The 2007-2009 Financial Crisis and Executive Compensation: 
an Analysis and a Proposal for a Novel Structure

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Keywords: compensation practices, executive compensation, risk taking, regulation, executive stock options, financial crisis

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Abstract

During the 2007-2009 crises financial institutions have come under increasing pressure from regulators, politicians and shareholders to change their compensation practices in order to remove the incentive for short-term excessive risk taking.

In this paper we analyze how commonly used executive compensation plans can lead to two socially undesirable outcomes: excessive risk taking at one extreme and complete freeze of risky activities (new lending) on the other. We propose adding a new component to the executive compensation, which is paid only if the value of the firm will be located in some predetermined range. These components will push the executive towards the first best solution in which a moderate (internal solution) level of assets risk will be optimal because of the convex relationship between assets risk and compensation value.

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1. Introduction

In the 2007-2009 economic crisis executive equity compensation has come under increased public scrutiny. A major criticism is that many executive pay packages have incentivize excessive risk taking which contributed to the financial turmoil. To respond to these concerns, governments and regulators have taken steps to restrict executive pay arrangements in regulated industries. For example, under the economic stimulus bill passed in mid-February 2009, TARP recipients are not allowed to deduct for tax purposes senior executive compensation in excess of sum fixed level. However, there is still ongoing debate in the financial literature and among policymakers regarding how has executive pay contributed to bringing about the financial crisis, how to fix compensation structure and if pay structures should be reformed, what role if any should the government play in bringing about such reforms.

The goal of this paper is both descriptive and normative. The descriptive contribution is focused on explaining the link between typical compensation scheme of executives and the different phase of the financial crisis by using an option based approach. The analyzed typical compensation is composed of two components that are sensitive to assets risk. The first is equity based compensation, paid in the form of restricted stock and stock options, and the second is risky cash to be paid if the firm remains solvent. The risky cash is composed of a relatively quantifiable component, in the form of executive’s unsecured pension fund, as defined benefit pensions and deferred compensation, that may be lost if the firm is insolvent (“inside debt” as defined by Jensen and Meckling 1976) and a relatively unquantifiable component in the form of lost future income due to the decline in CEO reputation in the event of financial distress.

We assume that the executives would choose an optimal volatility for the firms’ assets that maximize the value of their compensation. We show that such compensation package would
incentivize the executives to take excessive levels of risk or none at all because of the concave relationship between assets volatility and the value of total compensation. By calculating the sensitivity of the overall executive payoff to asset volatility we show that when leverage ratio is relatively low, the sensitivity to assets risk of the equity based compensation would dominate the risky cash compensation, and therefore the executive is motivated to choose the maximum possible level of asset risk. However, when the leverage ratio is relatively high (assets prices are low) the sensitivity to asset risk of the cash compensation is the dominant one and the executive will choose the minimum possible level of assets risk.

The analysis of the executive motivation under this typical compensation structure is consistent with the behavior of financial institutions before and during the 2007-2009 financial crises. The first stage of the financial crises was characterized by bankruptcy of many financial institutions and bailout of some others. This was caused in part at least by the increased motivation for risk taking by financial institutions that can be explained by the rapid growth of executive equity based compensation in recent years.\(^1\) This increase is also consistent with agency theory, where the value of the equity based compensation is positively related to the underlying stock variance and therefore motivates executives to take higher levels of risk which are aligned with the shareholders interest (Jensen and Meckling, 1976 and Hirshleifer and Suh, 1992).\(^2\) The analysis in the paper is also in line with the recent empirical finding of Cheng, Hong and Scheinkman (2009) and Bebchuk and Spamann (2009) who confirm that equity compensation motivated excessive risk-taking before the current financial crisis.

\(^1\) Between 1993 and 2003, equity-based compensation has increased considerably, but their growth was not accompanied by a substitution effect, that is a reduction in non-equity compensation (Gabaix and Landier 2008, Bebchuk and Grinstein 2005).

\(^2\) Empirical studies have provided support to the agency theory hypothesis (Agrawal and Mandelker 1987, DeFusco et al. 1990, Guay 1999, Coles et al. 2008 and Chen et al 2006).
The second stage of the crises was characterized by a freeze in lending to households and businesses.\(^3\) The freeze in the market is shown in our analysis to be due to the negative incentive for risk taking as a result of the increase in leverage ratio (drop in asset prices) of many financial institutions which causes the sensitivity to assets risk of the cash compensation to be the dominant one. When a firm’s assets value is low enough such that there is a high chance that the executive would be terminated, the executive has a strong incentive to reduce assets risk due to the potential income loss as a result of reputation effect and the risk of losing unsecured pension. We show that a major cause for the bankers’ reluctance to lend is the limitation to increase executives’ package of equity based compensation, due to restrictions that were imposed by TARP and not due to a change in the risk aversion of banks’ executive this is consistent with Bebchuk and Spamann (2009). Without those restrictions, the stockholders could have increased the equity based compensation of the executives and consequently increase their motivation for risk taking.

