Optimal Incentive Contracts for Loss-Averse Managers:
Stock Options vs. Restricted Stock Grants

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Abstract

During the last 20 years the structure of a typical CEO compensation package has changed drastically and the pay-to-performance sensitivity of an incentive contract has increased. As a result, stock options grants are becoming increasingly important and currently they are the main component of any CEO compensation contract. However, as Hall and Murphy (2001) show, restricted stock grants provide 50% higher pay-to-performance sensitivity than stock options. In particular, by using less options and more stocks, shareholders can reduce the cost of a CEO compensation package without affecting the pay-to-performance sensitivity and the CEO’s expected utility level. This paper provides an explanation for this puzzle: the widespread use of options when restricted stocks are a more efficient way to provide higher pay-to-performance sensitivity. The model presented in this paper shows that the optimal incentive contract for loss-averse managers must contain a substantial portion of stock options even when, under the classical principal-agent theory, the optimal contract must exclusively consist of stock grants. The paper also provides an explanation for the drastic increase in the risk-adjusted level of CEO compensations and argues that populist attacks on high executive pay level in the late 1980s - early 1990s resulted in the decreased pay-to-performance sensitivity and pay level in the short run but, in the long run, lead to an inefficiently high share of options in a typical CEO compensation package, excess pay-to-performance sensitivity of contracts, and excess pay level.
1. Introduction

During the last 20 years the structure of a typical CEO compensation package changed drastically. To make managers more willing to undertake more risky projects, stock options grants have to become increasingly important and currently they are the main component of any CEO compensation contract (Murphy (1998)). The popularity of option grants may be explained by changes in the US and global economy that made it profitable for the firms to adopt more risk-taking behavior (Murphy (1995), Jensen (1993)). To make managers willing to take on risks the optimal managerial contract should have higher pay-to-performance sensitivity (Hall and Liberman (1998), Murphy (1998)), which could be provided by stock option grants. Stock options, however, are not the only way to increase pay-to-performance sensitivity. There is a number of ways to make managerial compensation to be dependant on the firm’s performance, e.g., restricted stock grants or efficiently designed bonus structures may also provide the desired pay-to-performance sensitivity.

Although there are a number of empirical studies that document a high share of stock option grants in a typical CEO compensation contract, it is not clear why stock options and not restricted stocks become the main component of CEO payoffs. Hall and Murphy (2001) examine the pay-to-performance sensitivity of stock options and stock grants for risk-averse managers taking into account that managers cannot diversify unsystematic risk of their companies stocks and options. They show that at-the-money and in-the-money options provide higher pay-to-performance sensitivity (relative to restricted stocks of the
same market value) when shareholders cannot reduce the CEO’s base salary\(^1\). High unsystematic risk of stock options, however, makes them unattractive for the CEOs who cannot diversify this risk away. Thus, CEOs value options much lower than their market value and would prefer to have fewer options and more stocks in their contracts. For example, for a risk-averse undiversified CEO, $1 of cash may be equivalent to $2 worth of restricted stocks or to $10 worth of restricted stock options. In this example, shareholders may substitute $10 worth of options and $8 cash for $18 worth of equity without affecting the cost of the CEO compensation package and the CEO’s utility level. So, instead of providing incentives through $10 worth of options, shareholders may provide incentives through $18 worth of stocks. Of course, $1 worth of options have a higher pay-to-performance sensitivity than $1 worth of stocks, so, the final effect of this substitution on the pay-to-performance sensitivity is undetermined. However, as Hall and Murphy (2001) show, for reasonably risk-averse CEOs\(^2\) restricted stock grants combined with a decrease in the base salary provide 50% higher pay-to-performance sensitivity than stock options of the same market value. In fact, they also show that reduction in stock option grants and base salary accompanied by an increase in restricted stock grants will reduce the average CEO pay level without changing CEOs expected utility and pay-to-performance sensitivity of their contracts. Thus, in the light of these arguments, the popularity of stock options remains a puzzle.

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1 Hall (1998) receives the similar results for the perfectly diversified CEOs by using standard Black-Sholes approach to estimate the CEO’s value of the stock options. This approach, however, would lead to an upward bias for undiversities managers who cannot diversify the unsystematic risk of restricted stock.

2 Hall and Murphy (2001) consider CRRA CEOs with risk-aversion parameters of \(\rho = 2\) and \(\rho = 3\) who hold 1/2 or 2/3 of their wealth in their company stocks and show that in all cases restricted stock grants provide higher pay-to-performance sensitivity.
Another puzzle concerns the risk-adjusted compensation levels of CEOs. An increase in pay-to-performance sensitivity combined with managerial risk-aversion must lead to an increase in the nominal levels of CEO compensations. Indeed, empirical studies show that the median CEO pay tripled from $2m in 1992 to $6m in 1999 (in CPI-adjusted 1999-constant dollars). What is puzzling, however, is that the risk-adjusted CEO compensation level (defined as a certainty equivalent of the risky CEO pay structure) has also increased drastically from $1.5m in 1992 to $3m in 1999 (Hall and Murphy (2001)). One may explain this drastic increase in risk-adjusted payoff level by an increase in demand for high-skilled CEOs. In this paper I provide an alternative explanation that is not based on a sudden increase in CEOs’ reservation utility level.

A third unexplained phenomenon is the huge cross-country differences in CEO pay structure and the fact that the CEO pay structure depends both on the firm’s location and on whether or not that firm is a subsidiary of a multinational conglomerate (see, e.g., Murphy (1998), Abowd and Bognanno (1995), Kato and Rockel (1992), Angel and Fumas (1997), Conyon and Murphy (2000)). Although some of these differences can be explained by cultural and institutional differences among countries, it is not clear why CEOs of international subsidiaries have different pay structure than CEOs of similar foreign single segment firms (Murphy (1998)).

My paper offers explanations for these three puzzles: the widespread use of options when restricted stocks are the cheaper way to provide higher pay-to-performance sensitivity, a dramatic increase in risk-adjusted CEO pay level and the dependence of CEO pay level on whether or not his firm is an international subsidiary.
There are two premises behind my model. The first premise is that managerial utility depends not only on his compensation level but also on his relative payoff in comparison with what he would have got under some “benchmark” compensation contract. The second premise is that managers are loss-averse (Kahneman and Tversky (1979)), i.e., their utility from getting more than the “benchmark” by $1 is lower than their disutility from getting less than the “benchmark” by the same $1. The benchmark I use is a “typical” (or “average”) managerial contract in a “peer group” at the time the contract is signed. Namely, I argue that a manager treats the average managerial contract in his “peer group” as a “fair” contract. He understands, however, that his wage must depend on his firm’s realized profit and, thus, he does not compare his realized payoff with the average realized payoff of the managers in his “peer group”, but he does compare his realized payoff with the payoff that he would have had if he had the “fair” contract. In particular, if a manager receives a larger payoff than he would have received under the “typical” contract, then he obtains additional utility. If, however, he gets a lower payoff, then he obtains a much higher disutility. Since managers of foreign subsidiaries and similar foreign firms form their benchmarks based on different “peer groups”, the differences in benchmarks will lead to the differences in the optimal incentive contracts.

The intuition behind the model is the following. Assume that, in response to an economy-wide shock that makes risk-taking a profitable strategy, the optimal pay-to-performance

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3 The fact that people’s utility depends not only on their absolute consumption level but also on their consumption level relative to some benchmark (e.g., past consumption, adaptation level, peer group consumption, etc.) is well documented in the economics and psychology literature (see, e.g., Thaler (1985)).
sensitivity of compensation contracts increases\textsuperscript{4}. Managers form their benchmarks based on the existing incentive contracts of other managers. Since these contracts were signed before the shock, they have low pay-to-performance sensitivity. Thus, a new contract (that must have a higher pay-to-performance sensitivity) will give higher rewards (relative to the benchmark portfolio) for the good performance and higher punishment for the bad performance. Loss-averse managers are very reluctant to accept any possible reduction to their payoffs in any state of the world. Thus, to keep managers at their reservation utility level any $1 increase in punishment for the bad performance should be accompanied by more than $1 increase in rewards for the good performance\textsuperscript{5}. This type of an incentive contract (that gives high rewards for the good performance and low punishment for the bad performance) is exactly the one that can be achieved by stock option grants (that have limited downside risk). Thus, we might expect a high proportion of options in the CEO contracts in the short-run following this economy-wide shock. Moreover, since an increase in the punishment must be compensated by much higher increase in rewards, it may appear that the “risk-adjusted” (but not “loss-adjusted”) compensation level is increased.

Over time, a “typical” (i.e., “benchmark”) compensation contract will have increasingly higher pay-to-performance sensitivity and CEOs will be willing to accept more and more stock options and stock grants in their compensation package. Thus, we should expect some inertia in CEOs’ contract setting (this is consistent with Hall and Liberman (1998) who documented that the increase in option compensation has increased monotonically since the early 1980s).

\textsuperscript{4} This assumption is supported by Hall and Liberman (1998) and Murphy (1998) who documented that pay-to-performance sensitivity of CEO contracts increases in the 1990s.

