Real Options and Earnings-Based Bonus Compensation

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Abstract

This paper provides a real-option model which incorporates a regime-dependent earnings-based bonus compensation to scrutinize how this compensation affects manager's investment and financing decisions. We particularly find that manager's optimal financing decision is quite different when the compensation is offered by ownership shares or by earnings-based compensation. Manager compensated for ownership shares provides manager an incentive to issue debt to finance the investment project, whereas earnings-based compensation provides an exactly opposite incentive. Therefore, the optimal leverage ratios, credit spreads and agency costs, when manager is partly compensated for earnings-based bonus, behave dissimilarly when manager is only compensated for cash salary and shares (Andrikopoulos, 2009). In addition, the effects of earnings-based compensation on the manager's investment and financing decisions and agency costs can vary according to different sizes of accompanying ownership shares compensation. We also investigate the effects of earnings-based compensation when the manager's expected compensation value is fixed.

Key Words: Real Options, Earning-Based Bonus Compensation, Agency Problem, Optimal Capital Structure

1. Introduction

Most executive compensation studies focus on stock-based incentives to align managerial and shareholder interests. However, there is little theoretical literature investigating characteristics of earnings-based compensation. This paper extends Mauer and Sarkar (2005) and Andrikopoulos (2009) by developing a real-option model where the manager's compensation including cash salary, ownership shares and regime-dependent earnings-based compensation. We complement literature by addressing how does earning-based compensation affect the manager's investment and financing decisions and agency costs, and why the impact of ownership shares differ from that of earning-based compensation? In the best of our knowledge, this is the first paper considering earning-based compensation in the real-option model and further clarifying the differences between stock-based and earnings-based compensations.

The use of earnings-based compensation in CEO incentive contracts is common in practice. As pointed by Murphy (1999) and emphasized in Câmara (2009), "virtually every for-profit company offers an annual bonus plan covering its top executives and paid annually based on a single-year's performance." Murphy (1999) reports that 91% of the sample firms use a measure of earnings performance in their annual bonuses plans based on the "Annual Incentive Plan Design Survey" conducted in 1996–1997 by Towers Perrin. Moreover, as summarized in Duru et.al. (2005), the amount of CEO earnings-based compensation accounts for around 23% of total compensation in the sample of 1993-1997[2]. In a compensation plan contingent on earnings, no earning-based bonus compensation is paid until earnings reach a threshold performance. When the threshold performance is reached, a designed compensation might be paid. Once earnings

[2] The amount of managerial compensation accounts for a large proportion of a firm's operation. As pointed out by Lambrecht and Myers (2008), for example, General Electric's annual appropriation for management bonuses has been 10% of the amount by which earnings exceed 5% of invested capital. Banks routinely allocate substantial fractions of gross income to annual bonuses.

exceed this threshold, the manager's compensation increases linearly with operating net incomes. In this sense, a firm pays its managers the excess threshold performance bonus, if the end-of-period earnings exceed the threshold performance, and no earning-based compensation is paid until the threshold performance is achieved. This paper therefore assumes that the manager compensation consists of cash salary, ownership shares and earnings-based bonus.

The direct difference between stock-based and earning-based compensation is that the former one is based on stock-performance measure while the second one is based on operation-performance measure. In the long run, these two performance measures should behave in a very similar way. Nevertheless, the natures of stock-based and earnings-based compensations provide the manager a totally opposite incentive to make a firm's financing decision. For example, a firm faces a valuable investment project and its manager can choose whether to employ debt financing. If the manager is totally compensated by the stock-based compensation, he/she would issue an optimal debt amount to finance the project, since the benefits of bondholders could easily be exploited by the shareholders. On the other hand, if the manager is totally compensated by the earnings-based compensation, he/she would not use any debt financing, because the debt's coupon payment would make the earnings-based compensation less valuable via lowering down a firm's net operating incomes. As a result, this paper attempts to investigate this difference by using a real option model, and further examine its impact on agency cost.

The real-option based corporate finance theories can be dated back to Mauer and Triantis (1994) and was further advanced by Leland (1994), Leland and Toft (1996), and Leland (1998). These works establish the recent development of structural credit risk model; however, the firm’s investment decision is not fully considered. Following this line of research, Mauer and Sarkar (2005) establishes a real-option framework which integrates a firm’s investment and capital structure decision and considers the conflict between shareholders and bondholders. However, despite these models captures many several empirical observations of capital structure and agency costs, these models have yet to fully consider the agency problem between owners and manager. Some researches investigate effects of the managerial discretion on corporate decisions. Cadenillas et al. (2004) uses the option-like features of corporate securities and examined shareholders-manager conflicts as well as the effect of managerial compensation on capital structure, where managers were only rewarded with stock and decided on optimal corporate risk policy. Grenadier and Wang (2005) reexamine the investment timing for an option to invest, in the context of owner-manager contracts in an all-equity firm with the presence of asymmetric information and costly effort. Andrikopoulos (2009), which is the one most related to our research, examines a firm’s investment and financing decisions given that manager’s compensation is composed of cash salary and ownership share. He shows that the combination of executive’s compensation greatly influences the firm’s investment and capital structure decision as well as corporate bond credit spreads. The agency cost between mangers and shareholders incurred while manager only maximizes his/her own wealth. However, he didn’t consider any earnings-based bonus compensation.