The normative contribution of our paper is motivated to overcome the undesirable consequences of existing compensation packages, and therefore we a modified structure for executive compensation which includes an additional new component in the form of a fixed payment that is paid upon maturity if the value of the firm assets ends up being between two upper thresholds. The new component of the executive compensation has a payoff identical to that of a combination of a long “cash-or nothing” call option (i.e., binary option) that pays a fixed amount of money at maturity if the value of assets is above some upper threshold, and a short position in a similar option with a higher strike price. The compensation value is bell-

\(^3\) See the Accountability for the Troubled Asset Relief Program: The Second Report of the Congressional Oversight Panel January 9, 2009. American Express, Bank of America, Goldman Sachs and Morgan Stanley are among big institutions that reported a sharp rise in their holdings of cash and easy-to-sell securities in the first quarter of 2009.
shaped with respect to assets volatility. Therefore, because of the convex relationship between the total value of the two options and volatility their maximum would be reached at some interior level of volatility and not as a corner solution of zero or infinity. Our proposal is in line with Bebchuk and Spamann (2009), which claim that in order to avoid excessive risk taking and systematic financial crises, the regulators should place constraints on the compensation structures that shape how bank executives choose from the menu of actions allowed by the direct regulation

The model presented here is related to papers that try to find ways to control the risk taking motivation of executive. These measures include bond covenants (Smith and Warner 1979), shortening debt maturity (Barclay and Smith, 1995 and Guedes and Opler, 1996), bank borrowing (Diamond 1989, 1991) and papers that analyze corporate securities that can reduce assets substitution (Green, 1984, Chesney and Gibson-Asner, 2001 and Eisdorfer 2009).

The remainder of the paper is organized as follows. Section 2 presents the basic model for the valuation of executive compensation under a traditional compensation structure. Section 3 analyzes executive compensation and its risk taking incentives in good times (the bubble of 2004-2007) and then analyzes executive compensation and incentives in bad time (the crises of 2007-2009). Section 4 presents the new suggested executive compensation component and analyzes its sensitivity to assets risk. Section 5 concludes the paper with a summary.

2. The analysis of executive compensation and its risk taking incentives

We consider a financial institution with a simple capital structure, where it is financed by equity $S_t$, and one debt obligation, maturing at time $T$, with par value $F$. Default occurs at debt
maturity if the value of the firm’s asset, $V_t$, is below the face value of its debt, $F_t$. The firm is managed by executive, who has a compensation which includes two components that are sensitive to asset risk and the two components expire at the same day, $T$.

The first component is a fixed payment, which is paid as long as the firm is solvent. In the event of insolvency the executive may lose this component, say the defined benefit pension that yields an equal claim with other creditors in bankruptcy (See Bebchuk and Jackson, 2005, Sundaram and Yermack, 2007, and Gerakos, 2007). Moreover, the reputation effect due to the insolvency event may reduce the future incomes of the executive. Gilson (1989) examines the turnover of executive beginning two years prior to bankruptcy filing or debt restructuring and finds that none of the executives who lose their position are employed by another publicly traded firm over a three-year period following their departure, suggesting that the personal costs are significant. The executive would loss out of her total compensation a percentage of $\beta$, where $0 \leq \beta \leq 1$ if at maturity the value of the financial institution asset is below its liability. 4 The payoff of this component, denoted by $E_T^F$, can be expressed as:

$$E_T^F = \beta 1_{(V_t < F)}$$

where $1_\psi$ is the indicator function of the event $\psi$. By assuming that the value of the components that are not sensitive to assets risk are equal to unity, we can say that $E_T^F$ is equal to the percentage change in the executive wage wealth in an insolvency event.