\textsuperscript{5} This increase is beyond the effect that the increase in the volatility of CEO’s contract has on the CEO’s average pay level.
In the long-run, all CEO contracts (and, thus, a benchmark contract) will include a substantial amount of stock option grants. This means that loss-averse managers will compare their new contracts with the new benchmark (that has high rewards for the good performance and limited punishment for the bad one). Managerial loss-aversion makes changing the compensation contracts very expensive. Indeed, any change that makes managers worse off in any state of the world must be accompanied by a substantial compensation increase in other states’ of the world. Thus, in the long-run it would be very expensive for the principal to get rid of the stock options in the compensation contracts since switching from options to stocks will result in decreasing rewards for good performance (which will be viewed by managers as losses in the good state of the world). Thus, the reluctance of loss-averse managers to accept any changes will lead to an inefficient long-run equilibrium in which CEO compensation contracts will have too many options and too few stocks. Moreover, the higher risk associated with options will lead to a higher expected pay level for risk-averse managers.

An alternative explanation of why there are so many options in CEOs’ compensation contracts may be based on the assumption about the degree of CEOs’ risk aversion. Indeed, if Hall and Murphy (2001) overestimate the CEOs’ risk-aversion, then options are not so unattractive for undiversified managers as they claim. However, Hall and Murphy (2001) use a very conservative assumption that CEOs’ relative risk aversion coefficient is equal to two\(^6\), so, an assumption of an even lower risk-aversion may not be very appealing.

\(^6\) For example, in one of the more widely cited estimates, Friend and Blume (1975) estimate relative risk aversion in the range of two to three based on the portfolio holdings of individuals. However, Koehlerlakota (1990) and others have argued that even this estimate is biased downwards.
Moreover, my model is also able to explain the increase in the risk-adjusted CEO compensation level (Hall and Murphy (2001)), while this increase, recalculated using the lower Constant Relative Risk Aversion (CRRA) coefficient, will be even greater than the 100% documented by Hall and Murphy (2001).

In the beginning of 1990s it was argued that populist attacks on high executive pay level may lead to the decrease in the number of option stock grants, pay-to-performance sensitivity and the average CEO compensation level.\(^7\) This turned out not be the case and, actually, the use of option grants, as well as the level of CEOs’ compensations, increased substantially during the 1990s (see Murphy (1998)). My paper argues that the increased publicity about CEO contracts makes CEOs to be more competitive and increases the probability that a CEO will compare his contract with a “typical” contract and, perhaps, to derive higher utility/disutility from his relative payoff. This, in fact, may help to reduce pay-to-performance sensitivity and average CEO pay level in the short-run (when managers were deriving additional utility from their relative payoff at no cost to shareholders), but leads to an inefficient equilibrium in the long-run with too many options, excess pay-to-performance sensitivity and too-high average CEO compensation level.

Although there exists a significant body of research that analyzes how specific terms of stock option grants affect CEOs’ behavior\(^8\), only a limited research was done to understand

\(^7\) See, Jensen and Murphy (1990).

\(^8\) See, for example, Yermack (1997), Aboody and Kasznik (2000)) who show that, since exercise price of options usually set to be equal to the stock price at the date when these options are granted, manager may be willing to manipulate the stock prices around the option grant day. (The same problem, although at a lower degree, may exist with restricted stock grants as well (see Narayanan (1996)).
the optimal “shape” (convex, linear, or concave) of the incentive contract. My paper is designed to fill in this gap. In particular, I show that taking into account managers’ loss-aversion (a fact well documented by Kahneman and Tversky (1979, 1984, 1991), Kahneman, Knetsch and Thaler (1990), Knetsch and Sinden (1984), Knetsch (1989), and Samuelson and Zeckhauser (1988)) makes the optimal incentive contract to be convex and, thus, can explain the current popularity of stock options.

The rest of the paper is organized as following. Part 2 outlines the basic assumptions of the model. Part 3 provides some analytical analysis of the model. Part 4 presents the numerical solution of the model and discusses the model’s empirical implications. In part 5 I conclude.

2. The model

Consider an economy that consists of an infinite number of identical firms. Each firm is run by a manager who must choose between two projects: good (G) and bad (B). Depending on his choice, the firm’s profit is determined. For simplicity, assume that there are 3 possible profit realizations: low (L), medium (M), and high (H), and that manager’s choice affects the probabilities of these profit realizations. If the manager chooses the good project, then the probability of profit $i \in \{L, M, H\}$ is $p_i$, while if the manager chooses the bad project then this probability is $q_i$, where $p_L L + p_M M + p_H H > q_L L + q_M M + q_H H$

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9 Holmstrom and Milgrom (1987) show that if manager can constantly observe the current performance and change his behavior during the contract period then the optimal incentive contract is linear. Hall and Murphy (2001) also show that for a manager with CRRA utility function with CRRA coefficient of 2 or higher linear contract provide higher pay-to-performance sensitivity than he convex contract does. Holmstrom and I Costa (1986) examined the optimal incentive contract in dynamic setting and show that in order to decrease managers’ unwillingness to take risk the optimal incentive contract must provide managers some options on their revealed ability.
and the likelihood ratios \( h_i = \frac{q_i}{p_i} \) satisfy the Monotone Likelihood Ratio Property\(^\text{10}\) \( h_i > h_M > h_H \). In addition bad project provides some private benefit \( c \) to the manager (e.g., saved effort, pet project, better working conditions, lower probability to be fired, etc.). I assume that everyone except manager is risk-neutral so that the firm’s stock price is equal to its expected profit. I also assume that the expected firm’s profit under the good project is \( M \) (i.e., \( p_L L + p_M M + p_H H = M \)) so that an option with strike price \( M \) will be “at the money” at the time it was granted.

Assume that the firm’s profit’s probability distribution functions under both good and bad projects are common knowledge. Assume also that the firm’s profit realization is observable and contractible while the selected project that the manager implements can be observed only by the manager. To make the manager to choose the good project, a principal wants to use an incentive contract \( w = \{w_L, w_M, w_H\} \) that pays manager \( w_i \) when the firm’s profit realization is \( i \in \{L, M, H\} \).

All the assumptions made above are standard assumptions for any principal-agent model (see, e.g., Grossman and Hart (1983)). The distinctive feature of my model is the assumption about the manager’s utility function. I assume that the manager’s utility depends not only on his wage (and private benefit when the bad project is chosen) but also on comparison of his wage with some benchmark. Namely, assume that the manager has some benchmark contract in mind \( r = \{r_L, r_M, r_H\} \), where this contract is the average

\(^{10}\) This assumption is needed to guarantee that manager’s wage will be an increasing function of the firm’s profit.
managerial contract in the economy prior to the time his contract is signed. When the firm's profit realization is \( i \in \{L, M, H\} \), the manager compares his wage \( w_i \) with the benchmark wage \( r_i \) (the wage that he would have had under the benchmark contract given the same realization of the firm’s profit). As a result of this comparison, he derives utility (disutility) if \( w_i > r_i \) (\( w_i < r_i \)). Note, that the manager’s benchmark is not a fixed payoff but another contract, i.e., his effective benchmark depends on the firm’s profit realization. Thus, the manager’s utility (less the private benefit \( c \) when the bad project is chosen) when the firm’s realized profit is \( i \in \{L, M, H\} \) is

\[
U(w_i, r_i) = u(w_i) + \alpha v \left( \frac{w_i}{r_i} \right), \tag{1}
\]

where \( u(w_i) \) is the manager’s utility from his wage and \( v \left( \frac{w_i}{r_i} \right) \) is his utility from the comparison of his wage with the benchmark wage\(^{11}\). The parameter \( \alpha \) measures how important relative compensation is in the manager’s utility. Consistent with the existing literature, I assume that the manager is risk-averse, i.e., that \( u'(\cdot) > 0 \), \( u''(\cdot) < 0 \), \( v'(\cdot) > 0 \) and \( v''(\cdot) < 0 \). I also assume that \( v(1) = 0 \), i.e., the manager feels no additional utility when his wage is equal to the benchmark wage.

\(^{11}\) This form of utility function is similar to the “catching up with the Joneses” type of utility function (Abel (1990)) except that in my model managers compare their payoffs with the hypothetical payoff that other managers would have had in the same situation while Abel (1990) assumes that people compare their consumption with the average consumption level in economy.
There are a number of evidences\(^\text{12}\) that people are loss-averse and their utility from overperforming the benchmark is less than their disutility from underperforming the benchmark by the same amount. Consistent with these evidences, I assume that

\[
v(x) = \begin{cases} v(x), & \text{if } x > 1 \\ z \cdot v(x), & \text{if } x \leq 1 \end{cases} \tag{2}
\]

where \(z > 1\).

For tractability, I will use the logarithmic utility function and assume that the manager’s utility, when firm’s realized profit is \(i \in \{L, M, H\}\), is given by

\[
U(w_i, r_i) = \begin{cases} \ln(w_i) + \alpha \cdot \ln\left(\frac{w_i}{r_i}\right) & \text{if } w_i > r_i \\ \ln(w_i) + z \cdot \alpha \cdot \ln\left(\frac{w_i}{r_i}\right) & \text{if } w_i > r_i \end{cases} \tag{3}
\]

3. Analysis

Assume that the parameters of the model are such that it is optimal for the principal to implement an incentive contract that makes the manager choose the good project\(^\text{13}\). In this case the principal will want to minimize the expected wage given that the manager would

\(^{12}\) See, e.g., Kahneman and Tversky (1979, 1984).