In this paper, we find that even though ownership shares and earnings-based bonus provides almost the same incentive for manager’s optimal investment trigger, manager’s optimal financing decision is quite different when the compensation is offered by ownership shares or by earnings-based compensation. Manager compensated for ownership shares provides manager an incentive to issue debt to finance the investment project, whereas earnings-based compensation provides an exactly opposite incentive. Therefore, the optimal leverage ratios, credit spreads and agency costs, when manager is partly compensated for earnings-based bonus, behave dissimilarly when manager is only compensated for cash salary and ownership shares. In particular, Andrikopoulos (2009) showed that credit spreads are increasing as manager is compensated for more ownership shares, while credit spreads are decreasing as manager is compensated for more earnings-based bonus. In addition, the effects of earnings-based compensation on the manager's investment and financing decisions and agency costs can vary according to different sizes of accompanying ownership shares compensation. We also investigate the effects of earnings-based compensation when the manager's expected compensation value is fixed and find similar results. There in one empirical implication. Since ownership shares and earnings-based bonus provide different incentives for manager to make financing decision, researcher should pay more attentions to manager's compensation composition when analyzing the issue concerning a firm's capital structure and manager's compensation (John and John, 1993, Ortiz-Molina, 2007).

The rest of this article is organized as follows. Section 2 introduces the real-option model with earning-based bonus compensation. Section 3 analyzes numerical results to explain the mechanism behind earning-based compensation and ownership shares. Section 4 concludes the paper.

2. The model

Using the real options framework developed by Mauer and Sarkar (2005), we assume a firm owns a monopolistic, perpetual right to exercise an investment project at the cost I. Once the project has been started, it would generate stochastic revenue P with a constant cost C per unit time. Assume that the dynamics of P can be replicated by forming a portfolio of traded assets in a no-arbitrage economy so that P is governed by the following stochastic differential equation under risk-neutral probability measure:

$$\frac{dP}{P} = \left(r - \delta\right) dt + \sigma dW \tag{1}$$

where r is a constant risk-free short rate, δ is a constant convenience yield, σ is a constant return volatility of the revenue, and W is a risk-neutral Wiener process.

Similar to Andrikopoulos (2009), we assume that managers are seeking their own benefits, instead of equity holder's benefits, and the shareholders can't manage the operation of the project themselves and managers are hired to do so. Since managers don't have 100% ownership of this company, managers' decisions may deviate from the equity-maximizing policies, and hence lead to the principal-agency problem. We further assume that manager has the discretion to decide when to invest the project and how much to issue debt to finance the investment costs. Although the investment and financing decisions are observable, they are not verifiable and hence not contractible. After the project has been started, equity holders, on the other hand, have control rights to decide to abandon the project or default the firm when financing with debt, which is consistent with Mauer and Sarkar (2005), but different from Andrikopoulos (2009).

In addition, we assume that originally the manager has existing income and after investment the manager must forego this previous income *PI*. Instead the manager gets a new compensation offer consisting of a cash salary m_0 per unit time, a faction (m_1) of equity and an earnings-based bonus which is a proportion (m_2) of net profit after taxes per unit time. Notice that the cash salary is a part of fixed cost, so m_0 must be less than C. Besides, when bankruptcy occurs, the manager could find another job which yields some reservation income *RI*. For simplification purpose, we follow Andrikopoulos (2009) by assuming $RI = PI$. When the option to invest is exercised, the manager can decide how much to finance this investment with equity and debt. If the amount for debt financing is K, then the shareholders contribute the remaining amount, $I-K$. As explained by Mauer and Sarkar (2005), this assumption implies this financing arrangement is a loan commitment, in which external funds committed to a specified amount can be supplied in the future when the firm needs.

2.1. Unlevered firm value

The unlevered firm does not use equity to finance investment. In this case, the shareholders can't decide to default the firm but have an option to abandon the project because of operating costs. Following Mauer and Sarkar (2005), the unlevered firm value $V^U(P)$ after the project has been exercised satisfies

$$\frac{1}{2}\sigma^2 P^2 V_{PP}^U + (r-\delta)PV_P^U - rV^U + (1-\tau)\left(P - C - m_2(P-C)^+\right) = 0 \tag{2}$$

and $V^U(P)$ has the following general solution:

$$V^U(P) = \begin{cases} (1-\tau)\left(\dfrac{P}{\delta} - \dfrac{C}{r}\right) + a_1 P^{\beta_1} + a_2 P^{\beta_2}, & P_A < P < C, \\ (1-\tau)(1-m_2)\left(\dfrac{P}{\delta} - \dfrac{C}{r}\right) + b_1 P^{\beta_1} + b_2 P^{\beta_2}, & P_A < C < P, \end{cases} \tag{3}$$

where

$$\beta_1 = \frac{1}{2} - \frac{r-\delta}{\sigma^2} + \sqrt{\left(\frac{1}{2} - \frac{r-\delta}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}} > 1,$$

$$\beta_2 = \frac{1}{2} - \frac{r-\delta}{\sigma^2} - \sqrt{\left(\frac{1}{2} - \frac{r-\delta}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}} < 0,$$

and a_1, a_2, b_1 and b_2 are constants, τ denotes corporate effective tax rate, and P_A is the abandonment trigger. In (3), only if P is greater than P_A, the investment project will be exercised. The setting defined in (2) differentiate our model from previous settings by the presence of the operating cash flows, $\left(P-C-m_2(P-C)^+\right)$, reduced by the manager's earning-based bonus compensation. It makes our model to depend on two regimes: $P>C$ and $P<C$ after the project is exercised. When P is greater than C, there is a earning-based compensation payable to managers. On the other hand, when P is less than C, managers will not be offered any earning-based bonus. That is to say, the earning-based compensation in our model is regime-dependent and determined by the relation between P and C.

