EXECUTIVE COMPENSATION, RISK TAKING

AND

THE STATE OF THE ECONOMY

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Abstract

In this paper we present a model of executive compensation to analyze the link between incentive compensation and risk taking. Our model takes into account the loss in the value of an executive's expected wealth from employment if the firm becomes insolvent during a bad state of the economy. We illustrate that a given compensation package may lead to different levels of asset risk under different economic states. Most importantly, we show that the positive relationship between equity-based compensation and risk taking may weaken and possibly disappear during systemic financial crises. An important policy implication from our analysis is that similar regulations may have different effects on risk taking depending on the state of the economy.

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Keywords: executive compensation; risk taking; regulation; equity based compensation; economic crisis

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1. INTRODUCTION

Following the financial crisis that erupted in 2007, large banking organizations have been asked to reconsider their executive compensation practices based on the view that incentive compensation practices in the financial industry were one of the many factors contributing to the financial crisis. In June 2010, U.S. regulatory agencies[1] jointly issued the Final Guidance on Banking Incentive Compensation, designed to ensure that incentive compensation policies do not encourage imprudent risk taking in financial institutions. However, there is mixed evidence regarding whether incentive compensation increases risk taking motivation among managers in literature.[2]

This paper contributes to the understanding of the relationship between equity based compensation and managerial risk taking in the financial sector by presenting a model in which the relationship depends on the state of the economy. We develop a model to estimate asset risk that an executive would optimally target given her compensation structure, firm's capital structure (leverage) and the state of the economy. Our main contribution to the existing literature is to integrate the state of the economy in the analysis of executive compensation and risk taking, and to illustrate that a given compensation package may lead to different levels of asset risk under different economic states.

To illustrate this result, we introduce *loss due to insolvency* - the decrease in an executive's wealth from her employment if the firm she is managing becomes insolvent, as a part

[1] The guidelines were issued by the following regulators: The Federal Reserve, the Office of the Comptroller of the Currency (OCC), the Office of Thrift Supervision (OTS) and the Federal Deposit Insurance Corporation (FDIC).

[2] The following papers provided supporting evidence for a positive link between equity-based compensation and asset risk: Coles, Daniel, and Naveen (2006), Core and Guay (2002), Chen, Steiner and Whyte (2006); Low (2009), Mehran and Rosenberg (2008), and Rajgopal and Shevlin (2002). On the other hand, Carpenter (2000) and Ross (2004) did not recognize such a relationship.

of an executive's compensation. We then separate loss due to insolvency in two distinct components:

1. *Loss due to firm-specific financial distress*, which is the expected loss in executive wealth from employment if the financial firm becomes insolvent during her tenure. This component may include an executive's uninsured pension benefits that would be foregone (Edmans and Liu, 2011; Gerakos, 2007; Sundaram and Yermack, 2007; Bolton, Mehran and Shapiro, 2010), reputation costs (Fama, 1980; Hirshleifer and Thakor, 1992), and loss of future employment opportunities (Gilson, 1989).

2. *Loss due to systemic crisis*, which is incurred only when the financial institution becomes insolvent at a time of systemic crisis (bad economic state). This component measures the additional loss in the value of an executive's expected wealth from employment if the financial institution becomes insolvent during a systemic crisis. The additional loss occurs because an executive's career concern since her alternative employment opportunities would be more limited during a systemic crisis. This theoretical assumption is supported by empirical work that shows being displaced in recessions may lead to higher income losses compared to being displaced during non-recession periods, which we review in Section 2.

In our analysis we let the asset risk of a financial institution be determined by an executive whose main objective is to maximize the value of her own compensation (e.g., Bhanot and Mello, 2006; Chesney and Gibson-Asner, 2001). The regulator is implicitly assumed to be the principal. As the principal, the regulator targets a desired level of asset risk and determines the compensation structure that would incentivize the executive to take that risk level. In cases where regulating executive pay is not sufficient, the regulator sets a maximum limit on the asset risk through alternative regulation such as capital adequacy ratios. Given this framework, we then analyze the risk taking under different states of the economy.

We illustrate that the relationship between equity-based compensation and risk taking depends on the state of the economy. In particular, we are able to show that a manager's optimal choice during bad states of the economy (i.e. systemic crises) is to target a lower level of asset risk, as evidenced by Kempf et al. (2009).[3] On the other hand, when the economy is healthy and far from the systemic crisis threshold, the same manager with exactly the same level of equity-based compensation and facing the same leverage ratio would optimally target a higher risk level. Our conclusion is in line with DeYoung, Peng and Yan (2012), who provide evidence for a significant positive correlation between economic conditions and risk taking in the banking industry, i.e. banks facing stronger (weaker) economic conditions choose more (less) risky business policies, and also with Albertazzi and Gambacorta (2009), who show that bank profits are procyclical. These results are consistent with the findings of Delis, Kien and Tsionas (2012), who show that banks give out very risky loans when the economy is booming, and use this finding as an evidence for a potential failure of capital regulation to contain risk during very good times. Jokipii and Milne (2011) also give evidence for cyclicality between capital and risk adjustments in the banking sector.

Since we use an option based approach and the no-arbitrage pricing methodology of the compensation is free of risk preference, the lower risk taking incentive during economic

[3] Kempf, Ruenzi, and Thiele (2009) show that mutual fund managers decrease risk during years marked by negative stock market returns when "employment risk" dominates "compensation incentives". However, Kempf et al. did not suggest a theoretical framework, as presented in this paper, that analysis the risk taking motivation of an executive by quantifying the value of its compensation under different state of the economy and compensation structures.

downturns solely stems from the new compensation component in our model– loss due to systemic crisis.

We also present four extensions of the model. First, we include an extra component of executive compensation which creates loss to the executive in the event of default during boom time. Second, we introduce bankruptcy costs to our pricing model, which create difference between the value of the levered and the unlevered financial institution. Third, we incorporate the possibility of early withdrawal of deposits by having more than one audit period. Forth, we analyze the effect of varying correlation levels between the returns of the economic index and the financial institution’s assets. While each contribution has a varying effect on the risk motivation of the executive in our model, our main conclusion in the paper remains unchanged in the extended model– same level of equity-based compensation induces lower risk taking when the economy is in a systemic crisis.

The paper findings contribute to the ongoing debate on the structure of needed reforms regarding executive compensation. In a recent study, comparing the banking firms with non-regulated firms, Minnick, Unal and Yang (2012) conclude that regulation cannot fully substitute for managerial incentives, thus incentive compensation may be used effectively in the banking firms, too. One policy implication from our paper is that if a regulator wants to limit a financial institution to a specific level of asset risk by suggesting limits on the proportion of equity-based compensation, then these limits may need to depend on the state of the economy, as well as financial firms’ leverage. Most importantly, in order to achieve similar asset risk in economic recessions as in normal times, the regulations on the proportion of equity based compensation may need to be relaxed during recessions.

The model can be used by regulators and policymakers to design limits on executive pay package that will induce an executive to optimally choose risk level, which is consistent with the desired level of assets risk. However, we would like to stress that the purpose of our paper is not to suggest the "optimal asset risk" for a particular financial institution, rather to enable the policymaker to understand the risk taking incentive created by a compensation package while accounting for the state of the economy.

The extant literature largely focuses on the risk taking motivation of executives when equity-based compensation is the only source of compensation that is sensitive to asset risk (e.g., Bebchuk and Spamann, 2010). One strand of literature argues that risk-taking motivation increases with equity-based compensation. The value of compensation would increase with asset risk, and therefore an executive whose objective function is to maximize her personal payoff would try to choose the maximum possible level of risk (Haugen and Senbet, 1981; Smith and Stulz, 1985). Another strand of literature argues that under the assumption of risk aversion, the link between equity-based compensation and risk-taking may be negative, because higher risk would lead to a lower utility for a sufficiently risk-averse manager (Lambert, Larcker and Verrecchia, 1991; Guay, 1999; Carpenter, 2000; Ross, 2004; Lewellen, 2006).

In more recent financial literature, "Loss due to firm-specific insolvency" has been offered as an additional factor that may explain the negative relationship between equity-based compensation and risk taking. Sundaram and Yermack (2007) analyze the compensation of a manager which includes equity-based compensation in the form of stock as well as loss due to firm insolvency in the form of inside debt, i.e., defined pension funds that may lose value in the event of firm insolvency. They point out that the executive would take the maximum possible level of asset risk when the proportion of equity-based compensation is greater than the loss of inside debt upon default, and the minimum possible level of asset risk if the reverse relationship exists. Empirical studies also find a positive relationship between equity-based compensation and risk and a negative relationship between debt-like compensation and risk (Tung and Wang, 2010; Wei and Yermack, 2011).

Landskroner and Raviv (2009) expand on the framework of Sundaram and Yermack (2007) to analyze equity-based compensation which could include other components besides stock, by letting the strike price of the equity-based compensation differ from the face value of debt. In such cases, the risk-taking motivation of the executive is also a function of the firm's leverage ratio. As the leverage ratio increases, there is a higher probability of default and the executive would be motivated to take a lower level of asset risk.

In our model, we introduce *loss due to systemic crisis* as a part of the executive compensation that is sensitive to asset risk. This component affects all financial institutions to some extent during a systemic crisis. Thus, we are able to present a mechanism that explains risk-reducing behavior for a wide range of compensation packages regardless of the capital structure (financial health).[4]

Our framework is closely related to the recent work of Bolton, Mehran, and Shapiro (2010) and Tung (2010), that recognize that loss in the event of firm insolvency can reduce the level of asset risk and suggest monitoring asset risk by adding debt-like incentives to executives' pay packages. In line with these proposals, our paper enables to quantify the risk-taking motivation of executives while also accounting for the effect of the economic cycle.