\(^{13}\) That is, assume that \(p_L + p_M + p_H > q_L + q_M + q_H\) and \(w_L + w_M + w_H > \alpha q_L + \alpha q_M + \alpha q_H\), where \(w = \{w_L, w_M, w_H\}\) is an optimal incentive contract and \(s = \{s_L, s_M, s_H\}\) is any contract that delivers the manager his reservation utility.
receive at least his reservation utility (Individual Rationality constraint) and that the
manager will implement a good project (Incentive Compatibility constraint). Thus, the
principal’s optimization problem can be written as:

\[
\begin{align*}
\min & \quad p_L w_L + p_M w_M + p_H w_H \\
\text{s.t.:} & \quad (\text{IR}): \quad p_L U(w_i, r_i) + p_M U(w_M, r_M) + p_H U(w_H, r_H) \geq \bar{u} \\
& \quad (\text{IC}): \quad \sum_{i \in \{L, M, H\}} p_i U(w_i, r_i) \geq \sum_{i \in \{L, M, H\}} q_i U(w_i, r_i) + c
\end{align*}
\]

where $\bar{u} = 0$ is the manager’s reservation utility.

Since the firm’s profit realization can take only three values: L, M, and H, any contract is a
function $f : \{L, M, H\} \rightarrow \mathbb{R}_+^3 \equiv [0, \infty) \times [0, \infty) \times [0, \infty)$ and can be written as $\{w_i, w_M, w_H\}$,
where $w_i = f(i)$, $i \in \{L, M, H\}$. Given this simplifying assumption about the set of the
firm’s possible profit realization, any incentive contract can be constructed from a base
salary (cash) $b$, stock grants $k$, and either option grants $opt$ with an exercise price equal to
the current stock price (M) or capped bonus $bon$ that is paid for achieving at least a
medium level of profit. In particular, if the contract is linear $\left(\frac{w_M - w_L}{M - L} = \frac{w_H - w_M}{H - M}\right)$, then
it may be constructed from $k = \frac{w_M - w_L}{M - L}$ shares of stock (assume that the total number of
shares is normalized to 1) and a base salary of $b = w_L - kL$. If the contract is convex
\[
\left( \frac{w_M - w_L}{M - L} < \frac{w_H - w_M}{H - M} \right), \text{ then it may be represented as } k = \frac{w_M - w_L}{M - L} \text{ stocks, }
\]

\[
\text{opt} = \left( \frac{w_H - w_M}{H - M} - \frac{w_M - w_L}{M - L} \right) \text{ options with the exercise price M and } b = w_L - kL \text{ dollars in cash. If, however, the contract is concave } \left( \frac{w_M - w_L}{M - L} > \frac{w_H - w_M}{H - M} \right), \text{ then it consists from }
\]

\[
k = \frac{w_H - w_M}{H - M} \text{ stocks, } \quad b = w_L - kL \text{ dollars in cash and }
\]

\[
\text{bon} = \left( \frac{w_M - w_L}{M - L} - \frac{w_H - w_M}{H - M} \right) (M - L) \text{ dollars of bonus for reaching at least medium profit.}
\]

### “Standard” optimal contract

Parameter \( \alpha \) measures the importance of relative compensation for a manager. If \( \alpha = 0 \) then the manager’s utility depends only on his wage \( U(w_i) = \ln(w_i) \) (I will call managers with such utility function by “classical” managers) and the model becomes a “standard” moral-hazard model with a risk-neutral principal and a risk-averse manager. Thus, I denote the optimal incentive contract when \( \alpha = 0 \) (i.e., the optimal contract for “classical” managers) as the “standard” contract and I will use this terminology throughout the paper.

Given the functional form of utility function (3), one can easily show that optimization problem (4)-(6) has a unique interior solution\(^{14} \). By writing a Lagrangian and taking First Order Conditions (F.O.C.) with respect to (w.r.t.) \( w_i \), one can show that the standard contract must satisfy

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\(^{14}\) See appendix for the proof.
\[ w_i = \lambda + \mu \cdot (1 - h_i) \tag{7} \]

for all \( i \in \{L, M, H\} \), where \( \lambda > 0 \) and \( \mu > 0 \) are Lagrange multipliers.

The likelihood ratios \( h_i \) and the set of the firm’s possible profit realizations \( \{L, M, H\} \) determine the shape of the optimal incentive contract. Since one of the goals of this paper is to analyze how managerial loss-aversion affects the shape of the optimal contract, let us assume that the standard contract is linear, i.e. that \( \left( \frac{w_M - w_L}{M - L} = \frac{w_H - w_M}{H - M} \right) \). This assumption seems especially plausibly in the light of the Hall and Murphy (2001) results that show that stock grants is a more efficient way to provide a specified level of pay-to-performance sensitivity than stock options. Since (7) implies \( \frac{w_H - w_M}{H - M} = \mu \frac{h_M - h_H}{H - M} \) and \( \mu \frac{h_L - h_M}{M - L} = \frac{w_M - w_L}{M - L} \), the linearity of the standard contract is equivalent to the following assumption:

\[
\frac{h_M - h_H}{h_L - h_M} = \frac{H - M}{M - L} \tag{8}
\]

**Optimal contract for loss-averse managers**

There is evidence (see, e.g., Hall and Liberman (1998) and Murphy (1998)) that the pay-to-performance sensitivity of CEO contracts increased in the 1990s. Consistent with this evidence, let us assume that at time \( t=0 \) there is an economy-wide shock that changes the
probabilities of firms’ profit realizations and increase the desired pay-to-performance
sensitivity of the “standard” contract. This shock, however, does not change the shape of
the “standard” contract and the “standard” contract is linear both prior and after the shock
(i.e., (8) always holds). Assuming that managers are loss-averse with the utility function
given by (3), what is the immediate (short-run) effect of this shock on the shape of the next
year compensation contract and how the compensation contract changes over time in
response to a change in managers’ benchmarks?

Each manager forms his benchmark contract based on the average managerial contract in
the economy that existed prior to the time his contract is signed, i.e.,
\[ r_{k,t} = f_b(\bar{w}_{t-1}, \bar{w}_{t-2}, \ldots, \bar{w}_{t-d}) \],
where \( r_{k,t} \) is the benchmark contract of manager \( k \) at time \( t \)
and \( \bar{w}_s \) is the average managerial contract signed at time \( s \). Since there are infinite number
of firms in the economy, each individual manager’s contract \( w \) has no effect on his (or
anybody else’s) future benchmark. Thus, in the absence of the long-run incentive contract,
the shareholder’s problem of maximizing discounted flow of firm’s profits may be
represented as a serial of problems of maximizing the firm’s one-period profits. In other
words, an incentive contract for a manager with benchmark \( r \) must solve principal’s short-
run optimization problem (4)-(6).

Before analyzing the effect of the shock and the properties of new incentive contract, we
need to make sure that the solution to optimization problem (4)-(6) exists. Furthermore,
assuming that all firms and managers in the economy are identical and, initially, all
managers had the same benchmark contract, we want to make sure that this shock cannot
lead to heterogeneity of incentive contracts and that it uniquely determines managerial contracts at any point in time. The following theorem provides us the assurance we want

**Theorem 1** *(existence and uniqueness of the optimal incentive contract):*

Given benchmark contract \( r \) the principal’s optimization problem (4)-(6) has unique solution \( w^*(r) \).

*Proof:* See appendix

To see how an increase in desired pay-to-performance sensitivity of incentive contract affects the structure of incentive contract in the short-run, we need to understand how managers react on changes in their compensation package. Since the manager’s benchmark contract \( r = \{r_L, r_M, r_H\} \) has a lower pay-to-performance sensitivity than a new contract \( w = \{w_L, w_M, w_H\} \), we should expect to have greater punishments for bad performance \((w_L < r_L)\) and greater rewards for good performance \((w_H > r_H)\). Thus, a manager will have lower than benchmark payoffs (“losses”) when his firm’s realized profit is low and greater than benchmark payoffs (“gains”) when firm’s realized profit is high. Disutility from losses for loss-averse managers is much higher than utility from gains. Thus, if the principal decreases the wage level in the bad state of the world \((w_L)\), he must increase the reward for good performance \((w_H)\) by a greater amount in order to keep manager at his reservation utility level \( \bar{u} = 0 \). In particular, implementing a linear contract will be very costly for the principal because, in order to compensate the manager for lower payoff in the bad state of the world, he needs to increase the expected pay level too much. Because of this, the principal will prefer to provide more incentive through the increase in rewards
than through an increase in punishment. Therefore, following an increase in pay-to-performance sensitivity, we should expect a convex contract for loss-averse managers even when the standard contract is linear. The following theorem summarizes the intuition above.

**Theorem 2 (convexity of the optimal incentive contract in the short-run):**

Assume that prior to time $t=0$ the optimal contract was $r = \{r_L, r_M, r_H\}$ while at $t=0$ an economy-wide shock changes the probabilities of firms’ profit distribution and makes the principal to increase the pay-to-performance sensitivity of the incentive contract such that the new contract $w = \{w_L, w_M, w_H\}$ satisfies $(w_L < r_L)$ and $(w_H > r_H)$. Assume also that (8) holds both prior to and after time $t=0$, i.e., that the “standard” contract is linear and consists only of cash and equity both prior and after the shock. Then, an optimal incentive contract for loss-averse managers in the short-run must be convex and must consist of cash, equity and stock options.

**Proof:** See appendix

In Theorem 2, I made a rather strong (but, nevertheless, very intuitive) assumption that the new optimal incentive contract has higher punishments for a bad performance $(w_L < r_L)$ and higher rewards for a good one $(w_H > r_H)$ instead of an assumption that the new standard contract consists of more stocks and less cash. One can easily show that if prior to $t=0$ the pay-to-performance sensitivity of the optimal incentive contract was low (i.e. if $r = \{r_L, r_M, r_H\}$ was close to $\{1,1,1\}$), or if the importance of “relative” wage is small enough ($\alpha$ is close to 0), then an increase in pay-to-performance sensitivity of the
standard contract will also lead to convexity of the new optimal incentive contract\textsuperscript{15}. I also solve numerically for an incentive contract under a wide range of parameters. In all cases the increase in pay-to-performance sensitivity of the standard contract leads to the convex optimal incentive contract.