For solving the unlevered firm value, the equation in (3) is subject to the following boundary conditions: (i) $\lim_{P\uparrow\infty} V^U(P)/P<\infty$ (non-bubble condition); (ii) $\lim_{P\downarrow P_A} V^U(P)=0$ (value-matching at P_A); (iii) $\lim_{P\uparrow C} V^U(P)=\lim_{P\downarrow C} V^U(P)$ (value-matching at C); and (iv) $\lim_{P\uparrow C}\frac{\partial V^U(P)}{\partial P}=\lim_{P\downarrow C}\frac{\partial V^U(P)}{\partial P}$ (smooth-pasting at C). We can respectively derive our solutions according to the cases of two regimes:

For $P_A<P<C$,

$$
\begin{aligned}
V^U(P) &= (1-\tau)\left(\frac{P}{\delta}-\frac{C}{r}\right)-(1-\tau)\left(\frac{P_A}{\delta}-\frac{C}{r}\right)\left(\frac{P}{P_A}\right)^{\beta_2} \\
&\quad -m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C}{\delta}+\frac{\beta_2}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P}{C}\right)^{\beta_1} \\
&\quad +\left(m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C}{\delta}+\frac{\beta_2}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P_A}{C}\right)^{\beta_1}\right)\left(\frac{P}{P_A}\right)^{\beta_2}.
\end{aligned}
\tag{4}
$$

The first term is the pure unlevered firm value when shareholders do not have any flexibility to abandon the project. The second shows the expected loss of the pure unlevered firm value when the project was abandoned. The third demonstrates the expected net loss of the unlevered firm value when paying the earnings-based bonus to the manager sometimes in the future if the firm operates at a profit. The last term shows the expected profit of the reduction in the manager's bonus when the project was abandoned. For $P_A < C < P$,

$$\begin{aligned}V^U(P) &= (1-\tau)\left(1-m_2\right)\left(\frac{P}{\delta}-\frac{C}{r}\right)-(1-\tau)\left(\frac{P_A}{\delta}-\frac{C}{r}\right)\left(\frac{P}{P_A}\right)^{\beta_2} \\ &\quad -m_2(1-\tau)\left(\frac{1-\beta_1}{\beta_1-\beta_2}\frac{C}{\delta}+\frac{\beta_1}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P}{C}\right)^{\beta_2} \\ &\quad +\left(m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C}{\delta}+\frac{\beta_2}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P_A}{C}\right)^{\beta_1}\right)\left(\frac{P}{P_A}\right)^{\beta_2}.\end{aligned} \tag{5}$$

The first term is the pure unlevered firm value if shareholders do not have any flexibility to abandon the project. The second shows the expected net loss of the unlevered firm value when the project was abandoned. The third demonstrates the expected present value of the manager's bonus that the firm might run at a loss sometimes and then run a profit again. The last term shows the expected profit of the reduction in the manager's bonus when the project was abandoned. The optimal abandonment strategy, chosen by shareholders to maximize equity value, is determined by the following smooth-pasting condition: $\lim_{P\downarrow P_A}\dfrac{\partial V^U(P)}{\partial P}=0$.

The compensation package of the manager in a unlevered firm (Com^U) can be expressed by

$$\begin{aligned}Com^U &= m_0+m_1\left[(1-\tau)\left(P-C-m_2(P-C)^+\right)\right]+m_2(1-\tau)(P-C)^+ \\ &= m_0+m_1(1-\tau)(P-C)+m_2(1-m_1)(1-\tau)(P-C)^+.\end{aligned} \tag{6}$$

where $(X)^+=\max\left(X,0\right)$. In equation (6), the manager's compensation package is composed of fixed salary m_0, ownership shares $m_1\left[(1-\tau)\left(P-C-m_2(P-C)^+\right)\right]$, and earnings-based bonus compensation $m_2(1-\tau)(P-C)^+$. Notice that earnings-based compensation is based on after-tax net "positive" profits, while ownership shares is based on after-tax, after-bonus net "positive" or "negative" profits. If the firm is unlevered, the total value of the manager's wealth, $M^U(P)$, then satisfies

$$\frac{1}{2}\sigma^2 P^2 M^U_{PP} + (r-\delta)PM^U_P - rM^U + Com^U = 0 \tag{7}$$

and $M^U(P)$ has the following general solution:[3]

$$M^U(P) = \begin{cases} \dfrac{m_0}{r} + m_1(1-\tau)\left(\dfrac{P}{\delta} - \dfrac{C}{r}\right) + d_1 P^{\beta_1} + d_2 P^{\beta_2}, & P_A < P < C. \\ \dfrac{m_0}{r} + (m_1 + m_2 - m_1 m_2)(1-\tau)\left(\dfrac{P}{\delta} - \dfrac{C}{r}\right) + e_1 P^{\beta_1} + e_2 P^{\beta_2}, & P_A < C < P. \end{cases} \tag{8}$$

