as follows.

4.1 Summary statistics and correlations

Table 1 provides summary statistics of the data and for the variables. Panel A shows the summary for the whole sample and Panel B are the descriptions for the variables used in the study. From the number of observations of R&D and other data of interest, one can see that there are more than 3,000 missing R&D expenditures data in total. So to maintain sufficient data size, the analysis treats them as zero when performing the regressions.

In addition, correlation analysis was run to see the correlations between variable ZLB and the managerial risk-taking proxies & ZLB and the executive compensation proxy. Table 2 shows the correlation results. Correlation coefficients that are significant at 1% level are marked with *.

Table 1: Summary Statistics

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. Panel A reports descriptive values of sample firms over the entire sample period. Panel B reports descriptive statistics for variables used in the study. The variables presented in Panel B are defined in Appendix I.
All variables in Panel B are Winsorized at the 1st and 99th percentiles.

Panel A: Descriptives

Variable	Observations	Mean	Std.	Minimum	Maximum
Average Executive Compensation (Thousands)	8778	2837	3010	96.93	72533
Research and Development (Millions)	5331	302.5	937.5	0	10991
Capital Expenditure (Millions)	8778	566.8	1986	-2285	47289
Total Asset (Millions)	8778	10620	36774	52.24	797769
Sales (Millions)	8778	8430	25710	2.960	474259
Earnings Before Interest and Taxes (Millions)	8778	1014	3301	-11982	66290
Market Value (Millions)	8778	10418	30475	30.28	626550
Book Value (Millions)	8778	3719	10727	-86154	174399
Total Debt (Millions)	8778	717.7	8494	0	382407

Panel B: Variables used in the study (Defined in Appendix I)

Variable	Observations	Mean	Std.	Minimum	Maximum
AVE_TDC	8778	2.695	3.141	-1.268	20.15
INVEST	8778	0.198	0.203	-0.170	1.284
RD	8778	0.0563	0.104	0	0.668
CAPEX	8778	0.140	0.164	-0.0903	0.955
ZLB	8778	0.487	0.500	0	1
SIZE	8778	7.819	1.512	4.887	11.79
SALESG	8778	0.0716	0.177	-0.568	0.636
EBIT	8778	0.253	0.286	-0.661	1.849
MB	8778	2.964	2.708	-1.475	18.47
DEBT	8778	0.0409	0.0837	0	0.554
B-INDEX	8778	4.717	0.922	0	6

Table 2: Correlation analysis

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. ZLB is an indicator variable equal to one for the post-ZLB policy period (2009-2014), and equals to zero if otherwise. R&D is set equal to zero if R&D is missing. All remaining variables are defined in the Appendix I. Correlation coefficients with * are significant at the 1% level.

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
AVE_TDC	-										
INVEST	0.3157*	-									
RD	0.3134*	0.5271*	-								
CAPEX	0.1662*	0.8255*	-0.00560	-							
ZLB	-0.0314*	-0.0489*	-0.0342*	-0.0408*	-						
SIZE	-0.4669*	0.1278*	-0.0838*	0.2177*	0.1145*	-					
SALESG	-0.0237	0.0446*	0.0265	0.0317*	-0.2101*	-0.0433*	-				
EBIT	0.1583*	0.2065*	0.0195	0.2544*	-0.00930	0.1826*	0.1539*	-			
MB	0.3748*	0.3185*	0.2909*	0.1883*	-0.0928*	0.000	0.1021*	0.6122*	-		
DEBT	-0.0758*	0.0652*	-0.0568*	0.1255*	0.0125	0.2398*	-0.0725*	0.0274	-0.1222*	-	
B-INDEX	0.1036*	0.0027	0.0853*	-0.0611*	0.1366*	-0.1879*	-0.0232	-0.0361*	0.0093	-0.0917*	-

One can see in Table 2 that AVE_TDC, INVEST, R&D, and CAPEX all have negative relations with the dummy variable ZLB. The negative relations are all significant at the 1% level. This correlation result does not contradict with the previous hypotheses that ZLB should be positively related with managerial risk-taking and executive compensation for all the risk measures are scaled by average book value of assets. To study the relations between the main variables of interest, one needs to account for control variables. Univariate analysis cannot fully reflect the relations that were investigated. Therefore, the analysis used the multivariate regressions to see the proposed relations correctly. The regression results are shown in the following sections.

In addition, one can see that the correlation between AVE_TDC and the three risk-taking measures are all positively significant, suggesting a positive relation between compensation and risk-taking as shown in prior studies.

Since the correlation results don’t show support for the hypotheses, the analysis also graphed the trends of R&D expenses and capital expenditures as shown in Figure 1 and Figure 2. From these two figures, one can clearly see an increase in R&D expenses and capital expenditures after 2009 when the zero lower bound policy was first announced. The Federal Interest Rate graph is also presented in Figure 1.

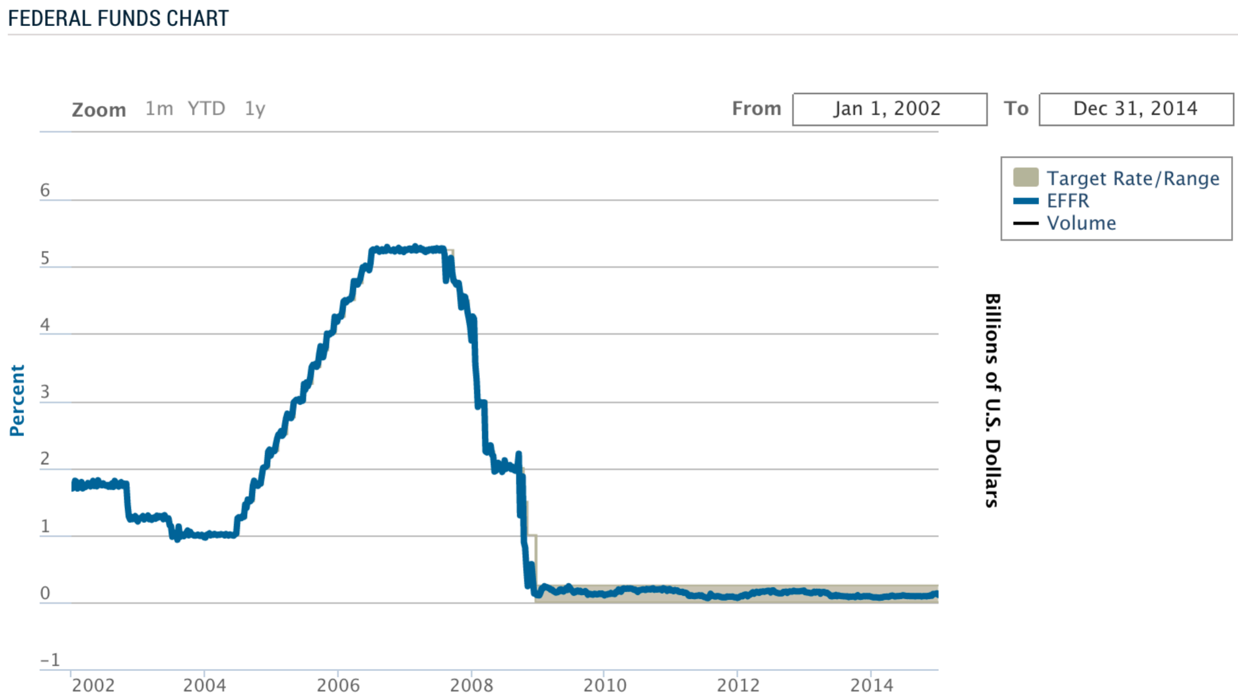
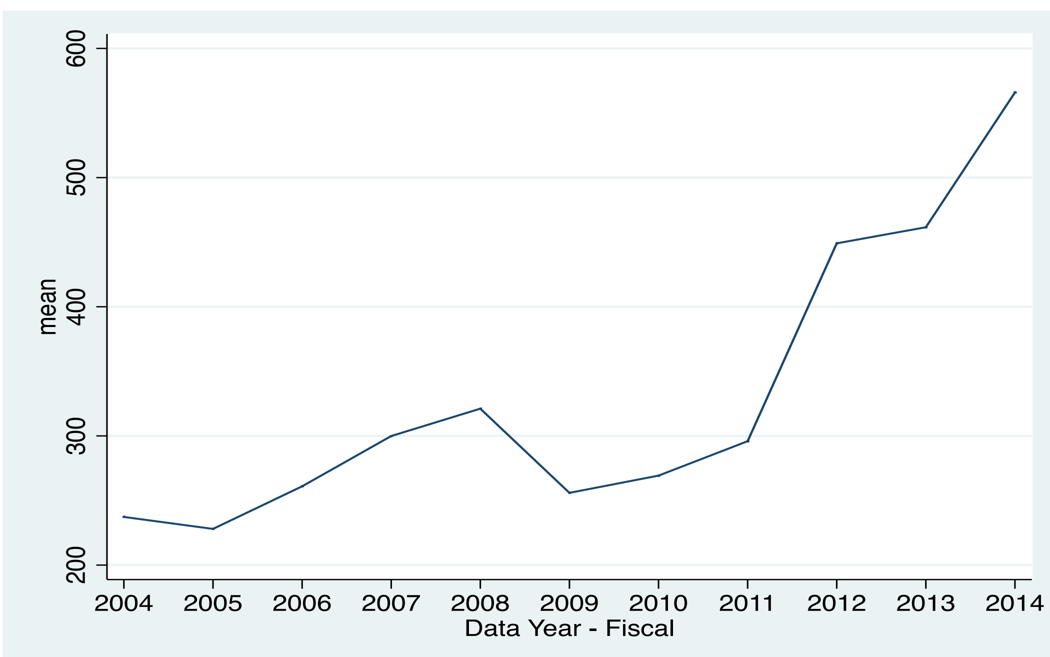