It is important to note that the result of theorem 2 requires both assumptions about the managerial utility function: the dependence on the relative payoff and loss aversion. Given the particular form of utility function (3), the dependence of the manager’s utility on his relative payoff ($\alpha > 0$) alone (without the loss-aversion assumption $z > 1$) has no effect on the shape of the optimal contract but affects only the size of the base salary (cash) in the short-run. (See appendix for the proof.)

Now, let us look at how the optimal incentive contract changes over time. Although there is only one economy-wide shock at $t=0$, the optimal incentive contract does not adjust instantly and requires some time to stabilize. Indeed, each time a new contract is signed, the manager looks at the “average” incentive contract in the economy that depends on the past contracts. Thus, we should expect some inertia in the managerial contract setting.

Before analyzing the dynamic of the optimal contract and the properties of the long-run equilibrium, we need several definitions.

\textsuperscript{15} Indeed, if $r_H = r_M = r_L = 1$ then it must be the case that $(w_L < r_L)$ and $(w_H > r_H)$. This is so because if $w_H > w_M > w_L > 1$ then the manager’s IR constraint (5) will not binding and if $1 > w_H > w_M > w_L$ then that constraint will be violated. Thus, conditions of theorem 1 are satisfied and the optimal incentive contract must be convex. In case when $\alpha$ is small, the optimal incentive contract will be closed to the “standard” contract. Thus, we will have $w_M > r_M$ (the proof is available from the author upon request) and, similar to the part (i) of Theorem 2, one can show that the optimal incentive contract is convex.
**Definition 1:** A contract $w = \{w_L, w_M, w_H\}$ is called a *long-run incentive contract* if it satisfies the Individual Rationality (5) and Incentive Compatibility (6) constraints when the benchmark contract $r \equiv w$.

**Definition 2:** A contract $w = \{w_L, w_M, w_H\}$ is called a *long-run equilibrium incentive contract* if it solves the principal’s optimization problem (4)-(6) when the benchmark contract $r \equiv w$.

In other words, in a steady state, when managers’ contracts $w = \{w_L, w_M, w_H\}$ are the same as their benchmark contracts $r = \{r_L, r_M, r_H\}$, a long-run incentive contract is the one that makes managers choose the good project, but it is not necessary solves the principal’s optimization problem. Each time when the principal sets a new contract he solves his optimization problem (4)-(6) and sets a new contract $w = w^*(r)$, where $w^*(r)$ is the solution of (4)-(6) given the benchmark portfolio $r$. In a long-run equilibrium we expect incentive contract to be constant and not to change over time. Thus, we also expect the benchmark contract to be the same as the actual contract. In other words, a long-run equilibrium incentive contract must be a fixed point of the function $w^*(.) : \mathbb{R}^3 \rightarrow \mathbb{R}^3$, i.e., it must satisfy $w^*(w) = w$.

One of the implications of Theorem 1 is that the time path of incentive contracts is uniquely determined by the initial benchmark contract. So, one of the remaining questions is: does initial benchmark affect the long-run equilibrium or does long-run equilibrium
depend only on the fundamental characteristics such as the p.d.f. of the firm’s cash flow? Or, alternatively, if current desired pay-to-performance sensitivity of managerial contract is 1%, does it matter whether the past pay-to-performance sensitivity was 0.5% or 1.5%? The answer to these questions depends on whether or not the long-run equilibrium incentive contract is unique. The following theorem, that proves the multiplicity of long-run equilibrium contracts, implies that the history of incentive contracts does matter even in the long-run.

**Theorem 3 (multiplicity of long run equilibrium incentive contracts)**

There is a continuum of long run equilibrium incentive contracts, i.e., equation $w^*(w) = w$ has a continuum solutions.

*Proof:* See appendix.

Having established the multiplicity of long-run equilibria, the next step is to determine which of these equilibria is the best and what can one do to make the realized equilibrium as close to the best as possible. Since any long run equilibrium incentive contract solves the principal’s short-run maximization problem (4)-(6) given $r=w$, the manager’s expected utility must be equal to his reservation wage $\bar{u}$. Therefore, the only criterion that we can use to rank contracts is the risk-sharing between the manager and the shareholders: “better” contracts must provide “better” risk sharing, i.e., they must have lower expected payoff.

**Definition 3:** A contract $w = \{w_L, w_M, w_H\}$ is called the “best” long-run incentive contract if it is a long-run incentive contract and has the minimum expected wage among all long-run incentive contracts.
Note that the "best" long-run incentive contract does not have to solve the shot-run optimization problem (4)-(6), i.e., it does not have to belong to the set of all long-run equilibrium incentive contracts even though a principal would prefer to have it in the steady state. The “best” long-run contract is, in some sense, the most efficient contract in a steady state because it provides the highest profit to the shareholders and delivers managers their reservation utility.

Since the long-run incentive contract must satisfy (5)-(6) when \( r = w \) and since \( v(1) = 0 \), the set of long-run incentive contracts coincides with the set of incentive contracts for the “classical” managers (i.e. with the set of the contracts that makes a manager with utility function \( U(w_j) = \ln(w_j) \) to choose the good project). The optimal “standard” contract (i.e., a contract that solves (4)-(6) for \( \alpha = 0 \)) has the minimum expected wage among all “standard” incentive contracts and this minimum is unique. Thus, we may state the following theorem:

**Theorem 4 (determination and uniqueness of the “best” long-run contract)**

The “standard” optimal incentive contract that solves the principal’s optimization problem (4)-(6) when manager’s utility depends only on his wage and does not depend on his gains or losses (i.e., when \( \alpha = 0 \) and, thus, \( U(w_j) = \ln(w_j) \)) is the “best” long-run contract for loss-averse managers. Moreover, the “best” long-run contract is unique.

Theorems 2, 3 and 4 combined lead to one important implication: despite a linear contract is the best long-run incentive contract, the fact that each individual manager’s contract has
negligible effect on future benchmarks leads to the inclusion of options into CEOs’ compensation packages in the short-run and might lead to an inefficient long-run equilibrium. The numerical examples that are presented in part 4 of the paper show that the resulting long-run equilibrium will have too many options.

Given a possibility of ending up in an inefficient equilibrium, one may be interested in how the government intervention can help to restore efficiency. In this regard one may ask an even more general question: if the government wants managers to have the “best” long run incentive contract, does it have to constantly intervene into the contract setting? To be able to provide an answer for the last question, we need to understand whether or not the “best” long-run incentive contract is self-supporting, i.e., whether or not it belongs to the set of long-run equilibrium contracts. The next theorem proves that the “best” long-run incentive contract is, in fact, a long-run equilibrium contract, and, thus, a proper short-run intervention by the government may help to restore the long-run efficiency.

**Theorem 5 (Self-supportiveness of the “best” long-run incentive contract)**

The “best” long-run incentive contract belongs to the set of long-run equilibrium contracts, i.e., it solves the equation \( w' (w) = w \).

*Proof:* See appendix.

### 4. Numerical solution

**Base case**

Since the principal’s optimization problem (4)-(6) does not have a closed-form solution, in order to be able to analyze the dynamic of an optimal incentive contract and investigate
additional properties of long-run equilibrium, I solved for an optimal incentive contract numerically. As a base case I take firm’s possible profit realizations \{L,M,H\} to be equal to \{0,100,200\} and the probabilities of these profit realizations (given that good project is chosen) to be equal to \( p = \{p_L, p_M, p_H\} = \{0.25, 0.5, 0.25\} \). I take the manager’s private benefit \( c = 0.05 \) to be small enough so that principal would prefer to implement an incentive contract under a wide range of parameters. I assume that the manager assigns equal weights on his utility from his absolute wage \( u(w_i) \) and from his relative wage \( v\left(\frac{w_i}{r_i}\right) \), i.e., assume that \( \alpha = 1 \). Following Kahneman and Twersky (1992), I take the risk-aversion parameter \( z = 2.25 \). I choose the probabilities of the firm’s profit realization (in the case when the bad project is chosen) \( q = \{q_L, q_M, q_H\} \) such that condition (8) holds (i.e., the “standard” contract consists only from cash and equity) and that the cash compensation (base salary) constitutes 50% of total compensation in the “standard” contract. I also assume that prior to \( t = 0 \) the optimal contract was a flat wage \( r = \{1,1,1\} \).\(^{16}\)

To take into account the fact that CEO compensation contracts are set for a period of several years (Murphy (1998)), I assume that each year \( t \) only 1/5 of all compensation contracts are signed and these contracts remain in effect for 5 years. Thus, at each year \( t \) the “benchmark” contract \( r(t) \) is the average of the actual contracts signed in the past 5 years\(^{17}\), i.e., \( r(t) = \frac{w(t-1) + w(t-2) + w(t-3) + w(t-4) + w(t-5)}{5} \). In all that follows

\(^{16}\)The qualitative results will be the same if \( r \) is an incentive contract that consists of cash and equity and in which cash compensation constitutes more than 50% of total compensation.

\(^{17}\)I also solved for the optimal incentive contract when new contracts are signed each year, i.e., when \( r(t) = w(t-1) \). The qualitative results are the same; the only thing that is different is the speed of convergence.
“contract at year t” \( w(t) \) means an actual contract signed at year t and not the average contract that exists in the economy at that year.