d_1, d_2, e_1 and e_2 are constants and can be solved by the following four boundary conditions: (i) $\lim_{P\uparrow\infty} M^U(P)/P < \infty$ (non-bubble condition) (ii) $\lim_{P\downarrow P_A} M^U(P) = RI$ (value-matching at P_A) (iii) $\lim_{P\uparrow C} M^U(P) = \lim_{P\downarrow C} M^U(P)$ (value-matching at C) (iv) $\lim_{P\uparrow C}\dfrac{\partial M^U(P)}{\partial P} = \lim_{P\downarrow C}\dfrac{\partial M^U(P)}{\partial P}$ (smooth-pasting at C). For, $P_A < P < C$,

$$\begin{aligned} M^U(P) &= \frac{m_0}{r} + m_1(1-\tau)\left(\frac{P}{\delta} - \frac{C}{r}\right) \\ &\quad - \left(\frac{m_0}{r} + m_1(1-\tau)\left(\frac{P_A}{\delta} - \frac{C}{r}\right) - RI\right)\left(\frac{P}{P_A}\right)^{\beta_2} \\ &\quad + (1-m_1)m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P}{C}\right)^{\beta_1} \\ &\quad - \left((1-m_1)m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P_A}{C}\right)^{\beta_1}\right)\left(\frac{P}{P_A}\right)^{\beta_2}. \end{aligned} \tag{9}$$

The first term is the manager's compensation value when the shareholders do not have flexibility to abandon the project. The second shows the expected net loss of the manager's compensation value when the project was abandoned. The third demonstrates

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[3] In the case of $P_A > C$, the manager will always obtain the bonus. That means the earnings-based bonus is equivalent to a faction of equity, so the model will reduce to that of Andrikopoulos (2009). Hereafter, we assume $P_A < C$.

the expected present value of the future bonus that the manager could obtain. It is named as the bonus flexibility value. The last term shows the expected loss of the bonus flexibility when the project was abandoned. For $P_A < C < P$,

$$\begin{aligned} M^U(P) = {} & \frac{m_0}{r} + \left(m_1 + m_2 - m_1 m_2\right)(1-\tau)\left(\frac{P}{\delta} - \frac{C}{r}\right) \\ & - \left(\frac{m_0}{r} + m_1(1-\tau)\left(\frac{P_A}{\delta} - \frac{C}{r}\right) - RI\right)\left(\frac{P}{P_A}\right)^{\beta_2} \\ & + (1-m_1)m_2(1-\tau)\left(\frac{1-\beta_1}{\beta_1-\beta_2}\frac{C}{\delta} + \frac{\beta_1}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P}{C}\right)^{\beta_2} \\ & - \left((1-m_1)m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C}{r}\right)\left(\frac{P_A}{C}\right)^{\beta_1}\right)\left(\frac{P}{P_A}\right)^{\beta_2}. \end{aligned} \tag{10}$$

The first term is the manager's compensation value when the shareholders do not have flexibility to abandon the project. The second shows the expected net loss of the manager's compensation value when the project was abandoned. The third demonstrates the expected present value of the manager's bonus that the firm might run at a loss sometimes in the future and then run at a profit again. The last term shows the expected loss of the bonus flexibility when the project was abandoned.

2.2. Levered firm

If the firm is levered with perpetual coupon bond with coupon flow R per unit time, equity value $E(P)$ after the project has been exercised if the firm is levered satisfies:

$$\frac{1}{2}\sigma^2 P^2 E_{PP} + (r-\delta)PE_P - rE + (1-\tau)\left(P - C - R - m_2(P-C-R)^+\right) = 0 \tag{11}$$

and $E(P)$ has the following general solution:

$$E(P) = \begin{cases} (1-\tau)\left(\dfrac{P}{\delta} - \dfrac{C+R}{r}\right) + h_1 P^{\beta_1} + h_2 P^{\beta_2}, & P_D < P < C+R. \\ (1-\tau)(1-m_2)\left(\dfrac{P}{\delta} - \dfrac{C+R}{r}\right) + i_1 P^{\beta_1} + i_2 P^{\beta_2}, & P_D < C+R < P. \end{cases} \tag{12}$$

Again, h_1, h_2, i_1 and i_2 can be solved by the following four boundary conditions: (i) $\lim_{P\uparrow\infty} E(P)/P < \infty$ (non-bubble condition) (ii) $\lim_{P\downarrow P_D} E(P) = 0$ (value-matching at P_D) (iii) $\lim_{P\uparrow C+R} E(P) = \lim_{P\downarrow C+R} E(P)$ (value-matching at $C+R$) (iv) $\lim_{P\uparrow C+R} \frac{\partial E(P)}{\partial P} = \lim_{P\downarrow C+R} \frac{\partial E(P)}{\partial P}$ (smooth-pasting at $C+R$).