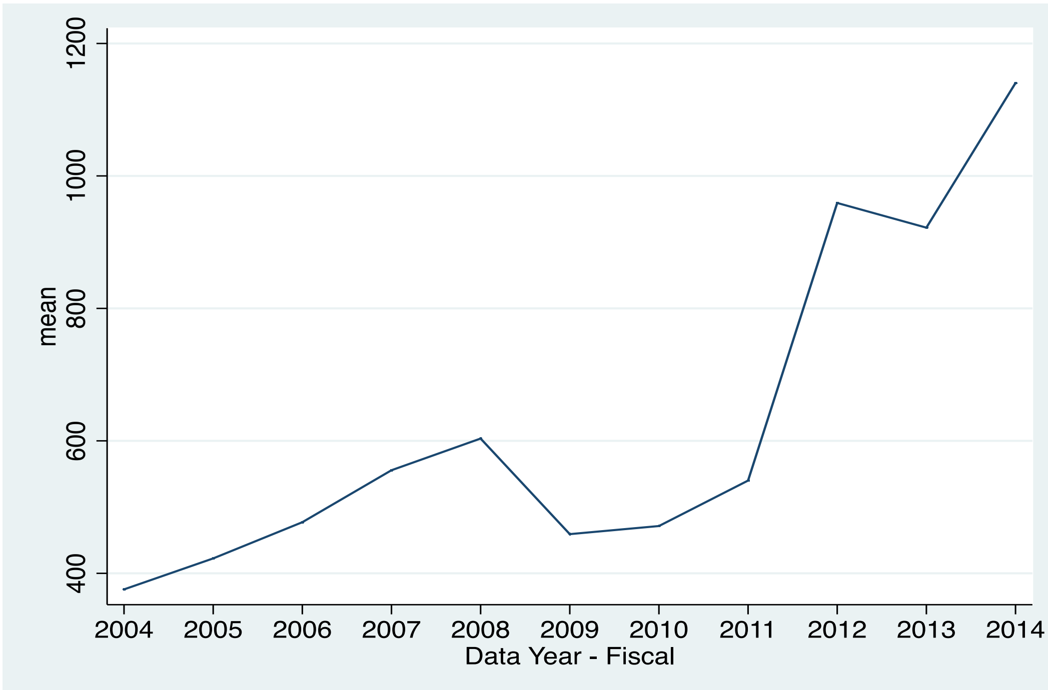
Figure 1: Historical Interest Rates

Source: Federal Reserve (https://apps.newyorkfed.org/markets/autorates/fed%20funds)



Unit for R&D: Millions

Figure 2: R&D Trends from 2004-2014



Unit for Capital Expenditures: Millions

Figure 3: Capital Expenditure Trends from 2004-2014

4.2 Basic regression results

To investigate deeper on the relations among zero lower bound policy, managerial risk-taking and executive compensation, the analysis estimated a series of regression equations consisting of control variables.

4.2.1 Zero lower bound policy and managerial risk-taking

To identify the link between zero lower bound policy and companies' managerial risk-taking, the analysis estimated the regression of INVEST, R&D, and CAPEX on ZLB (a dummy variable equals to 1 after zero lower bound policy and 0 otherwise) over the sample period as presented in Equations (1) to (3) below.

$$INVEST_{it} = a_0 + a_1 ZLB + a_2 X_{it} + \varepsilon_{it} \qquad (1)$$

$$R\&D_{it} = a_0 + a_1 ZLB + a_2 X_{it} + \varepsilon_{it} \qquad (2)$$

$$CAPEX_{it} = a_0 + a_1 ZLB + a_2 X_{it} + \varepsilon_{it} \qquad (3)$$

In all regressions, the analysis controlled for other variables that may affect managerial risk-taking (represented by X), such as firm size (SIZE), debt (DEBT), earnings before interest and taxes (EBIT), sales growth (SALESG), market to book ratio (MB) and b-index (B_INDEX). Furthermore, it accounted for any time-variant and firm-specific characteristics by introducing year-fixed and firm-fixed effects. The analysis clustered standard errors at the year dimension to account for any cross-sectional dependence of residuals due to the commonality of interest rates across firm observations. The results are reported in Table 3.

Table 3: Multivariate regression analysis

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in Model (1) is INVEST, in Model (2) is R&D, and in Model (3) is CAPEX. ZLB is an indicator variable equal to one for the post-ZLB policy period (2009-2014), and equals to zero if otherwise. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix 1. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels. The estimates are from firm fixed and year fixed effects regressions. P-values are in brackets.