[4] Benmelech and Bergman (2010) explain that such credit freeze might arise due to the interplay between financing frictions, liquidity, and collateral values.

The rest of this paper is organized as follows: Section 2 reviews the empirical literature, which supports our critical assumption of additional loss in the value of an executive's expected wealth from employment if the firm she is managing becomes insolvent during a systemic crisis. Section 3 describes our model. Section 4 uses a numerical example to characterize our solution and explain the link between executive compensation and risk-taking under different compensation structures and economic states. Section 5 presents some extensions of the model to show robustness to alternative parameterizations and assumptions. Section 6 provides a discussion and relates the results to government regulation, the current financial crisis, and design of executive pay packages to achieve a desired risk level. Section 7 concludes.

2. ADDITIONAL LOSS IN THE VALUE OF AN EXECUTIVE'S EXPECTED WEALTH FROM EMPLOYMENT AT TIMES OF SYSTEMIC CRISIS – EMPIRICAL EVIDENCE

A critical assumption in this paper is the additional loss in the value of an executive's expected wealth from employment if the firm she is managing becomes insolvent during a systemic crisis. We posit that this additional loss occurs because an executive's alternative employment opportunities would be more limited during a systemic crisis, and we incorporate this loss in the model of executive compensation in order to argue that risk-taking incentives may be different under good and bad states of economy. In this section, we provide a brief review of empirical literature, which supports the assumption that being displaced in recessions may lead to higher income losses compared to being displaced during non-recession periods.

Jacobson, LaLonde and Sullivan (1993) find that employees that are displaced during adverse labor market conditions have significantly larger losses than workers those displaced during good labor market conditions. They show that high-tenure employees separating from distressed firms suffer substantial and persistent earnings losses when they are displaced during or following mass layoffs: Five years after separating from their former firm, their losses amount to 25% of their predisplacement earnings. However, they find a different earnings loss pattern for high-tenure employees that lose their jobs during non-mass layoffs: these employees' earnings fully recover 3-5 years following their separations.

Farber (2005) analyzes the earnings losses of displaced workers during 1984-2003, covering the recent mini crisis of 2001-2003. He finds that the earnings losses have been dramatically larger during 2001-2003: The estimated earnings loss from displacement, which was 7.8% during the boom market of 1997-1999, increased to 17.1% in 2001-2003. The largest increase in estimated earnings loss is for highly educated employees: it increased from 4.5% in 1997-1999 to 21% in 2001-2003. Farber (2011) examines the experience of job losers in the Great Recession (December 2007 to June 2009) using the January 2010 Displaced Workers Survey. He finds that re-employment experience and earnings losses of job losers are substantially worse for those who lost their jobs in the Great Recession than in any earlier period in the last 30 years.

Most recently, Davis and von Wachter (2012) analyze the earnings losses of high-tenure employees associated with job displacement using the longitudinal Social Security records for U.S. workers from 1974 to 2008. They find that in present value terms, earnings losses from displacements that occur in recessions are twice as large for displacements in expansions.

Research also shows that there are significant non-pecuniary costs to job loss, which are higher during economic downturns. These costs include worse health outcomes due to higher incidence of stress-related health problems such as strokes and heart attacks (Burgard, Brand and

House, 2007), higher mortality (Sullivan and von Wachter, 2010), reduction in happiness and life satisfaction (Frey and Stutzer, 2002), higher anxiety (Davis and von Wachter, 2012). These non-pecuniary losses are also cyclical, rising significantly during economic downturns (Davis and von Wachter, 2012). For further empirical evidence on the cyclicality of earnings losses, we refer the reader to Krebs (2007) and Davis and von Wachter (2012).

3. A VALUATION MODEL FOR EXECUTIVE COMPENSATION

In this section, we construct a structural model for the value of executive wealth from employment at a financial institution. We consider a financial institution that is financed by equity and deposits. The deposits mature at time T and have a face value of F (as in Merton, 1974).[5] 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 chooses firm's asset risk at the beginning of the period, with the objective of maximizing the value of her compensation.[6]

3.1. Components of Executive Compensation That Are Sensitive to Asset Risk

We assume that the executive's wealth from employment has three components that are sensitive to the value of the financial institution's assets: equity-based compensation, loss due to firm-specific insolvency, and loss due to systemic economic crisis.

[5] We follow the standard assumption of the structural approach for pricing corporate securities as in Merton (1974). In the presence of deposit insurance (Diamond and Dybvig, 1983), where central bank acting as the lender of last resort (Martin, 2006) and performing annual audits of the financial institution (Marcus and Shaked, 1984; Ronn and Verma, 1986), a one period model would be a good fit. However, recent evidence suggests that banks that were more risky pre-deposit insurance increased their risk exposures after the introduction of deposit insurance (DeLong and Saunders, 2011). Thus, for robustness, in Section 5.3 we relax this assumption and allow for more frequent withdrawn of deposits.

[6] In our model, the executive is affecting the risk of the financial institution only through managing the bank's assets. One may very well argue that she can affect risk through adjusting bank's leverage, too.

(1) *Equity-based compensation* has a positive sensitivity to an increase in the value of the financial institution's assets above some value *H*, where $H \geq F$. This component may include stocks and stock options, bonus payments, as well as any other pecuniary or nonpecuniary benefits whose value increase with the value of the financial institution's assets. We note that equity-based compensation includes accumulated stocks and options as well as new grants.

The payoff of the equity-based compensation at maturity *T*, defined as E_T^S, is equal to the percentage change in the value of the assets , V_T, over the strike price, *H*, times the parameter α, which denotes the sensitivity of the compensation to an increase in the value of the firm's assets above the strike price, and can be expressed as:[7]

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

We normalize the portion of the executive's wage that is not sensitive to asset value (i.e. her base salary) to one. Under this normalization, E_T^S captures both: (i) the dollar change in the executive wage wealth for a given percentage change in the firm's assets value above the strike price of *H*, where α is the dollar-percentage sensitivity, and (ii) the percentage change in the executive wage wealth for a given percentage change in the firm's assets value above the strike price of H, where α is the percentage-percentage sensitivity.[8] In the special case when $H = F$, equity-based compensation is assumed to be in the form of common stock (as in Sundaram and Yermack, 2007).

[7] To keep the notation as simple as possible, all variables without subscripts are present values.

[8] The pricing of the executive stock option in the structural framework demands 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 formula given by Black and Scholes (1973) becomes a special case of the compound option formula, and the strike price in this instance is the sum of the face value of the claims with higher seniority and the striking price of the option, defined as H .

(2) *Loss due to firm-specific financial distress* has a positive sensitivity to a decrease in the value of a financial institution's assets below the face value of the deposits, *F*. For example, this component may include uninsured pension benefits that would be foregone in the event of insolvency, reputation costs, and loss of future employment opportunities.

The payoff from this component at maturity, defined as E_T^F, is equal to the percentage change in the value of the financial institution's assets below the value of the firm's debt face value, F, times the sensitivity of the compensation to a decrease in the value of the firm's assets below the face value of deposits, denoted by β. It can be expressed as:

$$E_T^F = \beta \max(\frac{F - V_T}{F}, 0) = \beta \frac{1}{F} \max(F - V_T, 0) \quad (2)$$

Assuming that the value of the compensation not sensitive to asset risk is equal to unity, E_T^F measures both: (i) the dollar change in the executive wage wealth for a given percentage change in the firm's assets value below the face value of deposits, where β is the dollar-percentage sensitivity, and (ii) the percentage change in the executive wage wealth for a given percentage change in the firm's assets value below the face value of deposits, where β is the percentage-percentage sensitivity.

(3) *Loss due to systemic crisis* is realized only when the financial institution becomes insolvent at a time of systemic financial crisis. This component measures the additional loss in value of an executive's compensation if the financial institution becomes insolvent during a systemic crisis. This additional loss occurs because the executive's alternative employment opportunities would be more limited during bad economic times, when payroll is shrinking. Even if the executive finds a new job during a systemic crisis, she may be given lower compensation.

Modeling the value of this component requires a signal that will suggest systemic crisis. We assume that there is an index that accurately tracks the economy and that signals whether there is a systemic crisis. [9] As long as this index is above a certain threshold, the economy is not in a systemic crisis and the loss in executive compensation, should the financial institution become insolvent, is limited to the insolvency cost due to firm-specific financial distress.

When the index goes below the threshold, the economy is in a systemic crisis. In this case, the loss in executive compensation, should the financial institution become insolvent, is the sum of the loss due to firm-specific financial distress (pension plans, reputation, etc.) and the loss due to systemic economic crisis (decrease in salary at next employment, cost of longer unemployment period, etc.).

The loss in value of executive compensation due to systemic economic crisis, E_T^M, is equivalent to a short position in a Two-Asset-Correlation Put option that pays, at maturity, γ units times the percentage decline in value of the firm's assets below the face value of debt, F, if the value of the economic index at maturity, S_T, is below some lower threshold, K. The following expression describes the loss of executive compensation due to a systemic crisis:

$$E_T^M = \gamma \max(\frac{F - V_T}{F}, 0) 1_{\{S_T \le K\}} = \gamma \frac{1}{F} \max(F - V_T, 0) 1_{\{S_T \le K\}} \qquad (3)$$

where 1_ψ is the indicator function of the event ψ.