For $P_D < P < C+R$,

$$\begin{aligned} E(P) &= (1-\tau)\left(\frac{P}{\delta} - \frac{C+R}{r}\right) - (1-\tau)\left(\frac{P_D}{\delta} - \frac{C+R}{r}\right)\left(\frac{P}{P_D}\right)^{\beta_2} \\ &\quad - m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P}{C+R}\right)^{\beta_1} \\ &\quad + \left(m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P_D}{C+R}\right)^{\beta_1}\right)\left(\frac{P}{P_D}\right)^{\beta_2}. \end{aligned} \tag{13}$$

For $P_D < C+R < P$,

$$\begin{aligned} E(P) &= (1-\tau)(1-m_2)\left(\frac{P}{\delta} - \frac{C+R}{r}\right) - (1-\tau)\left(\frac{P_D}{\delta} - \frac{C+R}{r}\right)\left(\frac{P}{P_D}\right)^{\beta_2} \\ &\quad - m_2(1-\tau)\left(\frac{1-\beta_1}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_1}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P}{C+R}\right)^{\beta_2} \\ &\quad + \left(m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P_D}{C+R}\right)^{\beta_1}\right)\left(\frac{P}{P_D}\right)^{\beta_2}. \end{aligned} \tag{14}$$

The optimal default policy, chosen by shareholders to maximize equity value, is determined by the following smooth-pasting condition: $\lim_{P\downarrow P_D} \frac{\partial E(P)}{\partial P} = 0$.

As for debt value, we assume that if the firm goes bankruptcy and the creditor becomes the sole owner (Leland, 1994) and could hire another ability-identical manager to run the unlevered firm since it is more efficient for the new owners to continue operating the project with managers that have more firm-specific knowledge and value (Andrikopoulos, 2009). Debt value $D(P)$ after the exercise of the project satisfies

$$\frac{1}{2}\sigma^2 P^2 D_{PP} + (r-\delta)PD_P - rD + R = 0 \tag{15}$$

and $D(P)$ has the following general solution:

$$D(P) = \frac{R}{r} + j_1 P^{\beta_1} + j_2 P^{\beta_2}, \quad P_D < P, \tag{16}$$

where j_1 and j_2 can be solved by the following two boundary conditions: (i) $\lim_{P\uparrow\infty} D(P)/P < \infty$ (non-bubble condition); and (ii) $\lim_{P\downarrow P_D} D(P) = (1-\alpha)V^U(P_D)$ (value-matching at P_D) where a bankruptcy cost amounting to fraction α $\left(0 \le \alpha \le 1\right)$ of unlevered firm value. The debt value is therefore given by

$$D(P) = \frac{R}{r} - \left(\frac{R}{r} - (1-\alpha)V^U(P_D)\right)\left(\frac{P}{P_D}\right)^{\beta_2}, \quad P_D \le P. \tag{17}$$

The compensation of the manager is now modified as:

$$\begin{aligned} Com^L &= m_0 + m_1\left[(1-\tau)\left(P-C-R-m_2(P-C-R)^+\right)\right] + m_2(1-\tau)(P-C-R)^+ \\ &= m_0 + m_1(1-\tau)(P-C-R) + m_2(1-m_1)(1-\tau)(P-C-R)^+. \end{aligned}$$

The total value of manager in a levered firm $M^L(P)$ satisfies the following ODE:

$$\frac{1}{2}\sigma^2 P^2 M^L_{PP} + (r-\delta)PM^L_P - rM^L + Com^L = 0 \tag{18}$$

and $M^L(P)$ has the following solution form:

$$M^L(P) = \begin{cases} \dfrac{m_0}{r} + m_1(1-\tau)\left(\dfrac{P}{\delta} - \dfrac{C+R}{r}\right) + f_1 P^{\beta_1} + f_2 P^{\beta_2}, \quad P_D < P < C+R. \\ \dfrac{m_0}{r} + (m_1 + m_2 - m_1 m_2)(1-\tau)\left(\dfrac{P}{\delta} - \dfrac{C+R}{r}\right) + g_1 P^{\beta_1} + g_2 P^{\beta_2}, P_D < C+R < P. \end{cases} \tag{19}$$

Again, $M^L(P)$ must satisfy the following boundary conditions: (a) $\lim_{P\uparrow\infty} M^L(P)/P < \infty$ (non-bubble condition); (b) $\lim_{P\downarrow P_D} M^L(P) = RI$ (value-matching condition at P_D); (c) $\lim_{P\uparrow C+R} M^L(P) = \lim_{P\downarrow C+R} M^L(P)$ (value-matching condition at $C+R$); and

(d) $\lim_{P\uparrow C+R} \frac{\partial M^L(P)}{\partial P} = \lim_{P\downarrow C+R} \frac{\partial M^L(P)}{\partial P}$ (smooth-pasting condition at $C+R$), where RI is the reservation income. For $P_D < P < C+R$,

$$\begin{aligned} M^L(P) &= \frac{m_0}{r} + m_1(1-\tau)\left(\frac{P}{\delta} - \frac{C+R}{r}\right) - \left(\frac{m_0}{r} + m_1(1-\tau)\left(\frac{P_D}{\delta} - \frac{C+R}{r}\right) - RI\right)\left(\frac{P}{P_D}\right)^{\beta_2} \\ &\quad + (1-m_1)m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P}{C+R}\right)^{\beta_1} \\ &\quad - \left((1-m_1)m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P_D}{C+R}\right)^{\beta_1}\right)\left(\frac{P}{P_D}\right)^{\beta_2}. \end{aligned} \tag{20}$$