	(1) INVEST	(2) RD	(3) CAPEX
ZLB	0.059***	0.022***	0.034***
	(0.009)	(0.005)	(0.007)
SIZE	-0.047***	-0.023***	-0.019**
	(0.009)	(0.004)	(0.007)
DEBT	0.049	0.016	0.030
	(0.048)	(0.013)	(0.039)
EBIT	-0.013	-0.012	0.008
	(0.024)	(0.010)	(0.015)
MB	0.024***	0.007***	0.014***
	(0.004)	(0.002)	(0.002)
SALESG	-0.003	-0.007	0.004
	(0.012)	(0.005)	(0.009)
B-INDEX	0.001	0.001	-0.00009
	(0.002)	(0.001)	(0.002)
Constant	0.457***	0.199***	0.231***
	(0.072)	(0.032)	(0.053)
Year-Fixed Effects	Yes	Yes	Yes
Firm-Fixed Effects	Yes	Yes	Yes
Adjusted R^2	0.128	0.076	0.097
F	15.158	4.664	13.869
N	8778	8778	8778

Standard errors in parentheses

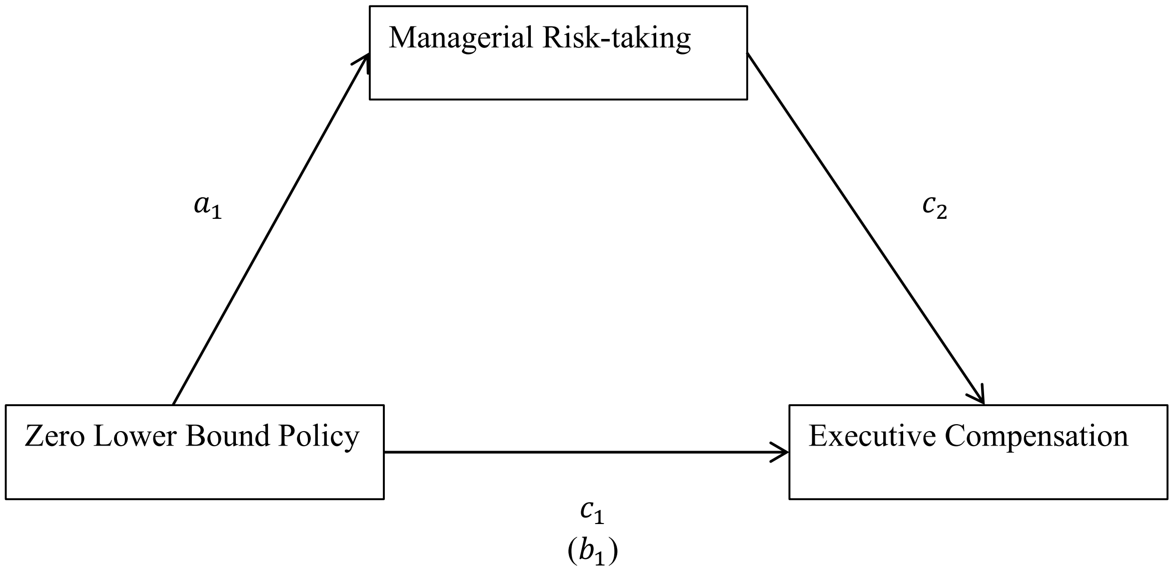
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results show that INVEST, R&D, and CAPEX increased significantly in the post-zero lower bound policy period, consistent with hypothesis H1a. For example, column 1 reports the regression results of INVEST being the dependent variable; the coefficient on the dummy variable is positive and significant at 0.1% level, indicating that INVEST was significant higher for sample firms in the post-zero lower bound policy period.

Table 3 also reports similar results for R&D and CAPEX regressions. These results are consistent with the prediction that zero lower bound policy resulted in an increase in managerial risk-taking for publicly traded U.S. firms. Since our hypothesis is directional, we also decide to perform an on-sided test to see whether the coefficient of ZLB is indeed positive. The one-sided t-test results show that the possibility of a positive ZLB coefficient is 99.99% for all three risk-taking measures. Overall, all of the regression results show a significantly positive correlation between zero lower bound policy and managerial risk-taking, in support of hypothesis H1a.

4.2.2 Mediation effect of managerial risk-taking

According to Table 3, the results show support for hypothesis H1a that zero lower bound policy leads to an increase in managerial risk-taking. The positive relation between managerial risk-taking and executive compensation was already documented in prior research. Thus, this study proposed that the executive compensation increased after zero lower bund policy as a result of the mediation effect of managerial risk-taking. The analysis in this study used the mediation model proposed by Baron and Kenny (1986). In summary, the mediation model concerning zero lower bound policy, managerial risk-taking, and executive compensation as proposed is shown in Figure 4.



The figure represents relations between variables as well as their direct and indirect effects. All the coefficients besides the paths are defined as the coefficients in Equations (1) to (5). These are the coefficients are the ones needed to evaluate and test the mediation hypothesis.

Figure 4: Path diagram for mediation

The study used this three-step model to test for possible mediation effects. The first step was to test if there is a significant relation between zero lower bound policy and executive compensation. Equation (4) was used for this step. It mainly evaluated the significance of b_1. The second step was to show that zero lower bound policy is positively related to managerial risk-taking. Since a_1 is positive and significant for H1, then it is already confirmed that zero lower bound policy can lead to an increase in managerial risk-taking. Finally, one has to see if zero lower bound policy and managerial risk-taking can impact executive compensation when they are both present in the regression. This regression was performed using Equation (5). In this regression equation, it focused on coefficients c_1 and c_2. The regression results are presented in Table 4.

$$AVE\_TDC_{it} = b_0 + b_1 ZLB + b_2 X_{it} + \varepsilon \quad (4)$$

$$AVE\_DC_{it} = c_0 + c_1 risk_{it} + c_2 ZLB + c_3 X_{it} + \varepsilon \quad (5)$$

Table 4: Mediation analysis

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in all models is AVE_TDC. The independent variable in Model (1) is dummy variable ZLB, which equals to one for post-ZLB policy period (2009-2014) and zero for pre-ZLB policy period (2004-2008). The independent variable in Model (2) is ZLB and INVEST, in Model (3) is ZLB and R&D, and in Model (4) is ZLB and CAPEX. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix I. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels. The estimates are from firm fixed and year fixed effects regressions.

	(1)	(2)	(3)	(4)
	AVE_TDC			
	ZLB	INVEST	RD	CAPEX
ZLB	0.523***	0.122	0.235+	0.256*
	(0.147)	(0.128)	(0.138)	(0.130)
INVEST		6.838***		
		(0.652)		
RD			13.123***	
			(1.893)	
CAPEX				7.900***
				(0.886)
SIZE	-1.507***	-1.185***	-1.210***	-1.354***
	(0.160)	(0.142)	(0.151)	(0.148)
DEBT	1.616**	1.280*	1.410**	1.378**
	(0.491)	(0.518)	(0.488)	(0.511)
MB	0.371***	0.209***	0.279***	0.262***
	(0.053)	(0.041)	(0.051)	(0.046)
EBIT	-0.156	-0.069	0.008	-0.217
	(0.301)	(0.218)	(0.248)	(0.261)
SALESG	-0.684***	-0.665***	-0.587***	-0.714***
	(0.202)	(0.176)	(0.174)	(0.186)
B-INDEX	0.018	0.009	0.011	0.019
	(0.040)	(0.036)	(0.038)	(0.037)
Constant	13.143***	10.015***	10.526***	11.317***
	(1.300)	(1.136)	(1.207)	(1.180)
Year-Fixed Effects	Yes	Yes	Yes	Yes
Firm-Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.153	0.315	0.243	0.275
F	19.424	27.169	23.963	24.894
N	8778	8778	8778	8778

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Model (1) in Table 4 is the regression results for ZLB and AVE_TDC. This model includes all the control variables but only has ZLB as the independent variable. The coefficient of ZLB is positive (0.523) and significant at 0.1% level, suggesting that there is an increase in executive compensation after the zero lower bound policy is implemented.

Next, executive compensation on ZLB is regressed with managerial risk-taking measures. From the results of models (2) to (4), one can see that the coefficients for ZLB are not highly significant anymore. The coefficient for ZLB in Model (3), where R&D is the independent variable, is significant only at the 10% level. The coefficient is significant at the 5% level in Model (4). The most significance change is shown in Model (2) with INVEST as the independent variable. It is positive but not significant. However, the coefficients for risk-taking variables are highly significant at the 0.1% level. These results show that a partial mediation of risk-taking in the relation between zero lower bound policy and executive compensation is present.

After testing for mediation, there is another possibility where ZLB can have an impact on managerial risk-taking and executive compensation. In other words, ZLB is moderating the relation between risk-taking and compensation. If zero lower bound policy is an acting moderator, then it means that the relation between managerial risk-taking and executive compensation can be increasing or decreasing after the implementation of the policy. According to the theory, if there should be a moderation effect present, then it should be positive.