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4 In order to simplify things we decide to have only one trigger point in which the firm is insolvent and the executive’s income is declined due to the loss of reputation and unsecured benefits. However, the insolvent point may differ from the point where the executive is layoff and may be located below or above the insolvency point.
The second component The equity based compensation is the portion of the executive payoff which has a positive sensitivity to an increase in the value of the firm's asset at maturity above some strike price $H$, where $H \geq F$. Thus, this component can be composed of bonus payment, stock, stock options or any instrument which has an increasing payoff with respect to asset value. The payoff to the holder of such compensation at maturity, $E_T^S$, is equal to the percentage change in the value of the firm's asset above the strike price times the rate of participation of the executive in the upward movement of the firm's assets above this value, which is denoted by $0 \leq \alpha \leq 1$. The value of the component can be expressed as:

$$E_T^S = \alpha \max\left(\frac{V_T - H}{H}, 0\right) = \alpha \frac{1}{H} \max(V_T - H, 0)$$

By assuming that the value of the components that are not sensitive to assets risk are equal to unity we can say that $E_T^S$ is equal to the percentage change in the executive wage wealth for a percentage change in the firm assets value above the strike price of $H$.\(^5\) In the special case that $H = 0$ the stock based compensation is in the form of regular stock. The payoff at expiry of the executive compensation, defined by $E_T$, can be summarized and written as:

$$E_T = \frac{1}{H} \max(V_T - H, 0) + 1 - \beta 1_{\{V_T < F^B\}}$$

\(^5\) The pricing of the executive stock option in the structural framework demand a solution for the value of a compound option, as was solved analytically by Geske (1979). However, when the expiration date of the option and the stock are equal, as in our simple example, the Black and Scholes (1973) formula becomes a special case of the compound option formula and the strike price of this option is the sum of the face value of the claims with higher seniority and the striking price of the option, defined as $H$. 

8
The current value of this position can be replicated by using two options: the first is a plain vanilla call option with a strike price of $H$, denoted by $\text{Call}(V,H)$, and the second is a “cash-or-nothing” put option that pays a fixed amount of money at maturity if the value of the firm’s assets is below the face value of the deposit, denoted by $\text{BinaryPut}(V,F)$. The intuition behind this term is that if the institution becomes insolvent the government deposit insurance fund or the debtholders will layoff the executive who would lose part of her fixed compensation in the form of inside debt and reputation. The value of the fix payment, which is paid to the executive under any condition, can be simply calculated by discounting at the risk free rate for the period.\footnote{To keep the notation as simple as possible, all variables without subscripts are present values.} The current value of the executive’s position can be written as:

$$E = e^{-rT} + \alpha \frac{1}{H} \text{Call}(V,H) - \beta \text{BinaryPut}(V,F)$$

(2)

To model the value of these options we use the standard Black, Scholes and Merton (1973, 1974) assumptions where the value of the firm’s assets follows a geometric Brownian motion with a dynamic given by:

$$dV = (r - \delta)Vdt + \sigma VdW$$

(3)

where $W$ is a standard Brownian motion, $r$ is the risk free rate, $\delta$ is the institution’s payout ratio and $\sigma$ is the instantaneous constant standard deviation of the assets’ rate of return. The general
pricing equations for the call option and the cash or nothing put option can be expressed under the standard assumptions for risk-neutral contingent-claim valuation as:

\[
\text{Call}(T, K) = e^{-rT} [VN(d(K) - KN(d(K) - \sigma\sqrt{T}))]
\]

\[
\text{BinaryPut}(T, K) = e^{-rT} N(\sigma\sqrt{T} - d(K))
\]

Where \( N(\cdot) \) is the cumulative normal density and the function \( d(K) \) is defined as:

\[
d(K) = \frac{\ln(V/K) + (r + \sigma^2/2)T}{\sigma \sqrt{T}}
\]

By combining the values of the two options and the value of the non risky payoff, we can express the sum of the risky cash and the equity based compensation as:

\[
E = \frac{\alpha}{H} [VN(d(H) - KN(d(H) - \sigma\sqrt{T}))] + e^{-rT} - \beta e^{-rT} N(\sigma\sqrt{T} - d(F))
\]

\[
= \frac{\alpha}{H} [VN(d(H) - KN(d(H) - \sigma\sqrt{T}))] + e^{-rT} [1 - \beta N(\sigma\sqrt{T} - d(F))]
\]

The most interesting parameter of the model is risk, which enters the option pricing formula in the form of volatility. We assume that during the time between the current time, \( t \), and debt maturity, \( T \), the firm does not depart from its ex-ante investment policy and thus the executive’s choice of volatility is made at the beginning of the period, with the objective of maximizing the value of her compensation (See Chesney and Gibson-Asner, 2001 and Sundaram and Yermack, 2007). This objective does not necessarily coincide with the firm value maximization or with the
stockholders’ value maximization. The impact of a change in volatility on the value of the executive’s compensation can now be found by taking the derivative of \( E \) w.r.t. \( \sigma \):

\[
\frac{\partial E}{\partial \sigma} = \frac{\alpha}{H} VN'\left(d(H)\right) \sqrt{T} - \frac{\beta e^{-rT} N'(d(F)) - \sigma \sqrt{T} d(F)}{\sigma}
\]  