Figures 1-4 present the dynamics of the optimal incentive contract. Figures 1 and 2 present the size of options compensation as a percentage of all non-cash (stocks and options) and total compensation. Figure 3 presents the dynamics of pay-to-performance sensitivity of the optimal incentive contract, where pay-to-performance sensitivity is defined as the change in the manager’s realized compensation for $1 change in the firm’s realized profit. Figure 4 presents the “risk-adjusted” expected manager’s payoff, where “risk-adjusted” payoff is defined as a certainty equivalent payoff for a manager with the utility function \[ U(w_t) = \ln(w_t) \] of an actual payoff structure for a loss-averse manager with utility function \[ U(w_t, r_t) = u(w_t) + \alpha \left( \frac{w_t}{r_t} \right). \]

The first important result that can be drawn from these figures is that the optimal incentive contract does not converge to the “best” long-run contract (by theorem 4 the “best” long-run contract is the “standard” contract with 50% cash, 50% equity and zero options) but includes some significant non-zero amount of options. To understand this result, we need to look at the dynamics of the optimal incentive contract. At time \( t=0 \), when the “benchmark” contract is a flat wage \( r = \{1,1,1\} \), managers will not tolerate a significant wage reduction in the bad state of the world \( (w_L) \). Thus, the principal cannot achieve the desired pay-to-performance sensitivity and he provides incentives more through the use of rewards for good performance (an increase in \( w_H \)) than through the punishments for bad one (a decrease in \( w_L \)), i.e., he uses options (this behavior is consistent with the result of
As time goes by, the “benchmark” contract changes, and, since the “benchmark” contract depends on the past actual contracts, managers become used to high pay-to-performance sensitivity and high rewards and do not want to give them up (they consider a reduction in rewards as losses in the good state of the world). So, consistent with Hall and Lieberman (1998) and Murphy (1998), we should expect a gradual increase in the amount of options and in the pay-to-performance sensitivity over time. Since each individual contract has a very small effect on the future benchmark contract, at any point in time each principal solves his one-period optimization problem (4)-(6). The desire to use options in the short-run leads to an inefficient (relative to the “best” long run incentive contract) incentive contract in the long-run with too many options (figures 1 and 2). Moreover, since options provide higher pay-to-performance sensitivity than stocks of the same market value, the resulting equilibrium contract will have too high pay-to-performance sensitivity (figure 3).

To restore the long-run efficiency, the government may want to discouraged the use of the option-based compensation. Since it might be hard to estimate the optimal options/stock ratio in managerial contract and since the inefficiency of the long-run equilibrium comes from the excessive use of the options in the short-run, the government may want to impose the progressive tax rate on the manager’s income from option exercising or a regressive tax credit on option grants for the firms. Moreover, by theorem 2, it is enough to impose these taxes only for a limited period of time following an economy shock.

Finally, since loss-averse managers require an additional compensation for wage decrease in any state of the world, failing to take into account the managerial loss-aversion results in
overestimating the manager’s expected utility (risk-adjusted compensation) in the short-run. Thus, it may appear that the managers’ risk-adjusted compensation increased (see Hall and Murphy (2001)) even if their expected utility stayed the same (figure 4).

It is also interesting to notice the pattern of the expected manager’s compensation (Figure 5). In the short-run, when incentive contracts are just introduced, risk-averse managers require a higher expected wage to offset an increase in payoff volatility. Thus, in the short-run managers derive additional utility from comparison of their wages with the benchmark and this extra utility does not come at the expense of the shareholders. Thus, in the short-run the expected pay level of loss-averse managers is significantly lower than the pay level under the “standard” contract (for $\alpha = 1$ an increase in pay level of loss-averse managers is almost two times lower than an increase in the pay level under the “standard” contract). In the long-run, however, an excess pay-to-performance sensitivity results in a higher expected wage level than the wage level of the “best” long-run incentive contract.

Figures 1-5 present the numerical solutions for different values of $\alpha: \alpha = 1, 2, 10$. One can see that higher $\alpha$ decreases the speed of convergence (i.e., makes the short-run longer) and amplifies all of the results. Since $\alpha$ measures the importance of “relative” compensation for managers, one can argue that higher publicity of CEO contracts (e.g. CEO contracts data availability, discussion of CEO contracts and realized payoffs on TV, etc.) makes managers give more attention to their relative payoff (i.e. makes $\alpha$ higher). In particular, populist attacks on high CEO pay level in the late 1980s – early 1990s (see Murphy (1995, 1997)), that make CEO contracts to be of a public interest, may be
successful in decreasing the growth rate of CEO compensation and pay-to-performance sensitivity but lead to the higher long-run level of both of them.

The effect of $\alpha$ (a parameter that measures the importance of the relative component in the managerial utility function) on the optimal contract design may be helpful in explaining cross-countries differences in CEO contracts. As the model predicts, in countries with high level of competitiveness in society one can expect to see more options in CEO contracts. Although it is very hard to define and measure the level of competitiveness in society, the list of the things that positively affect the competitiveness level might include the grading system in public schools in universities (grading on a curve vs. grading based on the absolute level of knowledge), public attention to sport events, game shows and celebrity life, and the incentives provided for the employees by their firms at all levels (individual performance vs. team work, tournaments for a promotion, etc.)

**Additional empirical implications**

The fact that the manager’s utility may depend on other managers’ contracts and the way in which managers form their benchmarks may provide a number of cross-sectional and cross-country implications. To understand what some of these implications might be, I solved for the optimal incentive contracts for different values of the model’s parameters and I also altered some of the model’s assumptions.

**Cash flow volatility**

The first question one may ask is how the volatility of a firm’s cash flow affects the optimal incentive contract. To address this question, I take the “base case” parameters and
solve for the optimal contract for different probabilities of the medium cash flow realization $p_M \in [0.1, 0.9]$ keeping $p_L = p_H$ and adjusting $\{q_L, q_M, q_H\}$ such that the “standard” contract would consist of 50% cash and 50% equity. Consistent with the existing view, I found that the options/stock ratio in the optimal incentive contract increases with the firm’s total risk. The intuition behind this result is simple: higher cash flow volatility increases the probability that the manager will be punished, and, thus, increases the average compensation that loss-averse manager requires for an increase in punishment. As a result, shareholders of firms with highly volatile cash flows would prefer to provide incentives more through options (that have a limited downside risk) than through stocks. It is important to note that, since I assumed that the “standard” contract consists of 50% cash and 50% equity and does not depend on the firm’s cash flow volatility, this result is above and beyond any implications that higher cash flow volatility may have on the “classical” managers’ compensation contracts.

Heterogeneous firms

In the model discussed above I assume that all firms in the economy are identical. This is not, however, the case in reality, and it might be interesting to look at how firms’ heterogeneity affects the optimal incentive contract. Figures 6a and 6b present the long-run incentive contracts for two types of firms (firms whose “standard” contract consists of 80% cash and 20% equity and firms whose “standard” contract consists of 50% cash and 50% equity) under several different benchmark formation methods. These figures present the long-run incentive contracts in the case when the shock affects both types of firms at the same time and all of them evolve together after that. Figure 6a presents the value of
options (in the percentage of the total non-cash compensation) and Figure 6b presents the pay-to-performance sensitivity of the long-run optimal contracts.

Using these figures I compare three different benchmark portfolio formation methods: (1) “stand-alone” method when managers compare their contracts with managers’ contracts in similar firms (columns 1 and 5 on Figure 6a and columns 2 and 6 on figure 6b); (2) “looking at the most known” method when managers compare their contracts with managerial contracts of the highest pay-to-performance sensitivity, i.e., with contracts in the firms whose “standard” contracts are 50% cash and 50% equity \(^{18}\) (column 2 on Figure 6a and column 3 on figure 6b) and (3) “market-wide” method when managers compare their contracts with the average managerial contract (columns 3 and 4 on Figure 6a and columns 4 and 5 on figure 6b).

It is well known (see, e.g., Murphy (1995)) that, despite the fact that stock option grants are one of the main components of the U.S. managers’ payoff, they are not so popular outside of the U.S. The role of the U.S. as a world leader, however, makes managers in other countries compare themselves with U.S. managers. Assume, for example, that the “standard” contract in the U.S. should consist of 50% cash and 50% equity, while in the foreign countries, pay-to-performance sensitivity is much lower (e.g., because of the better monitoring, morale, traditions, or lower probability to find a new job once fired) and the “standard” contract there is 80% cash and 20% equity. Under this scenario, a foreign manager, who compares himself with U.S. managers (i.e. who uses “looking at the most known” benchmark formation method), will feel losses in the good state of the world.

\(^{18}\) I called this method by “looking at the most known” because I believe that managers with more volatile contracts are more likely to get high realized payoffs and, thus, more likely to be in the news.
(when he compares his small reward with high possible gains of U.S. managers who have more options to exercise). Thus, foreign managers will demand more options and higher pay-to-performance sensitivity. As a result of the U.S. example, incentive contracts in foreign countries will include too many options and will be too volatile.

A more interesting result can be obtained if we look at the cross-sectional differences in firm characteristics. Let us assume that the economy consists of the two equally-weighted industries. In one of the industries firms need high pay-to-performance sensitivity contracts (the “standard” contract is 50% cash, 50% equity), while in the other firms need low pay-to-performance sensitivity (the “standard” contract is 80% cash, 20% equity). However, when managers evaluate their contracts, they use a “market-wide” benchmark, i.e., an average of all the contracts in the economy. As one may expect, the desire to have a contract as close to benchmark as possible, decreases pay-to-performance sensitivity in the high pay-to-performance sensitivity industry and increases it in the low pay-to-performance sensitivity industry (Figure 6b). However, from Figure 6a one can see that the options/stock ratio in the optimal incentive contracts increases in both industries. One of the implications that can be drawn from figure 6a is that in countries with diverse industries (e.g., in the U.S.) managerial contract should have higher options/stock ratio than in countries with one leading industry (e.g., in oil-producing or tourism-oriented countries).