In short, the relation between managerial risk-taking and executive compensation becomes stronger after zero lower bound policy. This was not included as a hypothesis since there was not much theoretical evidence to believe in this possible relation. But based on existing evidence, when zero lower bound policy was implemented, the cost of money went down. It was shown that shareholders will award executives more for higher risk-taking (Conyon, 2006) and shareholders may be induced to award executives more since the cost of money decreased. Therefore, it was decided to further test for moderation of ZLB. The following model was used:

$$AVE\_DC_{it} = d_0 + d_1 ZLB + d_2 risk_{it} + d_3 ZLB \times risk_{it} + d_4 X_{it} + \varepsilon \quad (6)$$

The result for possible moderation testing is reported in Table 5. In this table, one can see that the coefficients of all three risk-taking measures are positive and highly significant (at the 0.1% level). This confirms the conclusions documented in previous research that higher managerial risk-taking is positively related to higher executive compensation.

The coefficients of the interaction terms in Model (2) and (4) are positive and significant at the 10% and 5% levels. This suggests that zero lower bound policy is moderating the relation between INVEST and executive compensation, and CAPEX and executive compensation. But for Model (3) where R&D is the independent variable, the interaction term is not significant. It means that zero lower bound policy does not moderate the relation between R&D and executive compensation.

One possible explanation would be that both managers and shareholders often treat R&D as a high-risk investment compared to capital expenditures (Kothari et al., 2002). Therefore, its relation with executive compensation does not change significantly after the implementation of zero lower bound policy because shareholders are aware of R&D's high risk and wouldn't reward managers more even if managers invest a lot in R&D. But since the cost of money is lower after the zero lower bound policy, shareholders may consider compensating managers more for investing more on capital expenditures such as property, plants and equipment.

Table 5: Moderation analysis

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in all models is AVE_TDC. The independent variable in Model (1) is dummy variable ZLB, which equals to one for post-ZLB policy period (2009-2014) and equals to zero if otherwise. The independent variable in Model (2) is ZLB, INVEST, and their interaction; in Model (3) is ZBL, R&D, and their interaction; and in Model (4) is ZLB, CAPEX, and their interaction. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix I. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels.

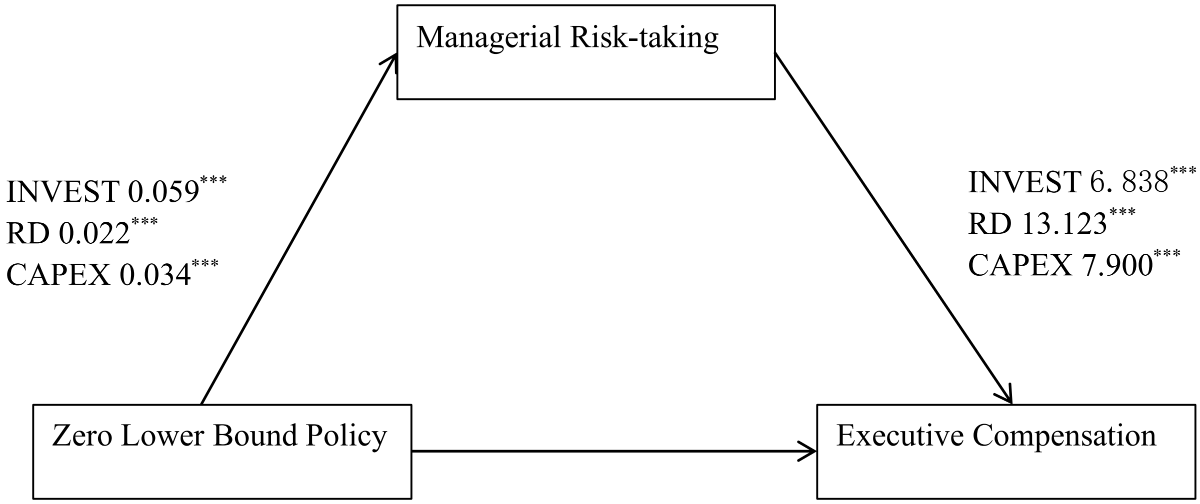
	(1)	(2)	(3)	(4)
	AVE_TDC			
	ZLB	INVEST	RD	CAPEX
ZLB	0.523***	-0.049	0.179	0.057
	(0.147)	(0.147)	(0.139)	(0.138)
INVEST		6.402***		
		(0.670)		
ZLB*INVEST		0.878+		
		(0.517)		
RD			12.611***	
			(1.878)	
ZLB*RD			1.045	
			(0.841)	
CAPEX				7.291***
				(0.870)
ZLB*CAPEX				1.379*
				(0.611)
SIZE	-1.507***	-1.182***	-1.200***	-1.362***
	(0.160)	(0.142)	(0.151)	(0.149)
DEBT	1.616**	1.281*	1.403**	1.396**
	(0.491)	(0.521)	(0.492)	(0.512)
MB	0.371***	0.211***	0.280***	0.264***
	(0.053)	(0.041)	(0.051)	(0.046)
EBIT	-0.156	-0.106	-0.017	-0.240
	(0.301)	(0.221)	(0.247)	(0.262)
SALESG	-0.684***	-0.657***	-0.586***	-0.703***
	(0.202)	(0.177)	(0.175)	(0.185)
B-INDEX	0.018	0.007	0.011	0.017
	(0.040)	(0.036)	(0.037)	(0.037)
Constant	13.143***	10.087***	10.478***	11.469***
	(1.300)	(1.144)	(1.206)	(1.193)
Year-Fixed Effects	Yes	Yes	Yes	Yes
Firm-Fixed Effects	Yes	Yes	Yes	Yes

Adjusted R^2	0.153	0.316	0.244	0.278
F	19.424	25.923	23.103	23.846
N	8778	8778	8778	8778

Standard errors in parentheses
$^{+} p < 0.10$, $^{*} p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

In summary, the regression results conclude with the following four figures. Figure 5 shows the coefficients of each path for mediation. One can clearly see that all coefficients for path one (zero lower bound policy to managerial risk-taking) are highly significant at the 0.1% level for all three risk-taking measures. The same results are documented for path two (managerial risk-taking to executive compensation). All three coefficients are positive and significant at the 0.1% level. For path three (zero lower bound policy to executive compensation), one can see that the coefficients are not very significant anymore.

Especially for INVEST, the coefficient is 0.122 but not significant. The other two coefficients are significant at the 10% and 5% levels respectively. Originally, path three was 0.523 and significant at the 0.1% level before introducing managerial risk-taking into the relation. Therefore, one can conclude that by introducing managerial risk-taking, the relation between zero lower bound policy and executive compensation is significantly weakened. It even disappears when risk-taking is measured by INVEST. On the other hand, the relation between managerial risk-taking and executive compensation is highly significant for all risk-taking measures.



The figure summarizes the coefficients size and significance for both mediation models and moderation models. All the coefficients besides the paths are defined as the coefficients in Equations (1) to (5). The detailed results are reported in previous regression tables.