(5)

where \( N'(X) = e^{-x^2/2} / \sqrt{2\pi} \). While the sensitivity of the equity based compensation to assets risk is always positive (the first expression on the R.H.S of equation (5)) the “cash-or-nothing” put option sensitivity to assets risk is always negative as long as the option is in the money and default has not occurred. Therefore, as long as the firm is solvent, the executive’s risk incentive is an increasing function of the value of the equity based compensation and a decreasing function of the value of the risky cash component. To analyze optimal risk taking by executives we consider in the next section two states of the world: “good times”, when the value of the assets of the financial firm far exceeds the value of its liabilities and “bad times”, where the value of the firm assets is close to the insolvency trigger.

3. Analyzing executive compensation and incentives in Good times and in Bad times

In this section analyze the risk taking motivation of the executive in good and bad times by using numerical analysis. In our model, unlike Sundaram and Yermack (2007) who also consider two forms of compensation, we consider the effect of the compensation structure on the risk taking motivation of the executive. Moreover, while unsecured pension funds are the only component of risky cash in their paper, we take into account also the loss of reputation as part of the risky
cash. We assume for simplicity that there are only two periods, the present, when managers make decisions, and the future, when gains or losses are realized and the manager gets paid. With multiple periods, the analysis would become more complex, but our general conclusions would not change.


We assume that the executives’ objectives do not necessarily coincide with firm value maximization when the financial institution is leveraged and their main objective is to maximize the value of their claims. Henceforth, the executive would choose a volatility level that maximizes the value of her compensation. The institution’s claims mature one year from now, consistent with Marcus and Shaked (1984) and Ronn and Verma (1986) that claim that the one-year expiration interval is justified because of the annual frequency of regulatory audits. If after an audit the market value of assets is found to be less than the value of total liabilities, regulators can choose to resolve the bank. In good times the value of the assets of the financial institution is assumed to be far above the value of its liabilities and thus the leverage ratio is relatively low. Thus, as a base case, we assume a financial institution with liability that mature one year from now. For the interest rate, we choose a continuously compounded constant interest rate of \( r = 1\% \). This is close to the low Treasury rates between 2004 and 2007. The quasi-leverage ratio, which is defined as \( LR = \frac{Fe^{-rT}}{V} \), is equal to 0.95, similar to the average leverage ratio of the top-5 investment bank in U.S at 2003-4 according regulatory filings with the U.S. Securities and Exchange Commission (SEC) on their 10-K and 10-Q forms. Therefore, if the firm’s debt face value of debt, \( F \), is normalized and set equal to 100, the financial institution asset value is equal to 104.2.
The parameter $\alpha$, which is equal to the sensitivity of the executive payoff to one percent increase in the value of the firm’s assets over the strike price, $H$, is equal to 0.48. The percentage of the executive wealth which is lost in the event of insolvency, $\beta$, is equal to 10%. However, later on we will relax these assumptions in order to show how different compensation scheme may change the risk taking motivation of the executive. We assume that the regulators do an effort to keep assets risk relatively low by using direct means, however, like in John, Sanders and Senbet (2000), the regulator’s ability to enforce capital regulation is limited and therefore it can only enforce the financial institution to a maximum level of assets volatility. In the presented example we chose a level of 32%, similar to the 95% quintile as calculated by Strebulaev and Schaefer (2008), who calculate the average firm’s assets volatility from a database, which is composed of 1738 issues of B-rated corporate bond prices. The strike price of the equity based compensation is equal to an asset value of 108, which means that on the maturity date, the stock price should be greater than 8% of the debt face value in order to be in the money.