The intuition for this result is simple. Managers with high pay-to-performance sensitivity contracts feel losses in the bad state of the world because they have more stocks (relative to cash) in their contracts. Thus, they will want to exchange stocks for cash and options so
that they will have fewer losses with the same pay-to-performance sensitivity. Managers with low pay-to-performance sensitivity, however, feel losses in the good state of the world (when their contracts pay them less than the “fair” amount). To decrease these losses without increasing pay-to-performance sensitivity too much, these managers must be provided with more options. Thus, one may expect more option-based contracts in the economy with heterogeneous firm. Note also that all contracts in the economy differ from the benchmark contract. Thus, all managers will experience losses in some states of the worlds. As a result, their “risk-adjusted” compensations must be higher.

Heterogeneous benchmark formation methods

Figures 6a and 6b consider an effect of differences in firms’ cash flow characteristics when managers of similar firms use similar portfolio formation methods. Different managers, however, have different “peer groups”. For example, a CEO of U.S. foreign subsidiary will include in his “peer group” managers of both U.S. and foreign firms while a CEO of a similar U.S. firm will compare himself only with U.S. managers and CEOs of foreign companies will compare themselves only with foreign managers. Similarly, if there is a cross-ownership of firms in different industries (e.g., a Financial Industrial Group), then managers of such firms will use a “market-wide” benchmark formation method while managers of similar firms without the cross-ownership may be looking only at the managerial contracts in their industry (“stand-alone” method). Since such managers constitute only a small portion of all the managers and since other managers may exclude them from their “peer groups”, we need to analyze the effects of “market-wide” benchmark formation method in the world where almost everybody uses “stand-alone” method.
Similar to figures 6a and 6b, Figures 7a and 7b present the value of options and the pay-to-performance sensitivity of the long-run incentive contracts for two types of firms (firms whose “standard” contract consists of 80% cash and 20% equity and firms whose “standard” contract consists of 50% cash and 50% equity) under the assumption that managers of these firms use the “stand-alone” benchmark formation method (columns 1 and 4 on Figure 7a and columns 2 and 5 on figure 7b). Unlike figures 6a and 6b, these figures also present the long-run incentive contract for the managers who live in this economy but use a “market-wide” method to form their benchmark portfolios (columns 2 and 3 on Figure 7a and columns 3 and 4 on figure 7b). Similar to the previously discussed example, we see that managers who use “market-wide” benchmark have an average level of pay-to-performance sensitivity of their contracts but have a higher options/stock ratio. Thus, one may expect that managers of foreign subsidiaries and managers of firms with cross-ownership (e.g., members of Financial Industrial Groups) will have more of their incentive to be provided through options rather than through stocks (i.e., will have higher options/stock ratio)

Several shocks

One of the main assumptions of the model is that there is an economy-wide shock that increases the desired pay-to-performance sensitivity of the “standard” contract. What if we have a shock that decreases the desired pay-to-performance sensitivity? In this case the intuition will work in the opposite way. A decrease in pay-to-performance sensitivity will lead to lower rewards in the good state of the world and lower punishments in the bad state of the world. Thus, loss-averse managers, who are used to the high pay-to-performance sensitivity, will feel losses in the good state of the world. As a result, a principal will have
to reduce punishment much more than the rewards. This will lead to a concave incentive contract that consists of cash, equity, and a fixed bonus for achieving at least the medium level of profit. So, we should expect the convexity of managerial incentive contracts to be positively correlated with their pay-to-performance sensitivity.

Firm’s $\beta$

In all that precedes I assumed that the managerial benchmark is state-dependent and that the manager compares his payoff with the payoff that he would have gotten under the “benchmark” contract given the same firm’s profit realization. Some managers, however, may not be that sophisticated and tend to compare their payoffs with the average realized payoff of other managers. In the present of non-zero correlation between a firm’s profit and the average market profit (a proxy for firm’s $\beta$), the manager’s benchmark may still be state-dependent (i.e., may depend on the firm’s profit realization), but be a random variable in every state.

To analyze the effect of firm’s $\beta$ on the optimal incentive contract, let us alter some of the model’s assumptions. Let us assume that the average market profit may be either low (L), medium (M), or high (H) with probabilities $\{p_L; p_M; p_H\}$, and that the firm’s profit is equal to the average market profit with probability $\rho$ and is independent of the market’s profit with probability $\rho$. Assume also that the principal cannot make a compensation contract to be contingent on market profit realization and that the parameters of the model are such that the “standard” contract is 50% cash, 50% equity. Figure 8 presents the share
of options and bonuses as a percentage of the total non-cash compensation.\textsuperscript{19} Thus, one can see that the convexity of the contract increases with the firm’s $\beta$ and one can expect to have a bonus-based (concave) compensation structure in low-$\beta$ industries, and option-based (convex) compensation in high-$\beta$ industries. This result may explain why CEOs in the utility industry have lower compensation levels and fewer options in their compensation packages than the managers in the other industries.

5. Conclusion

This paper analyzes the structure of the optimal incentive contract for loss-averse managers who care not only about their absolute payoff but also compare their payoffs with compensations of other managers. It shows that recent changes in the market that make principals to increase the pay-to-performance sensitivity of incentive contracts also make the contracts for loss-averse managers to be convex and include a substantial amount of stock options. Even though stock option grants are the best short-run mechanism to provide more incentives for the managers who cannot tolerate a sharp increase in the punishment for bad performance, the use of option grants leads to an inefficient long-run equilibrium incentive contract with too many options, too high pay-to-performance sensitivity, and, as a result, a too-high average compensation level.

The fact that managers may compare their incentive contracts with the other managers’ contracts in their “peer group” may help to explain why (otherwise identical) managers may have very different structures of compensation contracts. Indeed, a CEO of a U.S.

\textsuperscript{19} In this figure bonuses are depicted as negative amount of options. For example, -15\% of options means that there are no options and 15\% of bonus compensation.
subsidiary abroad will use the U.S. managers’ incentive contracts as his benchmark, and, thus, will demand more stock option grants than a CEO of a similar foreign single segment firm.

On the other hand, when managers fail to recognize the differences in firms’ specific characteristics and use the average market incentive contract as their benchmarks, the contracts of different firms’ managers become to look alike. Managers with low pay-to-performance sensitivity contracts will demand more options so that they will feel smaller losses when their firms perform well. Similarly, managers with high pay-to-performance contracts will be unwilling to exchange their base salary for restricted stocks since doing this will make them feel losses when their firms perform poorly. Thus, to keep pay-to-performance sensitivity at a high level, principals must include more options in their managers’ contracts. As a result, high heterogeneity of firms’ cash flows leads to more options in the optimal incentive contracts. In particular, we may expect to have more options/stock ratio in countries with diverse industries (e.g., in U.S.) than in countries with only one main industry (e.g., oil-producing or tourism-oriented countries). Similarly, if some of the managers use a wider ”peer group”, these managers should have more options in their compensation contract. In particular, we may expect managers of foreign subsidiaries and Finance Industrial Group members’ to have incentive contracts with higher options/stock ratio. If, however, one fails to take into account that loss-averse managers require an extra premium when their contracts are different from the benchmark, one may find that managers have too high “risk-adjusted” (but not “loss-adjusted”) compensation level.
References


Appendix

Proof of the existence and uniqueness of the “standard” contract

Denote $u_i = \ln(w_i)$. Using this notation we can rewrite the optimization problem (4)-(6) as:

$$\min p_L e^{u_L} + p_M e^{u_M} + p_H e^{u_H}$$ (A1)

s.t.:

$$p_L u_L + p_M u_M + p_H u_H \geq \bar{u}$$ (A2)

$$\sum_{i \in \{L, M, H\}} p_i u_i \geq \sum_{i \in \{L, M, H\}} q_i u_i + c$$ (A3)

One can easily show that $\exists \, k$ such that a solution to the problem (A1)-(A3) is the same as a solution to the problem:

$$\min p_L e^{u_L} + p_M e^{u_M} + p_H e^{u_H}$$ (A1)

s.t.:

$$p_L u_L + p_M u_M + p_H u_H \geq \bar{u}$$ (A2)

$$\sum_{i \in \{L, M, H\}} p_i u_i \geq \sum_{i \in \{L, M, H\}} q_i u_i + c$$ (A3)

$$-k \leq u_i \leq k \quad \text{for} \quad \forall \, i \in \{L, M, H\}$$ (A4)

The set of the point $\{u_L, u_M, u_H\}$ that satisfy (A2)-(A4) is a convex compact subset of $\mathbb{R}^3$ and the objective function $p_L e^{u_L} + p_M e^{u_M} + p_H e^{u_H}$ is convex. Thus, optimization problem (A1)-(A4) has unique solution.
Proof of theorem 1:

Similarly to the previous proof, one can show that optimization problem (4)-(6) is equivalent to the optimization problem:

\[
\min p_L w_L + p_M w_M + p_H w_H
\]

s.t.:

\[
p_L U(w_i, r_i) + p_M U(w_M, r_M) + p_H U(w_H, r_H) \geq \bar{u}
\]

\[
\sum_{i \in \{L, M, H\}} p_i U(w_i, r_i) \geq \sum_{i \in \{L, M, H\}} q_i U(w_i, r_i) + c
\]

\[-k \leq w_i \leq k \text{ for } \forall i \in \{L, M, H\}\]

for some large enough \(k\). Conditions (A6)-(A8) define a compact subset of \(\mathbb{R}^3\) and optimization function \(p_L w_L + p_M w_M + p_H w_H\) is continuous. Thus, optimization problem (A5)-(A8) has at least one solution.