Figure 5: Path diagram results for mediation

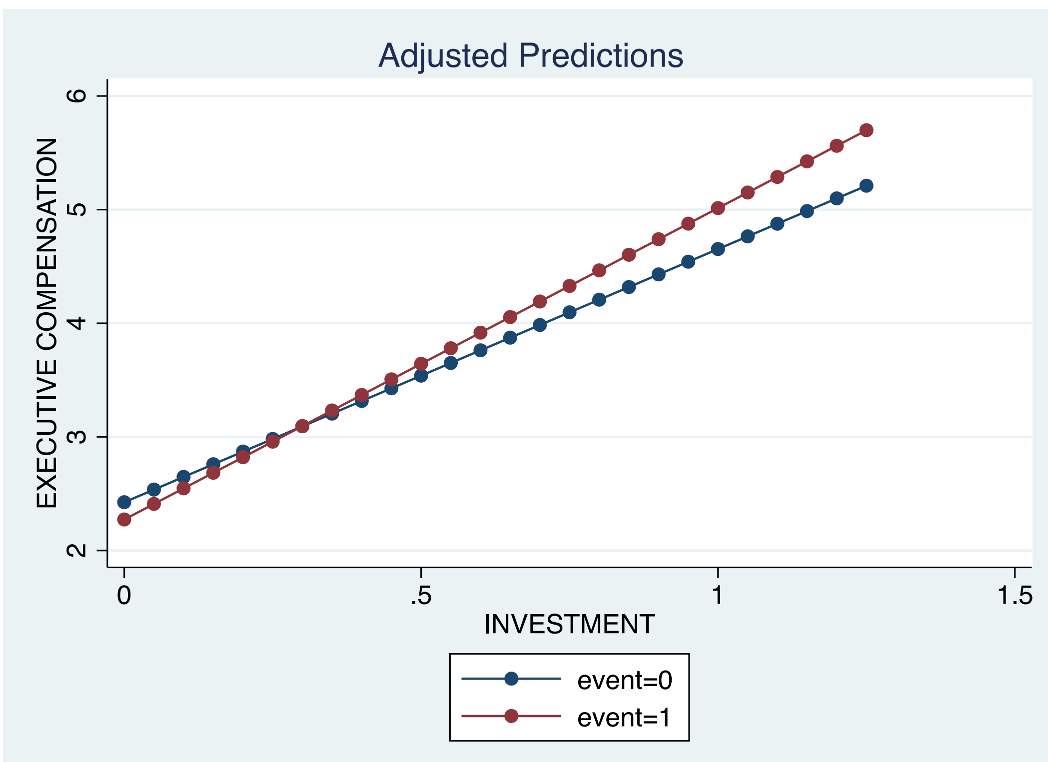


Figure 6: Moderation graph for INVEST and AVE_TDC

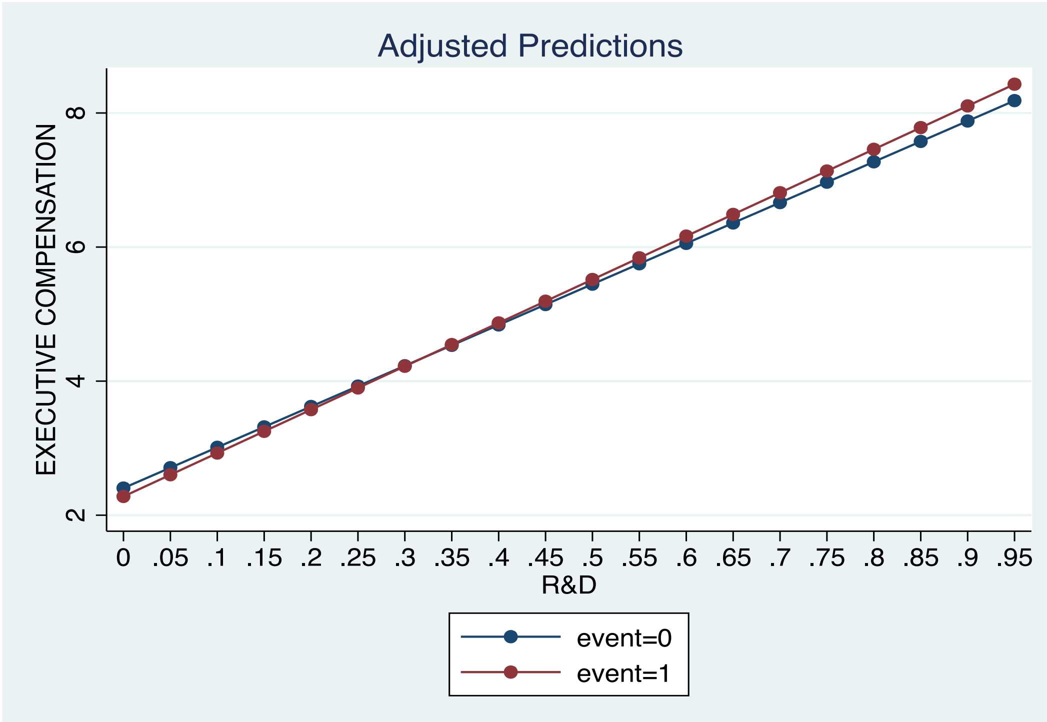


Figure 7: Moderation graph for RD and AVE_TDC

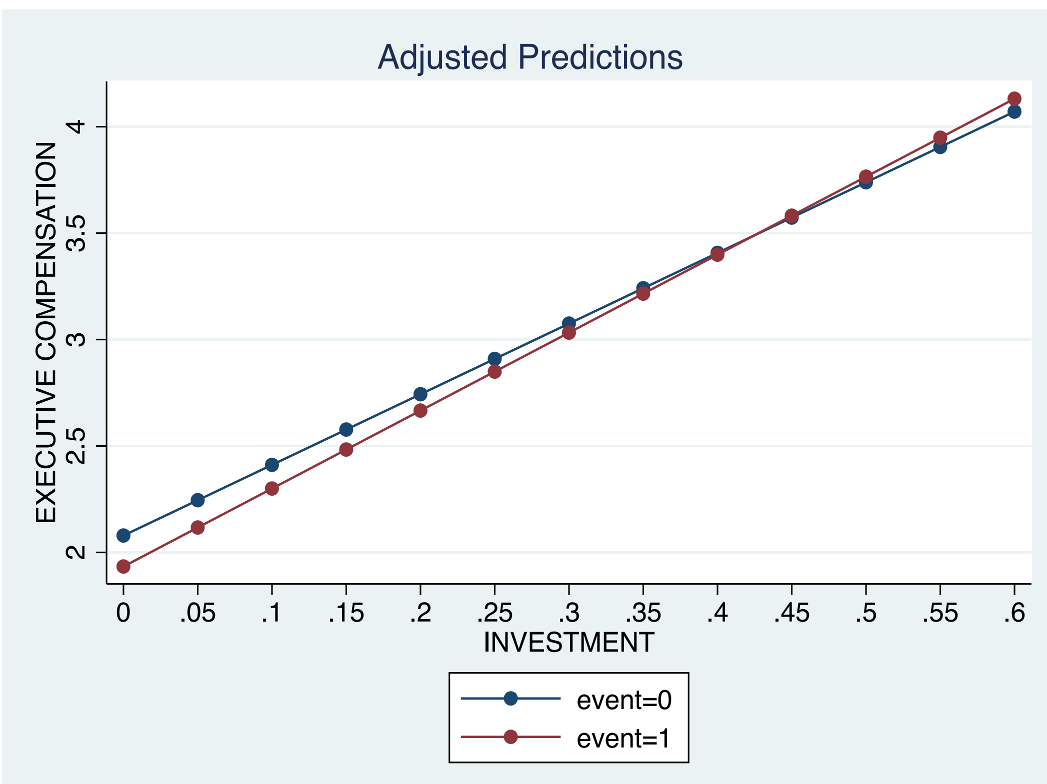


Figure 8: Moderation graph for CAPEX and AVE_TDC

For the moderation results, line graphs were used to show the interaction between zero lower bound policy and executive compensation. The line plots are shown in Figure 6, Figure 7 and Figure 8. Taking Figure 7 for example, the x-axis is RD and y-axis is AVE_TDC. The two lines represent the coefficient size before and after zero lower bound policy. By looking at Table 5, one can see that the coefficient RD is not significant. By looking at Figure 7, where the two lines represent the relation between managerial risk-taking and executive compensation before and after zero lower bound policy respectively, one can see that their slopes are almost identical.