Since the stockholders have a call option on the value of the firm’s assets the value of their holdings would increase with assets volatility (Jensen and Meckling 1976 and Galai and Masulis 1976). However, the executives’ incentive may differ from stockholders motivation due to their fixed compensation and therefore stockholders have a strong incentive to mitigate the negative risk taking motivation that is created by the executive’s fixed compensation by increasing the amount of equity based component hold by the executives. This wealth transfer effect exists mostly in the context of the banking industry since depositors (and deposit insurance funds) cannot perfectly monitor the actions of stockholders (Saunders et al. 1990).
Figure 1 presents the value of the executive compensation for different levels of asset volatility and leverage. If the executive can chose between volatility levels of 0%, 15% or 32%, she would chose the highest possible level when the value of assets is above 102.8 (leverage ratio below 0.963). Therefore, under such conditions executives in financial institutions have strong motivation to be busy in assets substitution and to implement actions that would increase assets risk. The phenomenon, of increased equity based compensation accompanied by increased level of assets risk was observed in the US between 2004 and 2007 (See Bebchuk and Grinstein, 2005 and Eisdorfer 2008).


The 2007-2009 financial crisis was characterized by a sharp decrease in the value of the assets of the financial sector and consequently a sharp decline in the share price of many financial institutions. Some of these institutions were forced to sell themselves, some went into bankruptcy and others were bailed out by the U.S. government. The crisis first caused to a credit crunch and then to a credit freeze when financial institutions stopped lending even to each other and increased their holdings of riskless assets.⁷

A common explanation in the recent financial literature, for the reluctance of banks to lend during the financial crises is the increase in the level of risk aversion of most financial institution (See Bebchuk and Spamann, 2009). However, we show that an alternative explanation may be the high leverage ratio of most financial institutions, due to their low assets value, that reduces the executives’ risk taking motivation. The decline in the value of assets decreases the distance to the trigger in which the firm stockholders would be diluted by the government or

⁷ U.S. depository institutions reduced net loans from 60.3% of total assets in 12/31/2006 to 55.6% in 12/31/2008, in the same periods their cash holdings doubled from 4% to 8%.
would enter into bankruptcy. In such event there is a high chance than usual that the management would be replaced by the new shareholders as shown by Betker (1995) and Gilson (1989), who found a significant higher turnover rate for executive in failing firms. The executive aware of this situation tries to reduce assets risk to the minimum level in order not to reach this point and threaten her reputation and unsecured benefit.

The decline in the risk taking motivation of the executive under low level of assets value is demonstrated in Figure-1, where under assets value below 102.8 (leverage ratio above of 0.963) the executive has the incentive to choose the minimum possible level of assets risk. This can explain why the various plans of the U.S. government of supplying liquidity to financial institutions have been ineffective in thawing the freeze in the credit markets. Executives had little motivation to substitute the relatively low risk government debt with risky credit to businesses and households.

The fact that the executive will always choose a corner solution is shown in Figure 2, where the value of the executive compensation versus assets risk is presented for different levels of leverage. When the value of assets is relatively high, and the firm is far away from the insolvency point, the executive would choose the highest possible level of risk. However, for low levels of assets value the executive would chose the lower possible level of risk. Figure 3 presents the total value of the risky components of the executive compensation, which are composed of the risky cash and equity based compensation for different levels of assets volatility. The figure highlights the fact that the executive payoff function is a concave function of assets risk and therefore the executive would choose either a high level of risk, which increases the risk of default of the financial institution and can cause systemic risk for the
The conclusion that the executive would prefer a low level of assets risk under relatively high leverage ratio when the firm is close to default, raises the question if there is a need for a government restriction on the level of executive compensation like that under TARP, where financial institutions are not allowed to deduct for tax purposes senior executive compensation in excess of sum fixed level. As noted by Bebchuk and Spamann (2009), under a relative high leverage ratio the stockholders have even a higher motivation to increase assets risk. However, we show that in the presence of a large enough risky cash component in the event of solvency, the executive motivation is to minimize the level of risk. If there are not any restrictions on executive payoff, the stockholders effort to align the executive payoff with their risk profile would probably end up in increasing the ratio of equity based compensation to fixed compensation.

To see this, consider again our numerical example. As in the previous example, the bank’s assets value is in the region where the minimum level of risk is chosen by the executive and the value of its assets is equal 101 (quasi leverage ratio of 0.98). However, the stockholder decides to equip the executive with an extra package of stock options and now the executive payoff at maturity is equal to 0.68 times the percentage change in the value of the firm’s asset above the strike price of \( H \) (a greater positive sensitivity than 0.48). The risk taking motivation of the executive at different assets value is shown in Figure 4, where the strategy with the highest level of risk is the dominant one, even for relative low value of assets.