The payoff of the executive's total compensation excluding her fixed compensation, which is denoted by E_T, can be expressed as the sum of the three components:

[9] In practice, an equity index such as the S&P500 Index, or VIX may be used as a proxy.

$$E_T = \alpha \frac{1}{H} \max(V_T - H,0) - \beta \frac{1}{F} \max(F - V_T,0) - \gamma \frac{1}{F} \max(F - V_T,0) 1_{\{S_T \leq K\}} \quad (4)$$

3.2. Valuation of the Executive Compensation Components

The value of the executive's compensation can now be determined using standard option pricing theory. The present value of the executive's position can be written as

$$E = \alpha \frac{1}{H} \mathrm{Call}(V, H) - \beta \frac{1}{F} \mathrm{Put}(V, F) - \gamma \frac{1}{F} \mathrm{TACPut}(V, F, S, K) \quad (5)$$

where the value of the various components of executive compensation is replicated by using options with identical payoffs. The European call option, $\mathrm{Call}(V, H)$ replicates the equity-based compensation, the European put option, $\mathrm{Put}(V, F)$ quantifies the loss in value of executive compensation due to firm-specific insolvency, and finally the Two-asset-correlation put option, denoted by $\mathrm{TACPut}(V, F, S, K)$ values the loss in executive compensation due to a systemic crisis.

To model the value of these options we use the standard Black and Scholes (1973) and Merton (1974) assumptions. The value of the firm's assets and the level of the index follow a geometric Brownian motion with a dynamic given by:

$$dV = \mu_V V dt + \sigma_V V dW_V \quad (6)$$

$$dS = \mu_{S'} S dt + \sigma_S S dW_S \quad (7)$$

where S is the value of the economic index, and μ_v and μ_s are the instantaneous expected returns on the financial institution's assets and the economic index, respectively. The pricing model further assumes that the instantaneous variances of the rate of return of the firm's assets (σ_V^2) and the market index (σ_S^2) are constant. The expressions dW_V and dW_S are standard

Wiener processes with correlation given by $dW_S dW_V = \rho_{SV} dt$. The pricing equations for the European call and put options can be expressed under the standard assumptions for risk-neutral contingent-claim valuation, as follows:

$$Call(V,H) = VN(d(V,H)) - He^{-rT} N(d(V,H) - \sigma\sqrt{T})$$

$$Put(V,F) = Fe^{-rT} N(\sigma\sqrt{T} - d(V,F)) - SN(-d(V,F))$$

Where N() is the cumulative normal density and the function *d*(I,J) is defined as

$$d(I,J) = \frac{\ln(I/J) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}.$$

Finally, the value of the two-asset correlation put option can be expressed as

$$TACPut(V,F,S,K) = Fe^{-rT} M(y_2, y_1, \rho) - SM(y_2 + \sigma_V\sqrt{T}, y_1 + \rho\sigma_V\sqrt{T}, \rho))$$

where

$$y_1 = \frac{\ln(S/K) + (r - \sigma_S^2/2)T}{\sigma_S\sqrt{T}},$$

$$y_2 = \frac{\ln(V/F) + (r - \sigma_V^2/2)T}{\sigma_V\sqrt{T}},$$

and M() is the bivariate normal distribution of two stochastic variables with a given correlation of ρ. We sum the values of these three options to calculate the value of the components of executive compensation that are sensitive to asset risk.

3.3. Limit on the Level of Asset Risk

We restrict the level of asset risk of the financial institution with an upper boundary denoted by σ^H. This level is determined either by a regulator's effort and her ability to restrict the riskiness of a financial institution's assets or by a limited set of technologies and projects in a specific time (similar to John, Saunders, and Senbet, 2000).

3.4. Executive's Choice

The executive would choose the level of asset risk that would maximize the value of her compensation (Equation 5). If the value of the compensation is monotonically upward (downward) sloping with respect to the asset risk, the executive would choose the maximum (minimum) possible level of risk to maximize the value of compensation. If the value of compensation is a convex function of asset risk, the executive would choose an intermediate level of risk that would yield the maximum compensation value.[10] This case would differ from previous cases where a corner solution is chosen, and can be expressed by the following equation:

$$\sigma = \frac{\partial E^*}{\partial \sigma}_{|\sigma=\sigma^*} = 0 \qquad\qquad \frac{\partial^2 E}{\partial \sigma^2} < 0 \tag{8}$$

We solve Equation (8) numerically to illustrate the impact of the executive's constrained maximization on the choice of investment policy and, thus, on risk taking. In line with the existing literature, we show that (1) sensitivity of equity-based compensation to asset risk is positive, and (2) sensitivity of loss in the value of executive compensation due to firm-specific

[10] One may argue that an interior solution (moderated risk-taking) is less likely for executives of banks that are too big to fail. However, Houston and James (1995) provide evidence that banks which were classified as "too big to fail" by the Comptroller of Currency did not give their CEOs compensation packages that were significantly different than rest of the banks, despite the fact that they were well insulated from regulatory pressure and therefore had greater incentives to take risk. Still, we are not suggesting that executive compensation can overcome problems associated with such financial institutions. Cukierman (2011) discusses in detail about the "too big to fail" banks and suggests some remedial devices such as (i) mandatory break-up of financial institutions that are TBTF, (ii) imposition of absolute limits on the amounts of leverage, (iii) ceilings on minimum capital requirements, and finally iv) a tax schedule proportional to the systemic risks created by the TBTF financial institutions.

insolvency and due to a systemic crisis is always negative, as long as the option is out-of-the-money and default has not occurred.

4. Executive Compensation And Risk-Taking

In this section, we analyze the link between executive compensation and risk taking using numerical examples. We summarize the parameters used in the base case of our analysis in Table I.

4.1. Case 1: Equity-Based Compensation

We begin by examining the link between executive compensation and risk taking when equity-based compensation is the only component of executive compensation that is sensitive to asset risk (i.e., $\beta = \gamma = 0$), as in Bebchuk and Spamann (2010). Under this scenario, the executive's payoff at maturity is reduced to:

$$E = \alpha \frac{1}{H} \mathrm{Call}(V, H)$$

In Panel A of Figure 1, we fix α to 2 and plot the value of the executive compensation. When we assume that there is no loss to the executive due to insolvency (i.e., $\beta = \gamma = 0$), the value of executive compensation strictly increases with asset risk of the financial institution.[11] As a result, the executive whose objective is to maximize personal compensation will optimally try to reach the maximum asset risk. If a regulator can limit the financial institution's asset risk to some

[11] This result is consistent with the conclusions of Jensen and Meckling (1976) and Galai and Masulis (1976), and will hold for any leverage ratio.

maximum level (σ^H), the executive would choose that level, given the existence of sufficient technology and financial instruments.[12]

4.2. Case 2: Equity-Based Compensation and Loss due to Firm-specific Financial Distress

The second component—loss in the value of executive compensation due to firm-specific insolvency has positive sensitivity to a decrease in value of the financial institution's assets below the face value of the deposits, *F*. This component may include any pecuniary and nonpecuniary compensation that would be lost if the financial institution become insolvent. As described in Section 3, the value of executive compensation at maturity can be expressed as

$$E = \alpha \frac{1}{H} \mathrm{Call}(V, H) - \beta \frac{1}{F} \mathrm{Put}(V, F)$$

This structure of compensation is similar to that of Sundaram and Yermack (2007), but they analyze a special case where the equity-based compensation is composed solely of stock. In that case, as in Merton (1974), the value of equity is identical to the value of a call option on the value of the firm's assets with a strike price equal to the face value of debt (i.e. $H = F$). In this special case, the executive would choose the maximum possible asset risk if the sensitivity of executive wealth to an increase in the value of assets above strike price is greater than the sensitivity of executive wealth to a decrease in the value of firm's assets below the face value of deposits, i.e. if $\alpha > \beta$[13], and choose the minimum asset risk if $\beta > \alpha$. The presented framework, following Landskroner and Raviv (2009), generalizes Sundaram and Yermack (2007) and allows the strike price of the call option on a firm's assets to exceed the face value of the firm's debt (i.e., $H > F$). When we allow *H* and *F* to differ, an executive's optimal risk choice is not limited to the maximum or minimum level of asset risk.

[12] In this case, the regulator will need to constantly monitor the financial institution and will bear the full cost of monitoring.

[13] In other words, if there are more units of equity-based compensation than inside debt.

In Panel A of Figure 1, we plot the values of executive compensation for different levels of asset risk. We fix α to 2, and analyze three cases for β: $\beta = \{0, 1, 2\}$.[14] Under such conditions, when the sensitivity of executive compensation to an increase in the firm's value above the strike price (H) is relatively high compared to the sensitivity of compensation to a decrease in the firm's value below its face value of debt (F), i.e. when $\alpha >= \beta$, the result is identical to that of Case 1. The value of executive compensation is a strictly increasing function of asset risk, and the executive would optimally target the highest possible asset risk, given the regulatory or technological limit, in order to maximize compensation.

In Panel B of Figure 1, we keep α fixed at 2, and analyze the relationship between executive compensation and asset risk for higher values of insolvency costs, where $\beta = \{3, 4, 5\}$. In this case, the sensitivity of executive compensation to an increase in firm value above the strike price is relatively low compared to the sensitivity of compensation to a decrease in firm value below its face value of debt ($\beta > \alpha$).[15] Under this scenario, the value of executive compensation is a convex function of asset risk and has a global maximum. Thus, the executive optimally targets an intermediate level of asset risk to maximize her compensation. Furthermore, the optimal level of asset risk targeted by the executive to maximize the expected compensation will decrease as β increases: The optimal level of asset risk is equal to 5.51%, 4.27%, and 3.73% for values of β equal to 3, 4, and 5, respectively.