To prove the uniqueness, let us drop the non-binding constraint (A8). Denote \(w^*\) to be a solution to the problem (A5)-(A7) and consider three possible scenarios:

\(w^*_i > r_i\), \(w^*_i < r_i\) and \(w^*_i = r_i\).

(i) In the case when \(w^*_i > r_i\), by writing down the Lagrangian and the F.O.C. with respect to \(w_i\) we can find
\[
\frac{\partial L}{\partial w_i} = -p_i + \frac{\lambda(1 + \alpha)}{w_i} p_i + \frac{\mu(1 + \alpha)(p_i - q_i)}{w_i} p_i = 0 
\]

(A9)

Thus, \( w_i^* \) must satisfy

\[
w_i^* = (1 + \alpha)(\lambda + \mu(1 - h_i))
\]

(A10)

Since \( \frac{\partial^2 L}{\partial w_i \partial w_j} = 0 \) for \( i \neq j \), to show that \( w_i^* \) is unique we need to show that the Lagrangian is concave function of \( w_i \).

If \( w_i > r_i \), then

\[
\frac{\partial^2 L}{\partial w_i^2} = -\frac{\lambda(1 + \alpha)}{w_i^2} p_i + \frac{\mu(1 + \alpha)(p_i - q_i)}{w_i^2} p_i = -\frac{w_i^*}{w_i^2} p_i < 0
\]

If \( w_i < r_i \), then

\[
\frac{\partial^2 L}{\partial w_i^2} = -\frac{\lambda(1 + \alpha \varepsilon)}{w_i^2} p_i + \frac{\mu(1 + \alpha \varepsilon)(p_i - q_i)}{w_i^2} p_i = -\frac{w_i^*}{w_i^2} 1 + \alpha \varepsilon p_i < 0
\]

If \( w_i = r_i \) then \( \frac{\partial^2 L}{\partial w_i^2} \) does not exist and we need to show that \( \frac{\partial L}{\partial w_i^+} < \frac{\partial L}{\partial w_i^-} \) where \( \frac{\partial L}{\partial w_i^+} \) and \( \frac{\partial L}{\partial w_i^-} \) are the right and left differential at \( w_i = r_i \) correspondently. By computing

\[
\frac{\partial L}{\partial w_i^+} = -p_i + \frac{\lambda(1 + \alpha)}{w_i} p_i + \frac{\mu(1 + \alpha)(p_i - q_i)}{w_i} p_i = -p_i + \frac{w_i^*}{r_i} p_i
\]

and

\[
\frac{\partial L}{\partial w_i^-} = -p_i + \frac{\lambda(1 + \alpha \varepsilon)}{w_i} p_i + \frac{\mu(1 + \alpha \varepsilon)(p_i - q_i)}{w_i} p_i = -p_i + \frac{w_i^*}{r_i} 1 + \alpha \varepsilon p_i
\]

we can see that \( \frac{\partial L}{\partial w_i^+} < \frac{\partial L}{\partial w_i^-} \).
(ii) In the case when $w_i^* < r$, by writing down the Lagrangian and the F.O.C. with respect to $w_i$ we can find

$$\frac{\partial L}{\partial w_i} = -p_i + \frac{\lambda}{w_i} (1 + \alpha \varepsilon) p_i + \frac{\mu}{w_i} (1 + \alpha \varepsilon) (p_i - q_i) i = 0$$

Thus, $w_i^*$ must satisfy

$$w_i^* = (1 + \alpha \varepsilon) (\lambda + \mu (1 - h_i))$$

(A11)

And, similar to the case when $w_i^* < r$, one can show that the solution is unique.

(iii) To show the uniqueness in the remaining case $w_i^* = r$, let us assume the opposite, i.e. that solution is not unique. In this case another solution must be either $w_i^* > r$ or $w_i^* < r$.

But in both of these cases the solution is unique which contradicts to the assumption that $w_i^* = r$ is a solution.

Q.E.D.

**Proof of theorem 2:**

Without loss of generality we may assume that $L=0$.\(^{20}\) In order to prove the theorem, let us consider two possible scenarios: (i) If $w_M > r_M$ and $w_M \leq r_M$

(i) If $w_M > r_M$, then by writing down a Lagrangian and taking F.O.C. w.r.t. $w_i$, one can find:

---

\(^{20}\) Only (M-L) and (H-M) affect the shape of optimal incentive contract. The size of L affects only the size of base salary (cash)
Thus,

\[
\begin{align*}
\frac{w_L}{1 + \alpha} &= \lambda + \mu \cdot (1 - h_L) \\
\frac{w_M}{1 + \alpha} &= \lambda + \mu \cdot (1 - h_M) \\
\frac{w_H}{1 + \alpha} &= \lambda + \mu \cdot (1 - h_H)
\end{align*}
\]

which means that the optimal contract is convex and must include some options.

(ii) Now, consider the case when \( w_M \leq r_M \). By contradiction, assume that the optimal incentive contract is not convex, i.e., assume that

\[
\frac{w_M - w_L}{M - L} \geq \frac{w_H - w_M}{H - M}
\]

To simplify notations, let us denote \( t = \frac{H - M}{M - L} \). Since \( p_L L + p_M M + p_H H = M \), one can find that \( p_L = t \cdot p_H \). Since we assumed that (8) is satisfied at any point of time, the incentive contract \( r = \{r_L, r_M, r_H\} \) is linear and can be written as:

\[
\begin{align*}
r_H &= r_M + t \gamma \\
r_L &= r_M - \gamma
\end{align*}
\]

where \( \gamma \) is some non-negative constant.
Let us denote $\beta = \frac{w_H - w_M}{t}$. Since $w_M \leq r_M$ and $w_H > r_H$, we must have $\beta > \gamma$. Using this notation, we can rewrite (A12) as $w_L \leq w_M - \beta$. Thus, the expected manager’s utility can be written as

$$
U(w, r) = p_L \ln(w_L) + p_M \ln(w_M) + p_H \ln(w_M + t\beta) + \alpha \ln\left(\frac{w_L}{r_M - \gamma}\right) + \alpha \ln\left(\frac{w_M}{r_M}\right) + \alpha \ln\left(\frac{w_M + t\beta}{r_M + t\gamma}\right)
$$

(A13)

Using $w_M \leq r_M$ and $w_L \leq w_M - \beta$, one can find

$$
U(w, r) \leq p_L \ln(r_M - \beta) + p_M \ln(r_M) + p_H \ln(r_M + t\beta) + \alpha \ln\left(\frac{r_M - \beta}{r_M - \gamma}\right) + 0 + \alpha \ln\left(\frac{r_M + t\beta}{r_M + t\gamma}\right)
$$

(A14)

Denote

$$
f(\beta) = p_L \ln(r_M - \beta) + p_M \ln(r_M) + p_H \ln(r_M + t\beta) + \alpha \ln\left(\frac{r_M - \beta}{r_M - \gamma}\right) + 0 + \alpha \ln\left(\frac{r_M + t\beta}{r_M + t\gamma}\right)
$$

Thus, $f(\gamma) = 0$ and (using the fact that $\beta > \gamma$ and $p_L = t \cdot p_H$)

$$
\frac{df}{d\beta} = -p_L \frac{1}{r_M - \beta} + p_H \frac{1}{r_M + t\beta} - \alpha \frac{r_M - \gamma}{r_M - \beta} + \alpha \frac{r_M + t\gamma}{r_M - t\beta} < 0
$$

Therefore, $U(w, r) < 0$ for $\beta > \gamma$ and it contradicts to the IR constraint (5)
Q.E.D.

**Proof that if \( z=1 \) then the optimal contract is linear**

If \( z=1 \) then \( u_i = (1 + \alpha) \ln(w_i) - \alpha \ln(r_i) \). By writing down the Lagrangian and taking F.O.C. w.r.t. \( w_i \) we can find \( w_i = \lambda + \mu \cdot (1 - h_i) \). Using (8), we can find that

\[
\left( \frac{w_M - w_L}{M - L} = \frac{w_H - w_M}{H - M} \right)
\]

which means that the optimal contract is linear.

Q.E.D.