This suggests that even though there is a little change in the relation between managerial risk-taking and executive compensation after zero lower bound policy, it is not significant and small in size. Combining the results of Figure 6, Figure 7 and Figure 8, one can draw the conclusion that zero lower bound policy indeed strengthened the relation between managerial risk-taking and executive compensation a little, but it is significant compared with the mediation effect as discussed earlier.

Therefore, by running both mediation and moderation models, there is sufficient evidence to support the hypothesis that managerial risk-taking is mediating the relation between zero lower bound policy and executive compensation. This mediation effect is partial mediation, which means that the increase in executive compensation is not only the result of the increase in managerial risk-taking due to zero lower bound policy, but also a direct impact of zero lower bound policy on executive compensation.

5 Robustness tests

5.1 Considering industry differences

Previous results are documented using models with firm-fixed effect and year-fixed effect. Even though it accounts for the differences between firms, it does not consider the differences between industries. Therefore, we feel the need to include industry fixed effect in our models and see if there is any difference due to the differences between industries.

For our H1, we re-run the model with year-fixed effect and industry-fixed effects and results are documented in Table 6 below. The mediation results are documented in Table 7.

Comparing the results in Table 6 and Table 3, we can see that there is not much difference. The significant levels of ZLB in all three models in Table 6 are all still at 0.1%. The coefficient size decreased by 0.01 for ZLB model 1, where INVEST is the dependent variable. Overall, we can conclude that the result holds for H1 where we find an increase in managerial risk-taking after zero lower bound policy.

Comparing the results in Table 7 and Table 4, we can see that the coefficient size decreased slightly for both ZLB and risk-taking measures across all models. The only change in significance level is for CAPEX in model 4. When using industry-fixed effect, the significance level is at 10%, while using firm-fixed effect we can see 5% significance. Even though, there appear to have slight differences between the firm-fixed effect and industry-fixed effect. The main results for our hypotheses still hold. Therefore, we believe that our results are robust after considering the differences across all industries.

Table 6: Robustness test for H1 with industry-fixed effect

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in Model (1) is INVEST, in Model (2) is R&D, and in Model (3) is CAPEX. ZLB is an indicator variable equal to one for the post-ZLB policy period (2009-2014), and equals to zero if otherwise. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix 1. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels. The estimates are from firm fixed and year fixed effects regressions. P-values are in brackets.

	(1) INVEST	(2) RD	(3) CAPEX
ZLB	0.058***	0.022***	0.034***
	(0.009)	(0.005)	(0.007)
SIZE	-0.047***	-0.023***	-0.019**
	(0.009)	(0.004)	(0.007)
DEBT	0.047	0.015	0.028
	(0.048)	(0.013)	(0.039)
EBIT	-0.013	-0.013	0.008
	(0.024)	(0.010)	(0.015)
MB	0.024***	0.007***	0.014***
	(0.004)	(0.002)	(0.002)
SALESG	-0.002	-0.008	0.004
	(0.012)	(0.005)	(0.009)
B-INDEX	0.001	0.000	-0.000
	(0.002)	(0.001)	(0.002)
Constant	0.457***	0.199***	0.230***
	(0.073)	(0.032)	(0.054)
Year-fixed Effects	Yes	Yes	Yes
Industry-fixed Effects	Yes	Yes	Yes
Adjusted R^2	0.128	0.076	0.097
F	15.041	4.662	13.777
N	8744	8744	8744

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Robustness test for H2 with industry-fixed effect

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in all models is AVE_TDC. The independent variable in Model (1) is dummy variable ZLB, which equals to one for post-ZLB policy period (2009-2014) and zero for pre-ZLB policy period (2004-2008). The independent variable in Model (2) is ZLB and INVEST, in Model (3) is ZLB and R&D, and in Model (4) is ZLB and CAPEX. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix I. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels. The estimates are from firm fixed and year fixed effects regressions.

	(1)	(2)	(3)	(4)
	AVE_TDC			
	ZLB	INVEST	RD	CAPEX
ZLB	0.514***	0.116	0.227+	0.249+
	(0.148)	(0.128)	(0.138)	(0.130)
INVEST		6.835***		
		(0.653)		
RD			13.179***	
			(1.893)	
CAPEX				7.883***
				(0.888)
SIZE	-1.500***	-1.179***	-1.203***	-1.348***
	(0.160)	(0.142)	(0.151)	(0.149)
DEBT	1.592**	1.272*	1.392**	1.368**
	(0.495)	(0.522)	(0.491)	(0.515)
MB	0.371***	0.209***	0.279***	0.263***
	(0.053)	(0.041)	(0.051)	(0.046)
EBIT	-0.155	-0.067	0.010	-0.216
	(0.301)	(0.219)	(0.248)	(0.261)
SALESG	-0.667**	-0.650***	-0.567**	-0.700***
	(0.203)	(0.177)	(0.174)	(0.187)
B-INDEX	0.021	0.011	0.014	0.021
	(0.040)	(0.036)	(0.038)	(0.037)
Constant	13.091***	9.968***	10.463***	11.274***
	(1.302)	(1.138)	(1.208)	(1.184)
Year-fixed Effects	Yes	Yes	Yes	Yes
Industry-fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.153	0.315	0.244	0.275
F	19.341	27.062	23.882	24.784
N	8744	8744	8744	8744

Standard errors in parentheses
$^{+} p < 0.10$, $^{*} p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

5.2 S&P 500 and non-S&P 500 firms

Even though prior studies indicated that stock options tend to promote executives to take big risks, they also showed that high-risk investments are not all wise investments. One research study by Sanders (2001) showed that stock options result in managers taking more risk as expected, but managers also tend to make more acquisition transactions, which are generally seen as a form of value destroying (Jensen and Ruback, 1983; Porter et al., 1996). This current study proposed the idea that stock options can induce risk-taking by executives, but not all risk-taking actions are value-increasing ones. For example, Huang et al. (2011) studied equity mutual funds, and find that when funds take excess risk; their performance is negatively impacted.

This idea was developed more fully by Sanders et al. (2007). They found that stock options encourage CEOs to place relative large bets on uncertain investment categories such as R&D, capital expenditures and acquisitions. In turn, these risk-taking investments result in possible extreme corporate performance: big wins and big losses.

Further empirical analysis showed that option-loaded CEOs delivered more big losses than big wins. Similar results were found in Bromiley's (1991) study, where he found that poorly performing companies take higher risks and that risk-taking results in further poor performance. All the studies mentioned support the argument that not all risk-taking will generate higher returns for the company.

Denis et al. (2003) found that because S&P 500 firms are more exposed to markets and media, they are expected to generate higher future cash flows. At the same time, the market monitoring effect also has an impact on information asymmetry. According to Chen et al. (2004), firms that are included in the S&P 500 receive enhanced investor awareness. So managers may be forced to perform more efficiently and make wiser investment decisions due to investor and analyst monitoring. In addition, since these firms are highly exposed to the public, executives of these companies will make investment choices more discreetly for their reputations are at more risk if they fail to reach the expected performance goals.

According to Jacobs (1991), managers are encouraged to reduce investments in R&D to avoid not meeting earnings targets that can result in institutional investors' large-scale selling and a fall in stock prices. Porter (1991) also suggested that investors with short-term horizons can fail to recognize the future reward of long-term investments such as R&D. Empirical results documented by Bushee (1998) supported this view that managers sacrifice R&D for higher current earnings under the pressure of short-term oriented institutions. Therefore, due to the strong market monitoring mechanisms in place, managers of the S&P 500 companies may not be eager to invest in risky projects due to possible stock price falls.