[14] All other parameters are at their base case values as listed in Appendix 1, unless stated otherwise.

[15] Such a compensation structure may be relevant for an executive who has accumulated a significant amount in pensions and deferred compensation, or whose reputation costs would be very high should the financial firm becomes insolvent.

The level of asset risk that an executive would optimally target also depends on the financial institution's leverage[16]. As the financial institution's leverage ratio increases, the optimal asset risk decreases. For example, when $\alpha = 1$ *and* $\beta = 2$ (Table II, Panel A, first row), the executive would optimally target an asset risk of 6.21% if the leverage ratio is equal to 0.900. When the leverage ratio is increased to 0.975, the optimal level of asset risk is 1.40%.

4.3. Case 3: Equity-Based Compensation, loss due to Firm-specific Financial Distress and due to a Systemic Economic Crisis

The third component— insolvency cost due to a systemic economic crisis—has a positive sensitivity to decreases in the value of a financial institution's assets below the face value of the deposits, F, but is only realized if the financial institution becomes insolvent at a time of systemic crisis. As described in Section 3, the value of executive compensation at maturity can now be expressed as

$$E_T = \alpha \frac{1}{H} \max(V_T - H, 0) - \beta \frac{1}{F} \max(F - V_T, 0) - \gamma \frac{1}{F} \max(F - V_T, 0) 1_{\{S_T \leq K\}}$$

Panel A of Figure 2 shows the relationship between the value of executive compensation and asset risk when the economy is doing well (the economic index is 30% above the threshold for systemic economic crisis). We fix α to 2 and β to 1, and plot the value of executive compensation for different levels of γ, that is, $\gamma = \{0, 1, 2, 3\}$. Under these conditions, the

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[16] We define the leverage ratio as the quasi-leverage ratio which can be expressed as $LR = Fe^{-rT}/V$. The leverage ratios we use in the analyses range between 0.90 and 0.975. These levels are equivalent to asset-to-equity ratios of 9 and 39 respectively. This range is typical for commercial and investment banks before and during the 2007-2009 crisis (He, Khang and Krishnamurthy, 2010).

component of loss due to systemic economic crisis has almost no effect on the value of executive compensation and does not affect the risk-taking motivation of the executive. The value of compensation strictly increases with asset risk. This result is intuitive, when the economy is far from the state of systemic crisis, the expected value of loss due to systemic crisis is close to zero.

Panel B of Figure 2 exhibits the relationship between the value of executive compensation and asset risk when the economy is in a systemic crisis state (the economic index is 10% below the threshold for systemic economic crisis). Under this condition the component of loss due to systemic crisis influences the risk-taking decision of the executive. Because of additional expected loss in value of compensation, for a large enough γ the relationship between asset risk and the value of compensation becomes convex, with a global maximum, instead of strictly upward sloping. In other words, even for cases in which equity-based compensation dominates the executive pay package (i.e., $\alpha > \beta$), the executive may optimally choose not to target the maximum possible level of asset risk, and may target an intermediate level of asset risk. For example, during a systemic crisis the executive would optimally choose an asset risk of 5.53% and 4.27% when γ is equal to 2 and 3 respectively, while in a good state of the economy (where $S/K = 1.3$), the maximum possible level of asset risk would have been chosen (Panel B of Figure 2).

5. Extensions

5.1. Economic Booms

We have assumed throughout the paper that the executive will incur an additional loss if the financial institution she is managing becomes insolvent at a time of systemic crisis, because her outside employment opportunities will be more limited at such times. One may as well argue for such an asymmetric loss during times of systemic economic boom, on the grounds that a manager that fails during good economic times would be sending the labor market a very bad signal of her quality, because such a failure would be an idiosyncratic event.

Accordingly, in this section we incorporate the possibility of additional loss if the executive fails during an economic boom. We model the loss in value of executive compensation due to default in boom time, E_T^{Boom} as being equivalent to a short position in a Two Asset Correlation Put option that pays, at maturity, δ units times the percentage decline in value of the firm's assets below the face value of debt (F), if the value of the economic index at maturity, S_T, is above some upper threshold, K_{Boom}. The following expression describes the loss of executive compensation due to default in boom time:

$$E_T^{Boom} = \delta \max(\frac{F - V_T}{F}, 0) 1_{\{S_T \geq K_{Boom}\}} = \delta \frac{1}{F} \max(F - V_T, 0) 1_{\{S_T \geq K_{Boom}\}}$$

The payoff of the executive's total compensation excluding her fixed compensation, which is denoted by E_T, can be expressed now as the sum of the following four components:

$$E_T = \alpha \frac{1}{H} \max(V_T - H, 0) - \beta \frac{1}{F} \max(F - V_T, 0) - \gamma \frac{1}{F} \max(F - V_T, 0) 1_{\{S_T \leq K\}} - \delta \frac{1}{F} \max(F - V_T, 0) 1_{\{S_T \geq K_{Boom}\}}$$

5.1.1. Valuation of E_T^{Boom}

Since the event where the value of an asset at maturity is above a chosen threshold is a complementary event to the event that asset value would be below that threshold, the value of the loss due to default in boom time can be calculated as the sum of two options that were already defined at equation (5). This position can be replicated as the sum of a plain vanilla put option with a strike price which is equal to the bank's face value of debt, *F*, minus the value of a Two Asset Correlation put option with the same strike price, which pays at maturity only if the economic index, S_T is below the economic threshold that signal a boom in the economy, K_{Boom}. Thus the value of the executive compensation with the component of default in boom times can be written in options terms as follows:

$$E = \alpha \frac{1}{H} Call\,(V, H) - \beta \frac{1}{F} Put\,(V, F) - \gamma \frac{1}{F} TACPut\,\,(V, F, S, K)$$
$$- \delta \frac{1}{F} Put\,(V, F) + \delta \frac{1}{F} TACPut\,\,(V, F, S, K_{Boom})$$

5.1.2. Results

We present the results in Figure 5 and Table III. Figure 5 shows the relationship between the value of executive compensation and asset risk for two different states of the economy that we have analyzed in the previous sections: Good times (S/K=1.3), and crisis times (S/K=0.9). As in Figure 2, we fix α to 2 and β to 1. We also fix γ to 3, its baseline level. We then plot the value of executive compensation for different levels of δ, that is, $\delta = \{0,\ 1.5,\ 3\}$. Thus, comparing Figure 5 with Figure 2 will shed a light on the effect of the new component we are introducing.

Our calibration results under the baseline parameters indicate that the loss in value of executive compensation due to default in boom time, E_T^{Boom}, would have an effect on risk-taking motivation of the executive when the economy is actually in good states (Panel A) and no effect if the economy is in a systemic crisis (Panel B). When δ is set to zero and 1.5, the manager would optimally target the maximum possible amount of risk – a result that is identical to the earlier result presented in Figure 2. However, for relatively higher levels of δ, the results change with the addition of the new compensation component: When δ is set to 2, the optimal risk is 12 percent[17], and when δ is set to 3, the optimal risk is 9 percent. In other words, the assumption about boom times will have some effect on managerial risk taking when its size is close to the component of loss during systemic crisis (γ).

In Table III, we present the optimal risk levels under alternative scenarios and the effect should be compared to Panel B in Table II. We infer that the new component will have an effect on executive's risk taking for relatively large values of δ (δ=3). When δ is sufficiently high, the manager would be motivated to target an intermediate risk level even at good economic times. For example, when the economy is in a good state (S/K=1.3), incorporating the new component would change the result from maximum risk-taking by the executive to a risk level of 9.39 under the baseline leverage ratio of 0.95.

Since the effect of the new component depends on the parameterization of δ, we search empirical literature to find a likely value for δ. Jacobson, LaLonde and Sullivan (1993) and Davis and von Wachter (2011) estimate that the earnings loss from displacement during recessions is twice of earnings loss from displacement during expansions. Thus, a plausible ratio between γ and δ is about 2 – i.e. for the baseline γ of 3, the corresponding value for δ would be about 1.5. Panel B of Table III analyzes the risk levels that an executive would optimally target when δ=1.5 and the rest of the compensation parameters are set at their baseline levels. Comparing the results to Panel B of Table II, we see that the addition of the new component does not change the optimal risk levels when the economic index is below the boom threshold (i.e. below S/K=1.3).

[17] We are not plotting the graph for δ=2 for brevity.

5.2. Incorporating Leverage in the Model: Bankruptcy Costs

In the previous sections, we have assumed that the values of the unlevered and levered firms are the same and independent of volatility. In this section, we extend the model by assigning a more direct role to the leverage of the financial institution. Specifically, we incorporate bankruptcy costs in the model, in which leverage has a significant effect on the value of the financial institution's assets through bankruptcy costs. Higher leverage ratios translate into higher default probabilities and increase the expected value of bankruptcy costs, which in turn lead to lower value of the financial institution. As a result, the wealth of the executive, who is exposed to loss in the event of default, is affected by the existence of bankruptcy costs[18].