**Proof of theorem 3**

By definition, a long-run equilibrium is a triplet \( \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \) that solves the principal’s optimization problem (4)-(6) given \( r = \hat{w} \). By writing down a Lagrangian and taking its first derivative w.r.t. \( \hat{w}_i \), we can find the necessary conditions for \( \hat{w}_i \):

\[
\frac{\partial L}{\partial \hat{w}_i} (w_i = \hat{w}_i) = -p_i + \frac{\lambda (1 + \alpha)}{\hat{w}_i} p_i + \frac{\mu (1 + \alpha)(p_i - q_i)}{\hat{w}_i} p_i \leq 0
\]

(A15)

and

\[
\frac{\partial L}{\partial \hat{w}_i} (w_i = \hat{w}_i) = -p_i + \frac{\lambda (1 + \alpha \varepsilon)}{\hat{w}_i} p_i + \frac{\mu (1 + \alpha \varepsilon)(p_i - q_i)}{\hat{w}_i} p_i \geq 0
\]

(A16)

By theorem 1, these conditions are also sufficient conditions. To complete the proof, we need to show that there is a continuum of points \( x = \{\lambda, \mu, \hat{w}_1, \hat{w}_2, \hat{w}_3\} \in \mathbb{R}^{3} \) such that \( \lambda > 0 \), \( \mu > 0 \), and \( \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \) satisfies (5), (6), (A15) and (A16).
Conditions (A15) and (A16) can be rewritten as one condition

\[(1 + \alpha)(\lambda + \mu(1 - h_i)) \leq \hat{w}_i \leq (1 + \alpha \varepsilon)(\lambda + \mu(1 - h_i))\]  \hspace{1cm} (A17)

Denote \( u_i = \ln(w_i) \) and \( \hat{u}_i = \ln(\hat{w}_i) \). Since (5) and (6) must be satisfied as equalities, we can rewrite them as:

\[\sum_{i \in \{L,M,H\}} p_i \hat{u}_i = \bar{u} \] \hspace{1cm} (A18)

and

\[\sum_{i \in \{L,M,H\}} q_i \hat{u}_i = \bar{u} - c \] \hspace{1cm} (A19)

and we can rewrite (A17) as

\[\ln(1 + \alpha) + \ln(\lambda + \mu(1 - h_i)) \leq \hat{u}_i \leq \ln(1 + \alpha \varepsilon) + \ln(\lambda + \mu(1 - h_i))\]  \hspace{1cm} (A20)

To be a long-run equilibrium, \( \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \) must satisfy (A18)-(A20) for some \( \lambda > 0 \) and \( \mu > 0 \). Equations (A18)-(A19) defined a straight line in the \( \mathbb{R}^3 \) space and inequality (A20) defines a 3-dimentional subspace. Thus, in general, we should expect a continuum of equilibria. Just to get an intuition how this works, remember that in the “classical” case the optimal contract must satisfy (A18)-(A19) and the F.O.C.

\[\hat{u}_i = \ln(\lambda + \mu(1 - h_i))\] \hspace{1cm} (A21)

which defines a 2-dimentional surface in the \( \mathbb{R}^3 \), i.e., we should expect the unique “classical” optimal contract.
To show the multiplicity of \( \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \) that satisfies (A18)-(A20) for some \( \lambda > 0 \) and \( \mu > 0 \), let us define

\[
\tilde{U}(w_i) = \frac{1 + \alpha + (1 + \alpha \varepsilon)}{2} \ln(w_i) 
\]

(A22)

\[
\tilde{u} = \bar{u} \frac{1 + \alpha + (1 + \alpha \varepsilon)}{2} 
\]

(A23)

and

\[
\tilde{c} = c \frac{1 + \alpha + (1 + \alpha \varepsilon)}{2} 
\]

(A24)

and consider an optimization problem

\[
\min p_L w_L + p_M w_M + p_H w_H 
\]

(A25)

s.t.:

(\text{IR}): \quad p_L \tilde{U}(w_i) + p_M \tilde{U}(w_M) + p_H \tilde{U}(w_H) \geq \tilde{u} 

(A26)

and

(\text{IC}): \quad \sum_{i \in \{L, M, H\}} p_i \tilde{U}(w_i) \geq \sum_{i \in \{L, M, H\}} q_i \tilde{U}(w_i) + c 

(A27)

Optimization problem (A25)-(A27) is a “classical” optimization problem that has a unique solution. Thus, there are \( \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \), \( \lambda > 0 \) and \( \mu > 0 \) that satisfy (A26)-(A27) and

\[
\tilde{U}(w_i) = \ln(\lambda + \mu(1 - h_i)) 
\]

(A28)

But (A27)-(A28) are equivalent to (A18)-(A19); and (A28) means that at \( x = \{\lambda, \mu, \hat{w}_1, \hat{w}_2, \hat{w}_3\} \in \mathbb{R}^5 \) both sides of inequality (A20) are not binding. This means that at given \( \lambda > 0 \) and \( \mu > 0 \) straight line defined by (A18)-(A19) is going through the inside
of the cube defined by (A20), which, in fact, means, that there is a continuum 
\[ \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \] that satisfies (A18)-(A20).

Q.E.D.

**Proof of theorem 5**

Let \( \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \) be a “standard” contract. Thus, we may say that it satisfies the F.O.C. of the “classical” problem:

\[ \hat{w}_i = \lambda + \mu \cdot (1 - \hat{h}_i) \quad \text{(A29)} \]

Let us denote \( \hat{\lambda} = \frac{\lambda}{(1 + \alpha)} \) and \( \hat{\mu} = \frac{\mu}{(1 + \alpha)} \) and use them as Lagrange multipliers in optimization problem (4)-(6) for loss-averse managers.

To show that \( \hat{w} = \{\hat{w}_1, \hat{w}_2, \hat{w}_3\} \) is a long-run equilibrium contract we need to show that it satisfies F.O.C. of the optimization problem for loss-averse managers when the benchmark contract is \( \hat{r} = \hat{w} \). These F.O.C. are:

\[
\frac{\partial L}{\partial \hat{w}_i^+}(w_i = \hat{w}_i) = -p_i + \frac{\hat{\lambda}(1 + \alpha)}{\hat{w}_i} p_i + \frac{\hat{\mu}(1 + \alpha)(p_i - q_i)}{\hat{w}_i} p_i \leq 0
\quad \text{(A30)}
\]

and

\[
\frac{\partial L}{\partial \hat{w}_i^-}(w_i = \hat{w}_i) = -p_i + \frac{\hat{\lambda}(1 + \alpha)}{\hat{w}_i} p_i + \frac{\hat{\mu}(1 + \alpha)(p_i - q_i)}{\hat{w}_i} p_i \geq 0
\quad \text{(A31)}
\]

Using \( \hat{\lambda} = \frac{\lambda}{(1 + \alpha)} \), \( \hat{\mu} = \frac{\mu}{(1 + \alpha)} \) and (A29) we can find:
\[
\frac{\partial L}{\partial w_i}(w_i = \hat{w}_i) = -p_i + \frac{\lambda(1 + \alpha)}{\hat{w}_i} p_i + \frac{\mu(1 + \alpha)(p_i - q_i)}{\hat{w}_i} p_i = \\
= p_i \left(-1 + \frac{\lambda + \mu(1 - h_i)}{\hat{w}_i}\right) = p_i \left(-1 + \frac{\hat{w}_i}{\hat{w}_i}\right) = 0
\]

and

\[
\frac{\partial L}{\partial w_i}(w_i = \hat{w}_i) = -p_i + \frac{\lambda(1 + \alpha \varepsilon)}{\hat{w}_i} p_i + \frac{\mu(1 + \alpha \varepsilon)(p_i - q_i)}{\hat{w}_i} p_i = \\
= p_i \left(-1 + \frac{1 + \alpha \varepsilon \lambda + \mu(1 - h_i)}{1 + \alpha \varepsilon \hat{w}_i}\right) = p_i \left(-1 + \frac{1 + \alpha \varepsilon \hat{w}_i}{1 + \alpha \varepsilon \hat{w}_i}\right) = p_i \left(-1 + \frac{1 + \alpha \varepsilon \hat{w}_i}{1 + \alpha \varepsilon \hat{w}_i}\right) > 0
\]

which means that (A30) and (A31) are satisfied.

Q.E.D.
FIGURE 1
The Dynamic of the Optimal Compensation Contract: the Amount of Option Compensation in the Total Non-Cash Compensation
FIGURE 2
The Dynamic of the Optimal Compensation Contract: the Amount of Option Compensation in the Total Compensation
Here the pay-to-performance sensitivity is defined as a change in the manager’s realized compensation for $1 change in firm’s profit realization. Namely, the pay-to-performance sensitivity is defined as
\[
\frac{1}{2} \left( \frac{w_H - w_M}{H - M} + \frac{w_M - w_L}{M - L} \right).
\]
FIGURE 4
The Dynamic of the Optimal Compensation Contract:
Risk-Adjusted Compensation

Here the risk-adjusted compensation is defined as a certainty equivalent payoff for a manager with the utility function \( U(w_i) = \ln(w_i) \) of an actual payoff structure for a loss-averse manager with utility function

\[
U(w_i, r_i) = u(w_i) + \alpha \left( \frac{w_i}{r_i} \right). 
\]

Independently of \( \alpha \), the risk-adjusted compensation converges to one as time goes to infinity.
FIGURE 5
The effect of Managerial Loss-Aversion on their Average Compensation
FIGURE 6a
Externality in the Contract-Setting Process and its Effect on Amount of Options in the Equilibrium Incentive Contract

FIGURE 6b
Externality in the Contract-Setting Process and its Effect on the Pay-to-Performance Sensitivity of the Equilibrium Incentive Contract

These figures present the properties of the long-run equilibrium contracts in the economy with heterogeneous industries that was exposed to the same economy-wide shock and evolve together. The different benchmark contract formation methods, that were considered, are described under the corresponding columns in the figures.
These figures consider an economy with heterogeneous industries that was exposed to the same economy-wide shock but where almost all managers form their benchmark portfolios using incentive contracts of managers of the firms in the same industry and compare the long-run equilibrium incentive contracts of these managers with the contracts of managers who uses the average market contract as a benchmark. The benchmark formation methods are described under the corresponding columns in the figures.
FIGURE 8
The Effect of the Firm’s Beta on the Long-Run Equilibrium Incentive Contract