While we demonstrated that the restriction on executive equity based compensation motivate them to take the minimum level of assets risk, a situation which exists during the
financial crises, our analysis is also consistent with the observed behavior of financial institutions to repay to the government capital received under the TARP program in the winter of 2008–09. As of August 2009, Goldman Sachs, JPMorgan Chase, and a number of other banks have returned funds originally received from the government in December 2008. Most commentators have argued that these banks were motivated by a desire to avoid the restrictions on executive compensation imposed by the TARP and stimulus bills on recipients of TARP funds. Reducing those restrictions would enable the stockholders to align again the motivation of the executives by adding equity-based compensation and thus motivating them to increase assets risk (as described at Figure 4).

4. New terms for executive compensation

This section presents a new form of executive compensation that counter to the existing compensation scheme, motivates the executive to take moderate level of assets risk in all times and therefore enhances financial stability. It may help avoid future crises and speed up financial recovery by eliminating the incentive for corner solutions for risk taking by the executives of financial institutions. Normally, the stockholders are the one that form and determine the structure of the executive compensation and the regulator focuses on the risk exposure of the financial institution. However, after the 2007-2009 financial crises governments intervened in the structure of executive compensation in a financial industry.

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8 A review and analysis of the different proposal for regulating the financial services industry can be found at Core and Guay (2010).
The proposed executive compensation scheme in this paper includes again risky cash that is paid as long as the company is solvent, an equity-based compensation and a new type of compensation in the form of a fixed payment, $\gamma$. This amount is paid at maturity if the value of the assets is between two thresholds, denoted $H^L$ and $H^H$ respectively, which are located above the current value of the firm’s assets. If however, at expiry, the value of the firm’s assets is outside of this range the executive’s payoff from this component is zero.

The new component of the executive compensation has an identical payoff as that of a combination of a long “cash or nothing” call option that pays a fixed amount of money at maturity if the value of assets is above some threshold, defined as $H^L \geq V$, and a short position of a similar option with a higher strike price $H^H \geq H^L \geq V$. The value of this compensation is bell-shaped with respect to assets volatility. Therefore, due to the convex relationship between the total value of the two options and volatility, their maximum would be reached at some moderate level of volatility and not in one of the corner solutions of zero or infinity. Under the suggested compensation, if the executive has the ability to choose the level of volatility, she would prefer a moderate level of volatility that would maximize the value of her compensation.\footnote{The presented compensation scheme may be criticized of creating moral hazard, since if an executive gets to the point where assets are in the range of maximum compensation she will want to reduce efforts, or might even have incentive to destroy value. Such incentive can be minimized by creating dynamics compensation, similar to Edmans, Gabaix, Sadzik, and Sannikov (2009), where the range of the cash or nothing compensation is update dynamically according to the executive performance. To demonstrate and to simplify our idea we did not expand the current static setting into a dynamic setting.}

The total payoff at expiry of the new suggested executive compensation $E^*_T$ can be written as:

\[
E^*_T = \begin{cases} 
\gamma & \text{if } H^L \leq V \leq H^H \\
0 & \text{otherwise}
\end{cases}
\]
\[
E^*_T = 1 + \alpha \frac{1}{H} \max(V_T - H, 0) - \beta 1_{[V_T \leq F]} + \gamma 1_{[H^{\infty}_T \geq V_T < H^\downarrow_T]}
\] (6)

The third term on the RHS of equation (6) is the payoff due to the suggested new component of executive compensation that can be priced as a pair of binary call options with different strikes. Therefore the option equivalent of the total value of the executive compensation can be expressed as:

\[
E^* = e^{-rT} + \alpha \frac{1}{H} \text{Call}(V, H) - \beta \text{BinaryPut}(V, F) + \gamma [\text{BinaryCall}(T, H^L) - \text{BinaryCall}(T, H^H)]
\] (7)

By using the standard Black, Scholes and Merton (1973, 1974) assumptions the value of the position can be expressed as:

\[
E^* = \frac{\alpha}{H} [VN(d(H)) - KN(d(H) - \sigma \sqrt{T})] + e^{-rT} [1 - \beta N(\sigma \sqrt{T} - d(F))] + \gamma [(H^L)e^{-rT} N(d(H^L) - \sigma \sqrt{T}) - \gamma (H^H)e^{-rT} N(d(H^H) - \sigma \sqrt{T})]
\] (8)