We define bankruptcy costs (*BC*) as the loss in the asset value when the bank is liquidated or reorganized.[19] Like in Anderson and Sundaresan (1996), we assume that bankruptcy costs reduce the collateral value of assets in a linear fashion, so the latter is simply the market value of assets net of bankruptcy costs $(V_T - BC)$. Bankruptcy costs are incurred if the realized value of the bank's assets is below the face value of debt at maturity and have a negative effect on the value of the executive compensation. This negative payoff associated with bankruptcy costs can be expressed by adding two components to Equation 5: (i) bankruptcy costs as part of the *Loss due to bank-specific financial distress* component, and (ii) bankruptcy

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[18] Leverage would also have a positive effect on the value of the financial institution by providing a tax shield. By assuming away from the tax benefits of leverage, we are biasing our results against our main argument that during times of systemic crisis the sensitivity of managerial risk taking to equity-based compensation will be less.

[19]In US, the liquidation of bank assets has historically been used in situations where a merger was unavailable or too costly or where the bank's loss to the community would impose few local costs. Reorganization of the failed banks traditionally included a merger of all or part of the assets of the insolvent bank with a stronger healthy bank's assets. In US, with the exception of the systematic risk exemption the least-cost resolution strategy requires the Federal Deposit Insurance Corporation (FDIC) to employ the method that imposes most failure costs on the uninsured depositors (Saunders, 1999).

costs as a part of the *Loss due to systemic crisis* component. The expected value of executive compensation becomes:

$$E_T = \alpha \frac{1}{H} \max(V_T - H, 0) - \beta \frac{1}{F} \max(F - V_T, 0) - \gamma \frac{1}{F} \max(F - V_T, 0) 1_{\{S_T \leq K\}}$$
$$- \beta \frac{BC}{F} 1_{\{V_T \leq F\}} - \gamma \frac{BC}{F} 1_{\{V_T \leq F, S_T \leq K\}}$$

5.2.1. Valuation

The present value of the executive's position can now be calculated by adding the value of two different options. The first option replicates the added effect of bankruptcy costs due to the loss in bank specific financial distress in the form of a Binary Put option that pays the amount of *BC* if the value of the bank at maturity is below the face value of debt. The second option replicates the effect of the loss due to systemic crisis component in the form of a Two Asset Cash-or-Nothing option that pays the amount of *BC* if both the bank assets value at maturity is below the face value of debt and the economic index is below the distress threshold. The value of the executive compensation with the existence of bankruptcy costs can be written in options terms as follow:

$$E = \alpha \frac{1}{H} Call(V, H) - \beta \frac{1}{F} Put(V, F) - \gamma \frac{1}{F} TACPut(V, F, S, K)$$
$$- \delta \frac{BC}{F} BinaryPut(V, F) + \delta \frac{BC}{F} TACBinaryPut(V, F, S, K)$$

The value of the Binary put option according to the Black and Scholes method, under the GBM process, which is presented at equations (6) and (7), can be calculated according to the following equation:

$$BinaryPut\,(V, F)) = BCe^{-rT} N(\sigma \sqrt{T} - d(V, F))$$

Where the value of the Two Assets Correlation Put option value is determined according to the following equation:

$$TACBinaryPut(V,F)) = BCe^{-rT} M(y_2, y_1, \rho)$$

5.2.2 Results

In Table 4, we present the optimal risk levels that would be chosen by the executive given her compensation contract. The parameters are as in the baseline case. The table summarizes managerial risk taking under different states of economy and varying bankruptcy costs.

The first column presents the results under no bankruptcy costs (*BC*=0). In the rest of the table, we analyze the effect of bankruptcy costs amounting to 2%, 4% and 6% of the initial value of the financial institution's assets. As bankruptcy costs increase, the optimal risk level decreases. For example when the economic index is at 10%, adding a 6% bankruptcy cost to the model would decrease the optimal level of assets risk from 4.56% to 2.20% when the leverage ratio is 0.95. All else equal, in the existence of bankruptcy costs the loss of the executive in the event of default would be greater. Therefore, the executive would choose a lower level of assets risk as the size of bankruptcy costs increases.

To summarize, in the existence of bankruptcy costs, an executive's choice of optimal asset risk will be more sensitive to the underlying leverage. While, our main argument in the paper remains unchanged – same level of equity-based compensation induces lower risk taking when the economy is in a systemic crisis, when bankruptcy costs are incorporated in the model, the difference is less stark for higher leverage ratios.

5.3. Incorporating the Possibility for Early Withdrawal of Deposits in the Model

In the previous sections, we have assumed an annual audits process (Marcus and Shaked, 1984; Ronn and Verma, 1986) and used a model were default can occur only at debt maturity if the value of the financial institution's assets falls below the face value of debt (Merton, 1974). In this section, we instead consider the possibility of early withdrawal of deposits. To do so, we use a model in which audit happens more frequently, thus revealing information about the financial health of the bank before debt maturity. With a more frequent auditing process the institution can be in default not just on debt maturity, but rather at any auditing period. In this case, the default trigger would resemble a constant barrier approach (Black and Cox, 1976; Ericsson and Reneby, 1998).

We assume that the regulator would trigger liquidation or reorganization, at any auditing time if the value of assets reaches a lower threshold which is equal to the discounted value of the deposit at that time $Fe^{-r(T-t)}$ (as in Black and Cox, 1976). The time of default, is denoted by, τ , and is defined formally by the first audit time where the value of assets is below the discount value of the liabilities:

$$\tau = \inf\{t > 0 \mid V_t < Fe^{-rT}\}$$

The current value of the executive compensation can now be expressed as follow:

$$E = E^Q[e^{-rT}\alpha \frac{1}{H}(V_T - H)1_{\{T \le \tau, V_T > H\}} -$$
$$e^{-r\tau}(\beta \frac{1}{F}\max(F - V_\tau)_{\{T>\tau\}} - \gamma \frac{1}{F}\max(F - V_\tau, 0)1_{\{T>\tau, S_\tau \le K\}})]$$

where E^Q denotes the conditional expectation under a risk neutral measure Q given all available information at time zero, and 1_ψ is the indicator function of the event ψ. Since an analytical solution is not available for the analyzed case of two assets with periodical sampling, we provide a numerical solution. We follow the Monte-Carlo simulation approach, since it is easy to implement and applicable. The frequencies of the audit which we checked are monthly, quarterly and yearly.

The results are presented in Table V. We see that as the audit frequency gets higher, risk-taking motivation of the executive will decrease. For example, when the economy is 20% above the crisis threshold, the optimal risk taking by the executive would decrease from 5.64% to 4.32% as the audit frequency increases from annual to monthly.

5.4. Effect of Correlation between Financial Sector and Economy

In the previous sections, we have fixed the correlation between the returns on the bank's assets and the economic index to 0.8 - the average correlation between the returns on the S&P 500 Index (SPX) and the KBW Bank Sector Index (BKX) between 2000 and 2012. However, one may argue that this correlation may not be constant. Accordingly, in this section, we perform a sensitivity analysis by varying the correlation between the returns on the bank's assets and economy between 0.6 and 0.9.[20]

The results of the sensitivity analysis are presented in Table VI. We present the level of asset risk that the executive will optimally choose to maximize the value of her compensation. The parameters are set at their base case values. The results reveal that as the correlation between the return on the assets of the financial institution and economic index gets lower, risk-taking by

[20] We have calculated the correlations for the returns on the two indices for each year. The correlations range from 0.67 and 0.91. We also note that we do not see any specific patterns in correlations associated with different states of economy.

the executive gets more sensitive to how the economy performs. For example if the correlation is 0.8, the optimal risk taking by the executive changes by a small amount from 5.64% to 4.27% as the economic index moves from 20% above the crisis threshold to 10% below the crisis threshold. However, for a lower correlation of 0.6, the optimal risk taking by the executive changes significantly from 9.30% to 4.35% as the economic index moves from 20% above the crisis threshold to 10% below the crisis threshold.

We conclude that the correlation between the financial sector returns and market returns is a significant determinant of the effect of the economy on executive risk taking. This being said, the main message of the paper remains intact: The same compensation package may lead to different levels of asset risk under different economic states.

6. WHY DOES "INSOLVENCY COST DUE TO A SYSTEMIC CRISIS" MATTER?

6.1. The Relationship between Executive Compensation and Risk Taking during a Systemic Economic Crisis

The model shows that the level of asset risk that maximizes the value of an executive's compensation may vary with the state of the economy. Most importantly, during a systemic crisis the optimal level of asset risk becomes less sensitive to an increase in the proportion of equity-based compensation. This result can be seen in Table II. When the economy is in a crisis (i.e. the economic index is 10% below the threshold for systemic crisis- S/K = 0.9), granting more incentive compensation (i.e. increasing α) does not have a crucial effect on risk taking. For example, for a financial institution with a leverage ratio equal to 0.975, the risk level that maximizes the value of executive compensation is 1.40% when α is equal to 1. Risk level increases to 1.97% when α is equal to 2, and to 3.76% when α is equal to 3. These results may explain why, during the 2007–2009 crisis financial institutions altogether shifted to a low level of asset risk despite the differences in their executive compensation structures and leverage ratios.

The shift to a lower level of asset risk may also occur when the economy is not in a crisis, but the distance from the threshold of economic crisis is relatively low. Figure 3 shows that an executive would switch from the maximum possible level of asset risk when the economic index is located 20% above the threshold to an intermediate level of asset risk (7%) when the index is located just 10% above the threshold.

6.2. Effect of Leverage during Systemic Crisis

Leverage is another channel that impacts the relationship between incentive compensation and risk taking. As in Landskroner and Raviv (2009), our model yields that as the leverage ratio increases, the asset risk that is optimally chosen by an executive would decrease (see Table II). However, our model has the power to show the combined effect of state of the economy, leverage and incentive compensation structure on the asset risk levels, especially during systemic crises.