Thus, even though the study results show support for the positively significant relation between zero lower bound policy and managerial risk-taking, previous studies also suggested the possibility of market pressure moderating this relation. Therefore, if a company were more exposed to the market, then the tendency for executives to invest a lot in risky investments would be mitigated by the monitoring effect of the market.

Therefore, the relation between zero lower bound policy and managerial risk-taking should be less significant for S&P 500 firms while the relation between managerial risk-taking and executive compensation should remain unchanged. At the same time, the mediation effect of managerial risk-taking for non-S&P 500 firms should still be present. Therefore, this study split the samples into S&P 500 and non-S&P 500 firms to perform this robustness test. The regression results are presented in Table 8.

For H1 concerning zero lower bound policy and managerial risk-taking, one can see in Table 6 that for S&P 500 firms, the coefficient for ZLB is only significant at 10% for CAPEX and not significant for INVEST or R&D. For non-S&P 500 firms, all the coefficients for ZLB are all significant at the 0.1% level. In summary, S&P 500 firms only increased capital expenditures after zero lower bound policy while non-S&P 500 firms significantly increased in both R&D and capital expenditures. This difference is because non-S&P 500 firms are less exposed to the market and therefore have less to worry about. This result supports the previous prediction regarding the moderation effect of market pressure.

The significance of CAPEX can be explained by the difference between R&D and capital expenditures. King and Wen (2011) believe that capital expenditure is a low-risk investment compared to R&D expenses. According to Coles et al. (2006), R&D expenses are considered as high risk investments compared to capital expenditures. Investors view capital expenditures as "good risk-taking" while R&D expenses represents "bad risk-taking". Therefore, since managers of the S&P 500 firms need to worry about firms' future performance and their reputations, they can only invest in "good risk-taking" that can let them to utilize the low nominal interest rate and protect themselves at the same time.

Table 8: Robustness test for S&P 500 and non-S&P 500 firms

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in Models (1) and (4) are INVEST, in Models (2) and (5) are R&D, and in Model (3) and (6) are CAPEX. ZLB is an indicator variable equal to one for the post-ZLB policy period (2009-2014), and equals to zero if otherwise. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix 1. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels.

	(1)	(2)	(3)	(4)	(5)	(6)
		SP=1			SP=0	
	INVEST	RD	CAPEX	INVEST	RD	CAPEX
ZLB	0.050	0.027^{+}	0.024	0.062^{***}	0.020^{***}	0.037^{***}
	(0.035)	(0.015)	(0.027)	(0.010)	(0.005)	(0.008)
SIZE	-0.050^{+}	-0.027^{*}	-0.023	-0.046^{***}	-0.022^{***}	-0.019^{**}
	(0.028)	(0.011)	(0.021)	(0.010)	(0.005)	(0.007)
DEBT	0.065	0.040	0.015	0.047	0.012	0.033
	(0.086)	(0.027)	(0.068)	(0.053)	(0.015)	(0.043)
EBIT	0.047	-0.009	0.060	-0.022	-0.012	-0.002
	(0.067)	(0.023)	(0.040)	(0.027)	(0.011)	(0.016)
MB	0.017^{+}	0.005	0.009^{+}	0.025^{***}	0.007^{***}	0.014^{***}
	(0.009)	(0.004)	(0.005)	(0.004)	(0.002)	(0.003)
SALESG	0.001	0.016	-0.022	-0.002	-0.010^{+}	0.008
	(0.033)	(0.015)	(0.025)	(0.014)	(0.005)	(0.010)
B-INDEX	-0.004	-0.000	-0.005	0.002	0.001	0.001
	(0.006)	(0.003)	(0.004)	(0.003)	(0.001)	(0.002)
Constant	0.518^{*}	0.239^{*}	0.287	0.444^{***}	0.194^{***}	0.221^{***}
	(0.249)	(0.101)	(0.184)	(0.076)	(0.033)	(0.056)
Year-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.166	0.070	0.143	0.121	0.078	0.088
F	7.112	1.685	7.410	12.451	3.803	10.650
N	1774	1774	1774	7004	7004	7004

Standard errors in parentheses

$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

In summary, the results indicate the moderation effect of market pressure for observing less significant results in S&P500 firms.

5.3 Strong governance and weak governance firms

When studying executive compensation, corporate governance is an important factor that needs to be considered. According to Core et al. (1999), when corporate governance structure is less effective, executives gain higher compensation. One important component of governance structure is the board of directors (BOD). The BOD is also the focus when studying corporate governance's impact on executive compensation.

Since the BOD is responsible for constructing executives' compensation packages, it is expected to be free of the CEO's influence to maximize value for shareholders. But this is often not the case in practice. In reality, people in the BOD are practically hired by the CEO and can also be removed by the CEO (Crystal, 1991). In addition, the BOD sometimes relies on outside consultants hired by the CEO when planning compensation contracts (Crystal, 1991). These can all have an impact on the BOD's independence. Core et al. (1999) confirmed that the CEO earns greater compensation when the CEO is also the BOD chair and the outside directors are actually appointed by the CEO. Therefore, one can see the apparent impact of corporate governance on compensation. As a robustness check, the difference between strong and weak governance firms was studied.

Since B-Index is composed of six parts and mainly measures the characteristics of the BOD, the robustness check was performed by separating high vs. low governance firms based on B-Index. The firms with strong corporate governance are defined as firms that have B-Index higher than the mean B-Index of the year, and are defined as weak governance if lower than the mean. The results are presented in Table 9.

Table 9: Robustness test for governance

The sample includes all U.S. firm data available from the Compustat and Execucomp databases during the 2004 through 2014 period. The dependent variable in all the models is AVE_TDC. ZLB is an indicator variable equal to one for the post-ZLB policy period (2009-2014), and equals to zero if otherwise. R&D is set equal to zero if R&D is missing. All remaining variables are defined in Appendix 1. The control variables are all lagged one year. All variables are Winsorized at the 1% and 99% levels.

	AVE_TDC							
	High Governance				Low Governance			
	(1) ZLB	(2) INVEST	(3) RD	(4) CAPEX	(5) ZLB	(6) INVEST	(7) RD	(8) CAPEX
ZLB	0.489*	-0.030	0.178	0.204	0.865**	0.427*	0.461**	0.446*
	(0.190)	(0.176)	(0.195)	(0.177)	(0.264)	(0.177)	(0.174)	(0.182)
INVEST		6.723***				7.570***		
		(0.667)				(1.178)		
RD			10.652***				17.055***	
			(1.765)				(3.463)	
CAPEX				7.685***				9.179***
				(0.835)				(1.597)
SIZE	-1.459***	-1.071***	-1.148***	-1.309***	-1.836***	-1.521***	-1.521***	-1.588***
	(0.217)	(0.191)	(0.208)	(0.206)	(0.256)	(0.222)	(0.230)	(0.222)
DEBT	1.239^{+}	1.099^{+}	1.301^{+}	0.999	1.984**	2.035**	1.682*	2.158**
	(0.708)	(0.651)	(0.692)	(0.657)	(0.703)	(0.753)	(0.683)	(0.808)
MB	0.448***	0.264***	0.360***	0.339***	0.165^{+}	0.110^{+}	0.146*	0.102^{+}
	(0.068)	(0.053)	(0.067)	(0.057)	(0.093)	(0.058)	(0.061)	(0.061)
EBIT	-0.257	-0.185	-0.114	-0.429	-0.141	-0.203	-0.196	-0.121
	(0.450)	(0.318)	(0.400)	(0.380)	(0.502)	(0.406)	(0.389)	(0.405)
SALESG	-0.951***	-0.845***	-0.865***	-0.885***	-0.065	-0.101	0.054	-0.177
	(0.273)	(0.231)	(0.241)	(0.244)	(0.235)	(0.249)	(0.239)	(0.248)
B-INDEX	-0.033	-0.009	0.008	-0.025	0.147	0.084	0.116	0.091
	(0.091)	(0.078)	(0.086)	(0.079)	(0.102)	(0.091)	(0.104)	(0.090)
Constant	12.785***	9.225***	9.964***	11.100***	16.041***	12.540***	12.998***	13.159***
	(1.678)	(1.460)	(1.577)	(1.578)	(2.243)	(1.932)	(1.986)	(1.937)
Year-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.186	0.330	0.241	0.290	0.094	0.302	0.266	0.277
F	15.690	22.822	18.972	20.389	6.517	8.482	7.497	8.381
N	5530	5530	5530	5530	3248	3248	3248	3248

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Before performing the regression in Table 9, the analysis first explored the relation between zero lower bound policy and managerial risk-taking (not documented). All ZLB coefficients are positive and significant at the 0.1% level, meaning that managerial risk-taking increased after zero lower bound policy for both high and low governance firms. Then the mediation hypothesis was tested.