For $P_D < C+R < P$,

$$\begin{aligned} M^L(P) &= \frac{m_0}{r} + \left(m_1 + m_2 - m_1 m_2\right)(1-\tau)\left(\frac{P}{\delta} - \frac{C+R}{r}\right) \\ &\quad - \left(\frac{m_0}{r} + m_1(1-\tau)\left(\frac{P_D}{\delta} - \frac{C+R}{r}\right) - RI\right)\left(\frac{P}{P_D}\right)^{\beta_2} \\ &\quad + (1-m_1)m_2(1-\tau)\left(\frac{1-\beta_1}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_1}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P}{C+R}\right)^{\beta_2} \\ &\quad - \left((1-m_1)m_2(1-\tau)\left(\frac{1-\beta_2}{\beta_1-\beta_2}\frac{C+R}{\delta} + \frac{\beta_2}{\beta_1-\beta_2}\frac{C+R}{r}\right)\left(\frac{P_D}{C+R}\right)^{\beta_1}\right)\left(\frac{P}{P_D}\right)^{\beta_2}. \end{aligned} \tag{21}$$

The first term is the manager's compensation value when the shareholders do not have flexibility to default the firm. The second shows the expected net loss of the manager's compensation value when bankruptcy occurs. The third demonstrates the expected present value of the manager's earnings-based bonus that the firm might run at a loss sometimes in the future and then run at a profit again. The last term shows the expected loss of the bonus flexibility when firm goes under.

2.3. Options to invest

After exercising the investment option, the manager starts receiving cash salary, being rewarded a fraction of the equity (thus sharing the same portion of investment cost), and receiving the earnings-based compensation, but giving up the past income. Similar to Andrikopoulos (2009), we define this case as "Manager-Best (MB)". For comparison, following Mauer and Sarkar (2005), we define "Firm-Best (FB)" where optimal investment decision is chosen to maximize value of the firm's all stakeholders, the sum of equity value (excluding the fraction held by manager), debt value and manager's compensation value.

If the manager has the right to choose the time of project implementation, the value of the option to invest $MB(P)$ satisfies the following ODE:

$$\frac{1}{2}\sigma^2 P^2 MB_{PP} + (r-\delta)PMB_P - rMB = 0\ ,\quad P < P_I^M \tag{22}$$

and $MB(P)$ has the following general solution:

$$MB(P) = k_1 P^{\beta_1} + k_2 P^{\beta_2}\ ,\quad P < P_I^M\ .$$

According to the following two boundary conditions: (a) $\lim_{P\downarrow 0} MB(P) < \infty$; and (b) $\lim_{P\uparrow P_I^M} MB(P) = \lim_{P\uparrow P_I^M} M^L(P) - m_1(I - K^M) - PI$, we have

$$MB(P) = \left(M^L(P_I^M) - m_1(I - K^M) - PI\right)\left(\frac{P}{P_I^M}\right)^{\beta_1}\ ,\quad P < P_I^M\ , \tag{23}$$

where P_I^M is the manager's investment trigger and $K^M = D(P_I^M)$ is the equilibrium value of debt under the investment policy that maximizes the manager's wealth. In equation (23), manager's option to invest can be shown as the expected present value of manager's net gains. The manager's net gain after investment can be defined as the benefit from compensation, $M^L(P_I^M)$, minus the net cost of investment, $m_1(I - K^M) + PI$. The optimal investment and financing decisions, chosen to maximize manager's wealth, are jointly determined by $\lim_{P \to P_I^M} \frac{\partial MB(P)}{\partial P} = \lim_{P \to P_I^M} \frac{\partial M^L(P)}{\partial P}$ and $R^M \equiv \arg\max_R MB(P_I^M)$. The associated credit spreads[4] (CS) and optimal debt ratios (DR) can thus be defined as: $CS = \frac{R^M}{D\left(P_I^M\right)} - r$ and $DR = \frac{D\left(P_I^M\right)}{D\left(P_I^M\right) + E\left(P_I^M\right)}$.

If the option is granted to the all stakeholders of a firm, value of option to invest of all stakeholders, $FB(P)$, satisfies the following ODE:

$$\frac{1}{2}\sigma^2 P^2 FB_{PP} + (r - \delta)PFB_P - rFB = 0\,, \quad P < P_I^F \tag{26}$$

and $FB(P)$ has the general solution as below

$$FB(P) = q_1 P^{\beta_1} + q_2 P^{\beta_2}\,, \quad P < P_I^F\,.$$

According to the following two boundary conditions: $\lim_{P \downarrow 0} FB(P) < \infty$ and $\lim_{P \uparrow P_I^F} FB(P) = \lim_{P \uparrow P_I^F} F(P) - I - PI$ where $F(P) = D(P) + (1 - m_1)E(P) + M^L(P)$, we have

$$FB(P) = \left(F(P_I^F) - I - PI\right)\left(\frac{P}{P_I^F}\right)^{\beta_1}, \quad P < P_I^F\,. \tag{27}$$

Similarly, in equation (27), all stakeholder's option to invest can be shown as the expected value of stakeholders' net gains. The stakeholders' net gains after investment can be defined as the benefit from compensation, $F(P_I^F)$, minus the net cost of investment, I and the manager's past income, PI.