We will again use 2007–2009 financial crisis as an illustrative example. Let's examine a typical financial institution pre-crisis, which was characterized by a relatively high ratio of equity-based compensation to costs due to firm-specific insolvency and systemic crisis (e.g., $\alpha = 3$, $\beta = 1$, $\gamma = 3$). Pre-crisis, the typical leverage ratio was 0.9, which is equivalent to Asset to Equity ratio of 9, as reported by He, Khang and Krishnamurty (2010), and the state of the economy was good (normalized economic index= 1.3). Under these parameters, our model yields a positive relationship between asset risk and the value of compensation, thus, the executive would try to take the maximum possible level of asset risk in order to maximize the value of her compensation. In return, the government, through the supervisor of banking, would try to limit the level of asset risk.

The financial crisis had two distinct effects on the risk taking motivation of executives in the financial sector. First, the state of the economy deteriorated (normalized economic index= 0.9) and thus according to the model the insolvency cost due to systemic crisis increased. Therefore, if leverage is kept fixed at 0.90, the level of asset risk that maximizes the value of the compensation drops from the maximum possible to 12.92%. Second, after the onset of the crisis the leverage of the financial intuitions increased due to a decrease in the value of assets. The increase in leverage ratios leads to a further reduction in executive risk taking. For example, if the leverage ratio increases to 0.975, the executive with a typical compensation package would choose an asset risk of only 3.02%.

6.3. Designing a Compensation Structure to Motivate a Target Level of Risk

An executive would find it optimal to increase the asset risk as high as possible when her equity-based compensation is sufficiently high (see Panel C of Table -2). If that is the case, there would be a need for a financial regulator to impose a limit on assets risk. An alternative to directly limiting asset risk would be to design a compensation structure that would align the executive's risk choice with that of the regulator.

Our model can be used to design a pay package that would induce an executive to target a risk level that is commensurate with that of the regulator. In other words, financial institutions and regulators may use this model to calculate the proportion of equity-based compensation, α, that would cause an executive to switch from the maximum possible level of asset risk to a an intermediate level of asset risk which coincide with the regulator's interest (see Panel A of Figure 4).

An advantage of our model is its relevancy over the entire business cycle because it explicitly takes the state of the economy into account. As we have discussed in the earlier sections, the relationship between incentive compensation and risk taking may change during systemic crisis. If that is the case, the level of equity based compensation, α, that would yield the desired risk level will change over the economic cycle. For example, if the desired asset risk is 5%, setting α to 2.42 would induce the executive to target it when the economy is in a systemic crisis (Panel B of Figure 4 where LR=0.95). However, when the economy is in a good state, setting α to 1.45 would induce the same asset risk.

Furthermore, as can be seen in Figures 4, a change in the state of the economy affects the point at which an executive would switch from an intermediate optimal level of asset risk to a corner solution (the maximum possible level of asset risk). For example, at a good state of the economy (when S/K = 1.3) an executive would choose the maximum possible of asset risk for α of 1.87, while when the economy is in systemic economic crisis (where S/K = 0.9), such level would be chosen when α is equal to 4.0.

6.4. Regulatory Implications

In this section, we discuss the regulatory implications for different states of the economy. Specifically, we discuss under which conditions regulating executive compensation may be a powerful tool and when accumulated equity-based compensation may be an impediment requiring greater emphasis for complementary regulation such as capital adequacy ratios.

1. <u>Economic boom times</u>: If the economy is in a very good state (S/K=1.3 or higher), then the executive would try to take the maximum amount of risk if she has a sufficiently high levels of equity-based compensation. For example, when α=2 the executive would be motivated to take the maximum possible level of assets risk when the economy is in boom time, where S/K=1.3

(see Table II, Panels B and C; Table II, Panels A and B). In other words, in an expansionary period, a manager may be motivated to take on too much risk because of her accumulated equity-based compensation. Under such conditions, compensation policy would not suffice to limit risk-taking to the desired level, and there is significant need for additional regulation to limit risk-taking activities by financial institutions. However, if the accumulated equity incentives are not very high (see Table II, Panel A), there may still be room to achieve desired risk levels through executive compensation contracts.

2. Normal states of economy: Under normal economic conditions ($1<S/K<1.3$), regulating compensation may achieve the desired level of risk taking if the accumulated equity-based compensation is not too high. Regulating executive compensation would be especially effective if a manager's accumulated equity-based compensation falls short of the level that would achieve the desired risk taking, because the manager could be provided by more equity incentives to take on more risk (see Table II, Panels A and B). Thus, regulating risk through executive compensation contracts may be a substitute to direct regulatory measures such as capital adequacy ratios. However, we should also note that if the accumulated incentives are already too high (see Table II, Panel C), there will still be a need for other regulatory measures to restrict risk taking.

3. Recessions: During a systemic crisis, a manager may take too little risk if she has a low level of equity incentives. In this case, there is again a role for compensation regulation. For example, for the baseline leverage ratio of 0.95 and low level of equity incentives as characterized by $\alpha=1$, the executive will target asset risk of 3.05% when the economy is in a recession. If the regulator assesses that this risk level is lower than the desired level, then adding more equity compensation would motivate the executive to take on additional risk.

This finding has policy implications for the post–financial crisis environment in which regulators of the financial industry have gained some "say on pay." A regulator can limit equity based compensation to achieve a target level of asset risk. Before the 2007–2009 financial crisis, government could only control asset risk directly through banking supervisors who, by very costly and sometimes inefficient procedures, were trying to force institutions to limit their asset risk. If limits on the quantity of equity-based compensation can be introduced effectively, a redundancy may be created in the activity of the supervisor of the banking, because executives may target a specific level of risk through their holding of the two types of compensation components.

7. Summary and Concluding Remarks

In this paper we developed a model for pricing executive compensation. Our main contribution to the extant literature is to identify and value a component of the compensation, which we define as "loss due to a systemic economic crisis". This component measures the additional loss in value of an executive's pay package if the financial institution she is managing becomes insolvent during a systemic crisis. This additional loss occurs because we expect that an executive's alternative employment opportunities would be more limited during bad economic times when payrolls are shrinking.

The novel component in our model, loss in executive compensation due to a systemic crisis, has important implications for understanding the relationship between executive compensation and risk taking. We show that during good states of the economy, an executive may optimally target the maximum possible level of asset risk. However, when the economy is in a systemic crisis, the same executive with exactly the same pay package may find it optimal to choose a lower and intermediate level of asset risk. Understanding how similar pay packages may yield different risk levels under different economic conditions is crucial to designing compensation packages that yield a desired level of asset risk over the business cycle.

This framework has important implications for executive pay reform in the financial sector because it points to some redundancy between more traditional forms of regulation that directly impose limits on asset risk (i.e., risk-based capital adequacy ratios), and proposed regulations that target executive compensation practices.

Furthermore, the model can be used to analyze the risk taking motivation of executives over the entire business cycle, because we explicitly incorporate the state of the economy in our analysis. Therefore, the presented framework can contribute to the understanding of different tools and measures that can be used to affect the risk taking motivation of executives in financial institutions.

Appendix 1: Discussion of the Base Case Parameters

A1.1. Characteristics of the Financial Institution

Maturity (T): We consider a financial institution whose claims mature in one year (T= 1), following Marcus and Shaked (1984) and Ronn and Verma (1986). The one-year maturity is reasonable with the annual frequency of regulatory audits, because if the market value of assets is found to be less than the value of total liabilities in an audit, regulators have the ability to seize the bank.

Leverage ratio of the financial institution (LR): We define the leverage ratio as $LR = Fe^{-rT}/V$. We set the face value of the financial institution's debt, F, to 100, and calculate for each level of leverage ratio the appropriate level for a firm's asset value, V. The leverage ratio range between 0.90 and 0.975. These levels are equivalent to asset-to-equity ratios of 9 and 39 respectively. This range is typical for commercial and investment banks before and during the 2007-2009 crisis (He, Khang and Krishnamurthy, 2010).

Asset risk (σ_V): In the model, the regulator exogenously sets a limit on the maximum level of asset risk that a financial firm can have. However, an executive of a financial firm has the flexibility to target any level that would maximize the value of her compensation, subject to the constraint that it cannot go above the maximum value set by the regulator.

A1.2. Economy

The Fundamental Index: We choose for our example a fundamental index of the economy that stays 30% above the threshold of economic crisis in good times and in the worst case scenario is 10% below the level of the threshold for financial distress. The chosen levels are very similar to the fluctuation of the S&P500 index, which had a negative 40% return in 2008 during the financial crisis, when the level of unemployment in the financial sector was already very high as the index value went down by 30% from its peak.

Fundamental Index Volatility: We fix index volatility at 20% in the base case. This is equal to the average of the VIX index (the traded index which relates to the volatility of traded options on the S&P-500 index) since it is the traded index which relates to the volatility of traded options on the S&P-500 index.

Interest Rate: We choose a continuous constant rate of 3% (r = 3%). This is on par with average annual returns on 3-month treasury bills between the years 2000 and 2007.