Table 9 documents the results for mediation hypothesis. Models (1) to (4) represent high governance firms. One can see that the coefficient of ZLB in Model (1) is positive and significant at the 5% level, but not significant in Models (2) to (4). The coefficients of risk-taking measures are all significant at the 0.1% level in Model (2) to (4). Combining the results of Models (1) to (4), one can conclude that managerial risk-taking is acting as a full mediator in the relation between zero lower bound policy and executive compensation.

This suggests that for high governance firms, zero lower bound policy does not have a direct impact on executive compensation. The proposed reason for this result is that when corporate governance is strong, executives have less influence over their compensation package. Therefore, the compensation can only by influenced by their risk-taking behaviors.

Looking at Models (5) to (8), one can see that all the coefficients of ZLB are positive and significant and all the coefficients of risk-taking measures are also positively significant. This shows that managerial risk-taking is acting as a partial mediator in the relation between zero lower bound policy and executive compensation. This suggests that for weak governance firms, zero lower bound policy has a direct impact on executive compensation. This means the direct impact is due to the CEO's influence over the compensation committee and in turn gains higher compensation.

In addition, when one compares the coefficient size of risk-taking measures across all models, one finds that the coefficients are larger for low governance firms, suggesting that high risk-taking have a bigger impact on compensation for firms with weak corporate governance. In summary, the result is consistent with the evidence provided in prior research confirming that weak corporate governance can result in executives' direct impact over their compensation.

6 Concluding remarks

After the financial crisis of 2008, zero lower bound policy was in effect for over seven years until very recently. More and more questions have been raised in terms of its impact and whether this policy is appropriate for today's economic situation. While journalists debated its impact on the national economy, researchers in the academic field tried to look at monetary policy's impact from another perspective. There is a growing stream of literature investigating how companies react differently due to the implementation of zero lower bound policy. With this policy still in effect, this study may provide shareholders and investors a better insight as to how this policy is affecting firms' managerial risk-taking and executive compensation.

There have been many studies on zero lower bound policy's impact on the banking and money fund industries. This literature provides direction for investigating other industries since the majority of companies are outside these two industries. With the widespread and profound influence of zero lower bound policy, there is a need to study its impact on companies in general because companies are playing an important role in the functioning of the financial market. By studying zero lower bound policy, one can provide an idea of how monetary policy can have an impact on companies' risk-taking choices and compensation plans.

These empirical results showed that after zero lower bound policy came into effect in December 2008, companies took more risks than before and executives earned more as well. Further analysis showed that part of the increase in executive compensation was caused by the mediation effect of managerial risk-taking. But there was also a direct positive impact of zero lower bound policy on executive compensation. The study also found that the relation between zero lower bound policy and managerial risk-taking was less significant for S&P 500 firms compared to non-S&P 500 firms. In addition for firms with strong corporate governance, zero lower bound policy did not have a direct impact on executive compensation, suggesting that the direct impact found in previous results may be due to executives' impact on their compensation planning. However, further analysis is needed to confirm this idea.

By extending the results of Di Maggio and Kacperczyk (2014), this study provided new evidence on the effects of zero lower bound policy on firms' asset allocation decisions, shedding new light on the determinants of firms' managerial risk-taking variations. It also provided indirect support for the idea that shareholders tend to prefer risky investments and encourage CEOs to take more risk by designing compensation plans with risk incentives. This study also has important practical implications for investors and boards of directors. They can gain better insight about CEOs' risk taking behavior under zero lower bound policy. The compensation committees can provide more proper compensation plans accordingly.

Our results are of importance for the time of low interest is still expected to last. Even though the Federal Reserve announced an interest rise on December 2015, the probability of an interest rate rise at the next Fed's meeting is zero (Fortune News, 06/27/2016). Traders hold the belief that there is only an 8% possibility that there will be an interest increase this year. While people have no confidence in an interest rise, they believe that there is 10% of chance that the Federal Reserve would actually announce an interest cut in its July meeting. More than 20% chance of a likely rate cut in the future. Based on the expectations of the general public, we also believe that the time of low interest rate would not end so soon. Therefore, our results concerning managers' risk-taking behavior and changes in their compensation should be able to provide some guidance to policy makers as well as shareholders during the current time.

There are a number of extensions possible to this study. Firstly, since it identified the mediation effect of managerial risk-taking on the relation of zero lower bound policy and executive compensation, one still cannot explain why it was only partial mediation. Therefore, there must be a mechanism that allows zero lower bound policy to directly influence executive compensation. It means that executives generally earned more after the implementation of the zero lower bound policy. Future research can look deeper to explain this direct impact.

Secondly, we did not provide analysis across different industries. Based on the evidence provided in previous research, there are reasons to believe that companies in different industries can have various investment decisions as well as compensation structures. Therefore, it is possible that the relations discussed in this study may be different when studied cross-sectional. For instance, high-tech and low-tech firms might present distinct results for they differ in R&D intensity.

Thirdly, we didn't consider the impact of business cycle in our study. One might argue that the increase in managerial risk-taking and executive compensation is due to the decrease in interest rate instead of the zero lower bound policy. Therefore, for future study, we would like to include control variables in our models to account for the changes in macroeconomic business cycle. If including the business cycle controls do not change our results, we then have enough evidence to say that zero lower bound policy indeed lead to an increase in managerial risk-taking and executive compensation. In addition, we could also find another period of time where the interest rate is decreasing but not near zero and run the models again to compare with our current results. If we couldn't find support for an increase in managerial risk-taking and the mediation effect of managerial risk-taking, then we would conclude that our result are robust.

Finally, previous studies showed that risky investments tend to generate big losses more than big gains. But with the interest rate as low as zero to 0.25%, there may be a difference in gains and losses for risky investments. So future research could look at the performance of high-risk companies under zero lower bound policy and see whether this policy has an impact on firm performance.

7 References

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Appendix: Definitions of variables used in the study

This appendix defines the variables used in the study. All the data are collected from the Compustat and Execucomp databases (Following Bargeron et al., JAE-2010).

Executive compensation measure:

- AVE_TDC is defined as the average executive compensation scaled by average book value of assets.

Managerial risk-taking measures:

- RD is defined as Research and Development Expense scaled by average book value of assets.
- CAPEX is defined as (Capital Expenditures - Sale of property, plants and equipment) scaled by average book value of assets.
- INVEST is defined as (RD+CAPEX).

Control variables:

- DEBT is defined as total debt scaled by lagged average market value of assets.
- EBIT is defined as earnings before interest and taxes scaled by lagged average market value of assets.
- MB is defined as the ratio between lagged market value of assets and lagged book value of assets.
- SIZE is defined as the logarithm of (lagged average asset + 1)