The sensitivity of the new executive component to assets risk can be derived as follows:

\[
\frac{\partial E^*}{\partial \sigma} = \gamma d(H^L)e^{-rT} N'(\sigma \sqrt{T} - d(H^L))/\sigma - \gamma d(H^H)e^{-rT} N'(\sigma \sqrt{T} - d(H^H))/\sigma
\] (9)
The value of the long call “cash-or-nothing” option with the low strike price, the first term on the RHS of equation (9), decreases with assets volatility, whereas the value of the short call cash-or-nothing option with the high strike increases with assets volatility. These two options that are both “out of the money” have opposing effects on the value of the total executive compensation and therefore its value reaches the maximum at some moderate level of risk. Executives would try to maximize their compensation by finding the volatility level that maximizes compensation such that:

\[
\frac{\partial E^*}{\partial \sigma_{|\sigma^*}} = 0 \text{, while } \frac{\partial^2 E^*}{\partial \sigma^2} < 0 \tag{10}
\]

Equation (10) is solved numerically, in the absence of a closed form solution, to illustrate the impact of the executive’s “constrained” maximization on the choice of investment policy and thus on risk taking.

The main results are, first, we show that with the “range compensation” there will be an interior solution for the optimal volatility. This is unlike the Black-Scholes-Merton equity pricing result, where as assets’ risk increases, the value of shareholders wealth increases as well. By choosing a relative low level of assets risk there is a high chance of not reaching the range in which the extra fixed compensation is paid. In contrast, by choosing a relative high level of assets risk the executive increases the chance of financial distress that may reduce her cash payment due to the potential loss of inside debt and reputation. Moreover, the high level of volatility may move the value of the firm assets above the range in which the extra fixed compensation is paid. These forces push the executive to choose an interior level of assets risk that maximizes the value of her compensation.
Figure 5 presents the value of the executive compensation versus assets value for levels of volatility of 0%, 17% and 32%. The “range compensation” has a fixed payoff if the value of the stock by the end of the year is between 15 and 40. This is equivalent to receiving the same payment if the value of the firm’s assets is between 115 and 140. If the value of the firm assets is between the value of 101 and the level of 113.5, which is below the lower threshold of the “range compensation”, in which an extra fixed amount of cash is paid, the executive can maximize the value of her compensation by choosing a moderate volatility level of 17%.

The second result shows that as the leverage ratio of the firm’s decreases and the distance from the insolvency point increases, the optimal volatility level would decrease for a given “range compensation”. Figure 6 presents the value of the compensation for different leverage ratio and volatility levels. Thus when the leverage is equal 0.96, the optimal volatility level is 16%, whereas when the leverage ratio decreases, and set equal to 0.94 and 0.92 the optimal volatility is equal to 14% and 11% respectively, that is only a relative small increase in the value of the firm’s is needed in order to let the “range compensation” to end up in the money.

Third, as the lower threshold, $L^H$ (the value of assets have to be above it at maturity for executives to receive their fixed payment, $\gamma$), increases, the optimal value of volatility increases as well. Finally, as the upper threshold, $H^L$ (the value of assets have to be below it at maturity for executives to get $\gamma$), increases, the optimal value of volatility is increases as well. Table 1 presents the optimal volatility level when the value of assets is equal 104.2, as in the base case, for different lower and upper levels of threshold. Table-1 shows that when the fixed compensation is paid only if the value of assets at maturity is between 110 and 125 the optimal volatility level is equal to 8.09%. However, when the “payoff window” is shifted to the levels between 115 and 130 the optimal volatility is equal to 11.82 %. Furthermore, when the payoff
window, at which the fixed compensation upon maturity is paid, is widened and located between 110 and 160 the optimal volatility level is equal 15%. In the extreme case, when a fixed compensation would be paid at maturity at any assets value that is above 110, the optimal volatility level is equal 18%. The implication is that a policymaker (regulator), who wants to restrict the volatility of the financial institution’s assets, can set an upper and a lower level for the moneyness of the compensation and thus to determine the range of asset volatility that the executives would choose.

5. Summary

The 2007-2009 financial crisis was caused by a number of factors, one of which was excessive risk taking by financial institutions. The increased motivation for risk taking can be explained by the rapid growth of equity based executive compensation in recent years. The paper first analyzes an executive compensation structure that is composed of a risky cash payment, which is paid unless the firm is insolvent and an equity based compensation in the form of executive stock options.

We first show that under relatively low levels of leverage (high assets values) the total value of a compensation that is dominated by equity based compensation is maximized by choosing the highest possible level of assets risk and therefore leads to excessive risk taking. The next step analyzes the same compensation structure but with a high level of leverage (low assets values), where the risky cash compensation is the dominant component. Under such circumstances the rational executives will choose the lowest possible level of assets risk, since this maximizes the value of their compensation. In the past, stockholders could restore the
executive incentives for taking risk, in a manner that is aligned with their interests by increasing the size of the equity-based compensation. However under the current regulations and trends in corporate governance they are more restricted in doing so. Therefore, the existing executive compensation scheme leads to a concave relationship between assets risk and the value of the compensation and creates an incentive for the executive to choose corner solutions, that either lead to an excessive risk taking or to a freeze out of the lending activity to the public.