Correlation between the returns of the bank's assets and the economic index (ρ): We set ρ to 0.8. This is equal to the correlation between the returns of KBW Bank Sector Index (BKX) and the S&P-500 Index (SPX) between 2000 and 2010 in our base case.[21]

A1.3. Executive Compensation

α: The parameter α is the percentage increase in the value of the executive compensation for a 1% increase in the value of a financial firm's assets over the strike price, H. The value of this parameter depends on the amount of stocks and stock options (accumulated grants plus new grants), as well as any other payments to the executive of which the value increases with the value of the financial institution's assets, such as bonus payments. Fahlenbrach and Stulz (2010) calculate that at the end of 2006, the mean (median) ownership of a commercial bank CEO from stock and stock option holdings was 2.4% (1.0%). Similarly, Adams and Mehran (2003) also find that CEO equity holdings average at 2.3%. In our baseline analysis, we fix α to 2. However,

[21] The KBW Bank Index consists of all companies in the Financial Sector of the S&P-500 Index within the U.S. For the composition of the KBW Bank Index, see www.kbw.com/research/BKX.asp

because in practice this is the compensation component which can be varied by stockholders and can be monitored and capped by the regulator, we would investigate how a change in the equity-based component affects the risk-taking motivation when other components are fixed.

β: The percentage decrease in the value of executive compensation for a 1% decrease in value of the financial firm's assets below the face value of its debt obligations. There is no evidence about loss in executive compensation in the event of insolvency. We assume that the parameter β is set to 1.

The strike price of the equity-based compensation (*H*): because the convention in the market is to set the strike price of stock options as being at the money (i.e., the value at maturity of the stock when the firm asset value is equal to the strike price) at first, we set the strike price for each leverage ratio between the current value of the stock according to the Black–Scholes–Merton model and the value of the stock at maturity when the option is exactly at the money.[22] To do so, however, we need to fix asset risk, which is the target parameter in the model. Thus, we set asset risk equal to 5.3%, similar to the average asset risk of bank found in a large sample studied by Mehran and Rosenberg (2008). Changing the asset risk by calculating the strike price for two standard deviations up or down did not change significantly the level of the strike price or the robustness of our results.

γ: The parameter γ is the percentage decrease in value of executive compensation for a 1% decrease in value of a financial firm's assets below the face value of its debt obligations, *F*, when the economic index, *S*, is below the threshold *K*. In the base case example, the value of this parameter is set to 3, because such a level has almost no effect on risk-taking motivation in good

[22] Palmon, Bar-Yosef, Chen, and Venezia (2008) study the optimality of option grants (with choice of the strike price) and find that unless there are tax-related disadvantages, in-the-money options are better for shareholders.

times (i.e., when the economic index is 30% above the threshold of financial crisis), but when the economy is in financial crisis (i.e., the economic index is 10% below the threshold of financial crisis) the component has a significant effect on the chosen level of asset risk.

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Table I: Parameters Used in the Base Case of the Model

Parameter	Symbol	Base Value
Leverage ratio	LR	0.95
Face value of deposits	F	100
Value of the firm's assets	V	102.15
Time to maturity	T	1
Economic index volatility	σ_S	20%
Risk-free rate	R	3%
Economic index value	S	90 to 130
Crisis threshold	K	100
Economic boom threshold	K_{Boom}	130
Sensitivity of compensation to a 1% increase of asset value above the strike price	α	2
Sensitivity of compensation to a 1% decrease in asset value below the value of liabilities	β	1
Sensitivity of compensation to the joint event of a decrease in asset value below the value of liabilities in a financial crisis	γ	3
Correlation between returns of the firm's assets and the economic index	ρ	0.8
The strike price of equity-based compensation	H	105.57

Table II: Optimal Asset Risk for Different Compensation Schemes, Firm Leverage, and States of the Economy

Table II presents asset risk (in percentages) that an executive would choose to maximize the value of her compensation. The parameter α, the sensitivity of the executive compensation to an increase in the value of the firm's assets above the strike price receives the values of 1, 2, and 3. All other parameters are set at their base case values as summarized in Table I. We also report the shape of the curve that describes the relationship between asset risk and the value of executive compensation. The curve can be upward sloping (US). When the curve is upward sloping we use the symbol US, otherwise, we report the value of asset risk that maximizes executive payoff.

Stock Option Quantity	**Normalized Economic Index**	**Bank Leverage Ratio**			
		0.975	**0.950**	**0.925**	**0.900**
Panel A $\alpha = 1$	**-10%**	1.40	3.05	4.62	6.21
	0%	1.40	3.05	4.62	6.22
	10%	1.41	3.08	4.67	6.28
	20%	1.45	3.18	4.83	6.49
	30%	1.56	3.50	5.31	7.14
	$\gamma = 0$	12.53	21.99	28.04	US
Panel B $\alpha = 2$	**-10%**	1.97	4.27	6.45	8.64
	0%	1.98	4.32	6.52	8.74
	10%	2.08	4.56	6.89	9.22
	20%	2.47	5.64	8.60	11.53
	30%	US	US	US	US
	$\gamma = 0$	US	US	US	US
Panel C $\alpha = 3$	**-10%**	3.02	6.52	9.75	12.92
	0%	3.22	7.01	10.48	13.87
	10%	5.19	US	US	US
	20%	US	US	US	US
	30%	US	US	US	US
	$\gamma = 0$	US	US	US	US

Table III: Optimal Asset Risk for Different size of "default in boom" compensation components, Firm Leverage and States of the Economy

Table III presents asset risk (in percentages) that an executive would choose to maximize the value of her compensation. The parameter δ, which is the sensitivity of the executive compensation to a decrease in the value of the firm's assets below the face value of debt when the economic index is in time of boom (S/K=1.3), receives the values of 0, 1.5 and 3. All other parameters are set at their base case values as summarized in Table I. When the curve is upward sloping we use the symbol US, otherwise we report the value of asset risk that maximizes executive payoff.

	Normalized Economic Index	**Bank Leverage Ratio**			
		0.975	**0.950**	**0.925**	**0.900**
Panel A δ=0	**-10%**	1.97	4.27	6.45	8.64
	0%	1.98	4.32	6.52	8.74
	10%	2.08	4.56	6.89	9.22
	20%	2.50	5.68	8.60	11.53
	30%	US	US	US	US
	40%	US	US	US	US
Panel B δ=1.5	**-10%**	1.97	4.27	6.45	8.64
	0%	1.98	4.32	6.52	8.74
	10%	2.08	4.56	6.89	9.22
	20%	2.47	5.57	8.43	11.29
	30%	6.05	US	US	US
	40%	US	US	US	US
Panel C δ=3	**-10%**	1.97	4.27	6.45	8.64
	0%	1.98	4.32	6.52	8.74
	10%	2.08	4.56	6.89	9.22
	20%	2.47	5.57	8.43	11.29
	30%	4.19	9.39	14.24	19.02
	40%	5.25	10.83	15.74	20.30

Table IV: Optimal Asset Risk for Different Bankruptcy Costs and States of the Economy

Table IV presents asset risk (in percentages) that an executive would choose to maximize the value of her compensation. The parameter *BC*, which is the constant deadweight costs in the event of bankruptcy as percentage of the total face value of debt, receives the values of 0, 2% 4% and 6%. All other parameters are set at their base case values as summarized in Table I. When the curve is upward sloping we use the symbol US, otherwise, we report the value of asset risk that maximizes executive payoff.

Leverage ratio	Normalized Economic Index	Bankruptcy Costs			
		BC=0%	BC=2%	BC=4%	BC=6%
LR=0.95	-10%	4.27	2.96	2.43	2.19
	0%	4.32	2.97	2.43	2.19
	10%	4.56	3.03	2.44	2.20
	20%	5.64	3.36	2.51	2.22
	30%	US	US	US	2.32
LR=0.90	-10%	8.64	7.10	6.04	5.39
	0%	8.74	7.16	6.06	5.40
	10%	9.22	7.46	6.19	5.46
	20%	11.53	8.94	6.84	5.73
	30%	US	US	US	US

Table V: Optimal Asset Risk for Different Audit Frequency, Leverage and States of the Economy

Table V presents asset risk (in percentages) that an executive would choose to maximize the value of her compensation. All of the parameters are set at their base case values as summarized in Table I. When the curve is upward sloping we use the symbol US, otherwise, we report the value of asset risk that maximizes the executive's payoff.

Normalized Economic Index	**Audit frequency by the regulator**		
	Monthly	***Quarterly***	***Yearly***
-10%	3.63	3.72	4.27
0%	3.65	3.74	4.32
10%	3.75	3.84	4.56
20%	4.32	4.45	5.64
30%	6.23	6.58	US

Table VI: Optimal Asset Risk for Different Correlation between the returns and States of the Economy

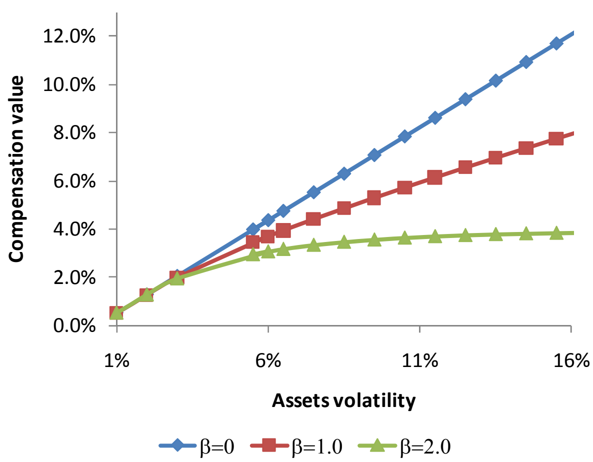
Table VI presents asset risk (in percentages) that an executive would choose to maximize the value of her compensation. The correlation between the returns of the economic index and the financial institution, ρ, varies between 0.6 and 0.9. All other parameters are set at their base case values as summarized in Table I. When the curve is upward sloping we use the symbol US, otherwise, we report the value of asset risk that maximizes the executive's payoff.