We then define the agency cost as the proportional value difference of option to invest between the Firm-Best case and the Manager-Best case as

[4] Here we simply assume yield spread of corporate debt is mainly composed of credit spread while ignoring other elements such as liquidity spread or tax spreads.

$$AC = \frac{FB\left(P_I^{F}\right) - FB\left(P_A^{M}\right)}{FB\left(P_A^{E}\right)} \tag{28}$$

where $FB\left(P_I^{F}\right)$ is the value of the option to invest for firm in which abandon and default options are given to shareholders, while investment and financing decisions are given to all stakeholders, and $FB\left(P_I^{M}\right)$ denotes the value of the option to invest for firm where abandon and default options are also given to shareholders, whereas investment and financing decisions are chosen by manager.

3. Numerical Analyses

This section first utilizes some numerical results to scrutinize similarities and differences between the effects of ownership shares compensation and earnings-based compensation on manager's optimal investment timing and financing decisions, optimal debt ratio, credit spread and agency cost. Second, we demonstrate that effects of earnings-based compensation can vary when accompanying various ownership shares. Finally, we report the impacts of a composition of ownership shares and earnings-based bonus compensation when manager's compensation wealth is fixed.[5]

In the following numerical analyses, we employ the base-case parameters, similar to those in Mauer and Sarkar (2005) and Andrikopoulos (2009), as below. The initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30%; the convenience yield of the output price, δ, is 2%; the risk-free rate, r, is 4%; the

[5] Numerical results on effects of past income and reservation income are similar to those of Andrikopoulos (2009). The results for other parameters, e.g: interest rate, bankruptcy costs, volatility, and tax rates etc., are also similar to those of Mauer and Sarkar (2005), and thus are omitted.

corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The past income, PI, and reservation income are the same given by \$1.5; the cash salary per unit time, m_0, is \$0.04; a faction of equity, m_1, is 3%, and a fraction of earnings-based bonus, m_2, is 0.3%.

3.1. The effects of manager's compensation: Ownership shares vs. earnings-based bonus

To investigate the similarities and differences between ownership shares and earnings-based compensation, we compare two special cases: manager is compensated for cash salary and ownership shares (i.e., $m_2 = 0$), and is compensated for cash salary and earnings-based bonus (i.e., $m_1 = 0$).

First of all, we employ Figure 1 to explore the manager's optimal investment decisions where the left panel shows the case of $m_2 = 0$ and the right shows the case of $m_1 = 0$. In view of Figure 1, more ownership shares and earnings-based bonus compensations both make manager starting from investing too late relative to the case of Firm-Best (underinvestment) to investing too early (overinvestment). There is one difference. The optimal investment trigger of manager converges to that of shareholders when manager holds a large fraction of ownership shares. On the other hand, the optimal investment trigger of manager will be lower than that of shareholders when manager is compensated for a large proportion of earnings-based bonus, but doesn't hold any ownership shares. This is because zero debt financing (explained later) and reservation income protection will lead manager to invest earlier than shareholders do.

Figure 2 illustrates manager's optimal financing decisions where the left panel shows the case of $m_2 = 0$ and the right shows the case of $m_1 = 0$. Notice that the Firm- Best financing decision is not related to manager's ownership shares, but is decreasing as manager's earnings-based bonus increases. The optimal financing decision of manager decreases and converges to that of shareholders when manager holds a large fraction of ownership shares. However, manager will not issue any debt to finance the investment when he/she is compensated for earnings-based bonus but doesn't hold any ownership share. The reason details as below. More ownership shares compensation provides an incentive for managers to act more like shareholders to transfer the wealth from debt holders to themselves, provided that investment cost is partially financed by corporate debt, and shareholders are only responsible for limited liability. On the other hand, manager's earnings-based bonus compensation is distributed whenever the firm has positive net profits. This compensation doesn't offer manager any ownership of firm, and thus manager doesn't have any benefit from limit liability of equity. More earnings-based bonus compensation provides manager a stronger inventive not to use any debt to finance the investment, since any coupon payment will reduce firm's net profit and can thus lower down manager's bonus compensation.[6]

In Figure 3, we examine agency costs where the left panel shows the case of $m_2 = 0$ and the right shows the case of $m_1 = 0$. Agency costs of our model result from three reasons: 1) manager's investment decision deviates from the Firm-Best one; 2) manager's financing decision deviates from the Firm-Best one; 3) shareholders' abandonment and bankruptcy decisions deviates from the Firm-Best ones. For the purpose of comparing the agency costs of two cases of $m_2 = 0$ and $m_1 = 0$, we can just employ the first two reasons to explore but ignore the third reason. Both the two cases demonstrate a U-shaped

[6] In this subsection, we omit the analyses of optimal debt ratio and credit spread, since manger does not have any incentive to issue any debt if only compensated for earnings-based bonus and cash salary.

agency cost curve which results from manager's investment decision from underinvestment to overinvestment, and the lowest agency cost occur when manager's optimal investment timing is equal to First-Best's one.[7]

In sum, although manager's optimal investment decisions (Figure 1) and agency costs (Figure 3) of the two cases share the same shapes, manager's financing decisions (Figure 2) of the two cases are significantly different. In particular, the manager who is compensated only for cash salary and earnings-based bonus will not use any debt to finance the investment.