After the 2007-2009 financial crisis, there have been many proposals aimed at aligning the risk taking motivation of the executive with the social desirable level of risk. However, none of them was concrete proposal that can motivate a firm’s executive to take a moderate level of risk as in our paper. The major contribution of this paper is a proposed new component for executive compensation that leads to an interior solution of risk taking. The suggested new component of executive compensation is paid only if the value of the firm’s assets is within a predetermined range of assets value at expiration. This new form of compensation creates a convex relationship between assets risk and the value of the compensation and therefore encourages the executive to choose a moderate level of assets volatility.
References


Table 1: The Optimal volatility in the presence of the new executive compensation

This table presents the optimal volatility level in percentages that maximizes the value of the executive compensation for different ranges of assets value of the novel “range compensation”. The executive would receive a fix payoff of 25% of her fixed compensation if the value of assets at maturity is between the lower threshold, defined as $H^L$ and the upper threshold, defined as $H^H$, where: $V < H^L < H^H$. There is no stock option compensation in this example. All the other data are the same as in Figure 1.

<table>
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<tr>
<th>$H^L$ Values</th>
<th>120</th>
<th>125</th>
<th>130</th>
<th>135</th>
<th>140</th>
<th>145</th>
<th>150</th>
<th>155</th>
<th>With no upper bound</th>
</tr>
</thead>
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<tr>
<td>110</td>
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<td>9.43</td>
<td>10.63</td>
<td>11.70</td>
<td>12.67</td>
<td>13.54</td>
<td>14.31</td>
<td>15.00</td>
<td>18.00</td>
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<td>14.91</td>
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<td>17.40</td>
<td>18.49</td>
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<td>18.33</td>
<td>19.72</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>130</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>49.84</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>54.23</td>
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</table>
Figure 1: Executive compensation versus leverage for different levels of assets risk.

This figure presents the total value of the executive compensation according to the option based method, where the executive can loss 10% of her fixed compensation if the firm is insolvent, i.e., the value of the firm’s assets is below the face value of debt ($F=100$) at maturity. The equity based compensation would pay 0.48% of the fixed compensation for each 1% increase of the firm’s assets above the strike price of $H=108$. The time horizon, $T$, is equal to 1, the risk free rate $r$ is 1%, and assets volatility is set at different values of 0%, 15%, and 32%. The firm assets value, $V$, is between 0.8 and 1.2 which is parallel to quasi leverage ratio ($LR = e^{-rT} F / V$) between where 0.825 and 1.1.
Figure 2: Executive compensation versus assets risk for different leverage ratio

This figure presents the total value of the executive compensation according to the option-based method, where the leverage ratio is equal to 0.92, 0.94, 0.96 and 0.98. Assets volatility can vary between 0% and 40%. All the other data are the same as in Figure 1.
Figure 3: Equity-based compensation, the risky cash compensation and the total value of the executive compensation versus assets risk

This figure presents the total value of the executive compensation, the equity based compensation and the risky-cash compensation. The value of the firm’s assets is equal to 104.2 (quasi leverage ratio of 0.95) and assets volatility varies between 1% and 50%. All the other data are the same as in Figure 1.
Figure 4: Executive compensation versus the firm’s assets value for different levels of leverage and for a high quantity of equity based compensation.

This figure presents the total value of the executive compensation according to the option-based method. The equity based compensation would pay 0.68% of the fixed compensation for each 1% increase of the firm’s assets above the strike price of $H=108$. All the other data are the same as in Figure 1.
Figure 5: The value of the novel “range compensation” versus leverage for different levels of assets risk

This figure presents the total value of the executive holding according to the novel suggested range compensation. The executive receives an extra compensation of 25% of her fixed payoff if at maturity the value of the stock price is between $15M and $40$, which is equivalent to assets value of $115M and $140M respectively. There is no stock options compensation in this example. All the other data are the same as in Figure 1.
Figure 6: The value of the novel “range compensation” versus assets volatility for different levels of leverage

This figure presents the total value of the executive compensation according to the new suggested compensation. The leverage ratio is equal to 0.92, 0.94 and 0.96. All the other data are the same as in Figure 5.