Normalized Economic Index	**Correlation between the returns of the economic index and the financial institution**			
	ρ**=0.6**	ρ**=0.7**	ρ**=0.8**	ρ**=0.9**
-10%	4.35	4.30	4.27	4.27
0%	4.59	4.43	4.32	4.27
10%	5.37	4.90	4.56	4.33
20%	9.30	6.95	5.64	4.82
30%	US	US	US	US

Figure 1: The value of executive compensation for different levels of asset risk and different losses due to firm-specific insolvency

This figure presents the value of executive compensation for different levels of asset risk and loss due to firm specific insolvency. The sensitivity of executive compensation to a 1% increase of asset value above the strike price (α) is set to 2. The sensitivity of compensation to a 1% decrease in asset value below the value of liabilities (β) varies between 0 and 5. γ is the sensitivity of executive compensation to the joint event of a decrease in asset value below the value of liabilities in a financial crisis and is set to 0. All other parameters are set at their base case values as summarized in Table I.

Panel A: Relatively low β



Panel B: Relatively high β

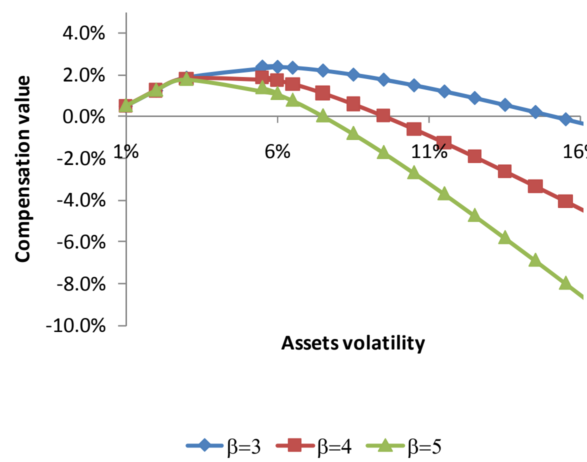
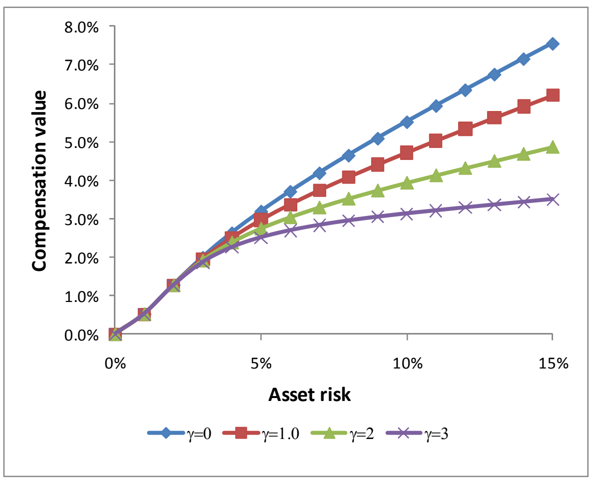


Figure 2: Value of Executive compensation for different levels of asset risk and loss due to systemic economic crisis during different state of the economy.

This figure presents the value of executive compensation for different levels of asset risk and loss due to systemic crisis. The sensitivity of executive compensation to the joint event of a decrease in asset value below the value of liabilities in a financial crisis (γ) varies between 0 and 3. The economic index is located 30% above the threshold of systematic economic crisis in good times in Panel A, and 10% below the threshold in bad times in Panel B. All other parameters are set at their base case values as summarized in Table I.

Panel A: "Good times" (S/K=1.3)



Panel B: "Bad times" (S/K=0.9)

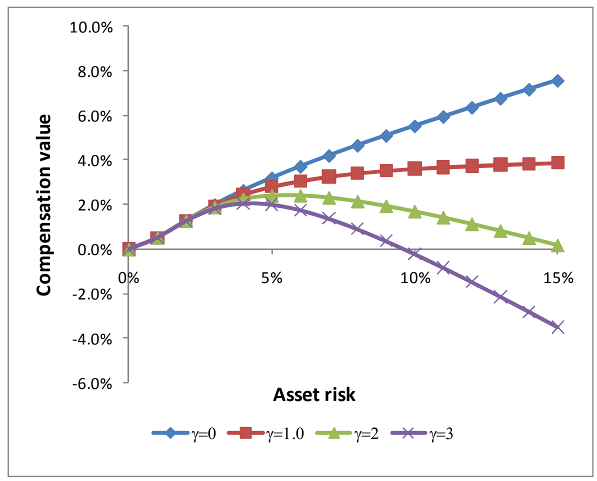


Figure 3: Value of executive compensation for different levels of asset risk and different states of the economy

This figure presents the value of executive compensation for different levels of asset risk and states of the economy. Economic index levels range from 30% above the threshold of systemic economic crisis to 10% below the threshold. All other parameters are set at their base case values as summarized in Table I.

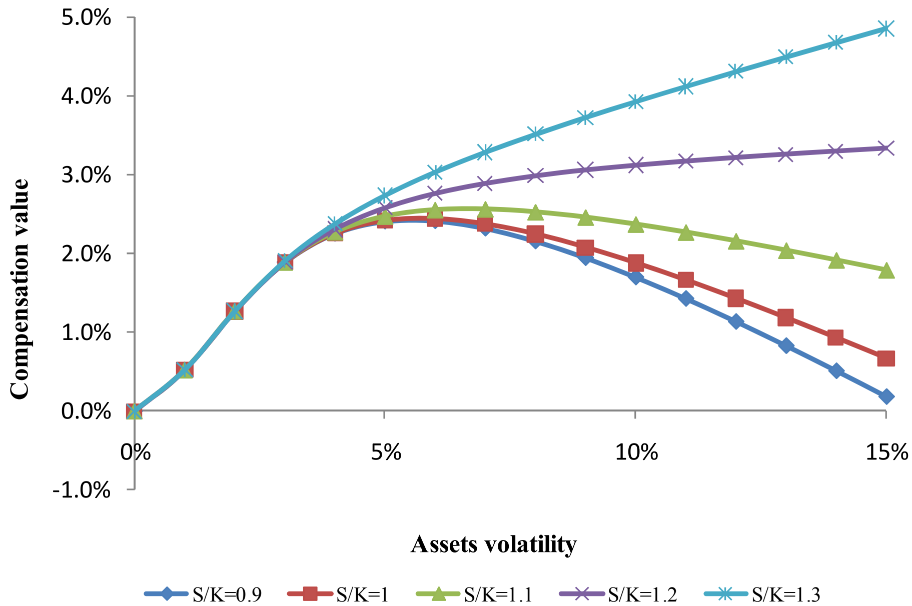
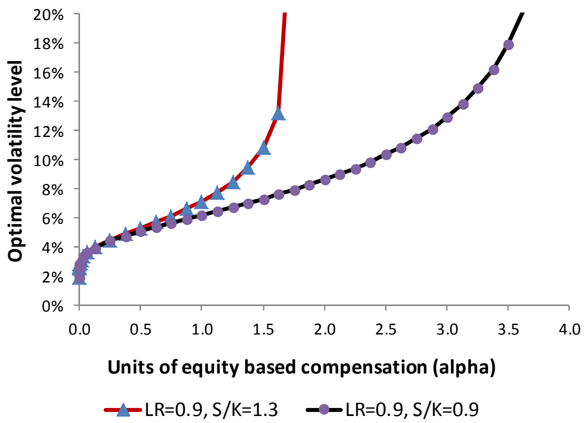


Figure 4: The Optimal asset risk for different levels of equity-based compensation, states of the economy and leverage.

The figure shows the level of asset risk that an executive would choose when the economic index is 30% above and 10% below the threshold of systemic economic crisis. In Panel A, the firm leverage ratio is relatively low (LR=0.9) and in Panel B it is relatively high (LR=0.95). All other parameters are set at their base case values as summarized in Table I.

Panel A: Low Leverage (LR=0.90)



Panel B: High Leverage (LR=0.95)

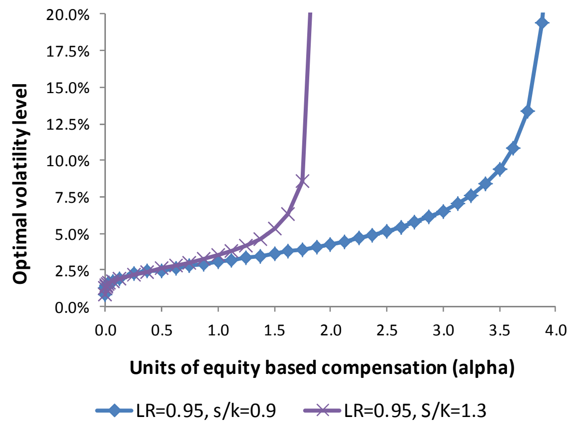


Figure 5: Value of Executive compensation for different state of the economy and loss due to default in "Boom times"

This figure presents the value of executive compensation for different levels of asset risk and loss due to default in "Boom times". The executive would lose an extra δ% of fixed income for each 1% decrease in value of firm assets below the face value of debt at maturity when the economic index is above an upper threshold that marks times of economic boom, K_{Boom}. The economic index is located 30% above the threshold of systematic economic crisis in boom times and 10% below the threshold in bad times. All other parameters are set at their base case values as summarized in Table I.