3.2. Optimal investment and financing decisions when manager is compensated for cash salary, ownership shares and earnings-based bonus

In this subsection, we demonstrate how manager's optimal investment and financing decisions vary according to different sizes of accompanying ownership shares compensation. Because manager's earnings-based bonus should not be a larger proportion of a firm's net earnings, we will assume the fraction of the earnings-based bonus ranging from 0.1% to 2.5%. On the other hand, firm's managers may also be a large owner of the firm even he/she is not compensated for a large fraction of ownership shares. We therefore employ the four cases when manager hold zero shares ($m_1 = 0$); hold 3% shares ($m_1 = 0.03$); hold 20% ($m_1 = 0.2$); and hold 50% ($m_1 = 0.5$).

In Figure 4, we investigate manager's optimal investment triggers when $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$ in the range $m_2 \in [0.001, 0.25]$. We first observe that manager will invest too late when manager holds relative small fraction of ownership

7 The lowest agency cost is still positive due to that the optimal abandonment and bankruptcy decisions are determined by shareholders and manager's financing decision is not the same as the firm-Best ones.

shares ($m_1 = 0$ and $m_1 = 0.03$), and will invest too early when manager holds larger fraction of shares ($m_1 = 0.2$ and $m_1 = 0.5$). This is consistent with Mauer and Sarkar (2005) and Andrikopoulos (2009). Second, except for the case that manager does not hold any ownership shares ($m_1 = 0$), manager may tend to defer the investment as m_2 increases. This can be explained as below. When manager holds ownership shares (no matter large or small), he/she will desire to employ debt to partially finance the investment. Then he/she has strong incentives to defer investment since existence of coupon payment will reduce a firm's net profit, thereby lowering down manager's compensation value and deferring to invest. In particular, when manager holds relative small shares ($m_1 = 0.03$ in Figure 4), this deferring investment motive will disappear soon since in the meanwhile manager will no longer have incentive to finance the investment project with debt, i.e., manager's optimal coupon payment becomes zero. Therefore, manager's optimal investment trigger displays a reversed-V shaped. As manager holds a larger fraction of shares ($m_1 = 0.2$ and $m_1 = 0.5$ in Figure 4), manager's debt financing incentive will not completely disappear and thus he/she will defer the investment project. When manager holds larger ownership shares, the optimal investment trigger becomes less sensitive to the fraction of earnings-based bonus compensation. Even in the same range of m_2, manager's investment timings are different for various fractions of ownership share holdings. Manager's optimal investment trigger is decreasing when $m_1 = 0$, is increasing and then decreasing when $m_1 = 0.03$, is increasing when $m_1 = 0.2$, and is insignificantly increasing when $m_1 = 0.5$.

Figure 5 shows manager's optimal financing decisions (coupon payments) when $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$ in the range $m_2 \in [0.001, 0.25]$. As we explained above, manager has no incentive to issue debt to finance the investment project when he/she does not hold any ownership shares ($m_1 = 0$). When manager holds a relative small fraction of ownership shares ($m_1 = 0.03$), manager's incentive to use debt to finance the investment is getting decreasing when m_2 increases but is less than a critical level (0.012 in this case). This decreasing period of manager's optimal financing decision is exactly the same as the increasing period of manager's optimal investment decision (Figure 4). On the other hand, when m_2 increases and is greater than this critical level, manager tends not to employ any debt financing, which is similar to the case when $m_1 = 0$. When manager holds a large fraction of shares ($m_1 = 0.2$), he/she tends to reduce debt issuance as m_2 increases. This debt-reduction incentive becomes less significant when manager hold relative large fraction of shares ($m_2 = 0.5$).

In sum, manager tends to defer investment and meanwhile to reduce debt financing as m_2 increases when he/she holds some fraction of ownership shares. This phenomenon becomes insignificant when manager holds a larger fraction of ownership shares. If the fraction of manager's share holdings is low, manager will tend not to use debt financing soon, and at the same time start making optimal investment earlier as m_2 increases more.

3.3. Agency costs, optimal debt ratios and credit spreads when manager is compensated for cash salary, ownership shares and earnings-based bonus

Figure 6 demonstrates the agency costs where investment and financing decisions are chosen by manager and abandonment and bankruptcy decision are decided by shareholders when $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$ in the range $m_2 \in [0.001, 0.25]$. Even though in the same range, shapes of agency costs are quite different. When $m_1 = 0$, agency costs are significantly decreasing in this range since manager's optimal investment trigger is approaching the Firm-Best one (Figure 4). Although manager's optimal financing decision is moving further away from the Firm-Best one, the impact is dominated by investment decision. When $m_1 = 0.03$, agency costs demonstrate a inversed V-shape which is mainly from the inversed V-shape of manager's optimal investment triggers (Figure 4), and the effect of deviated manager's optimal financing decision is again dominated. Surprisingly, the illustration of agency costs when $m_1 = 0.2$ is U-shaped though insignificant. This is because the difference between manager's optimal investment trigger and Firm-Best one is decreasing (Figure 4), while the difference between manager's optimal financing decision and Firm-Best one remains almost unchanged (Figure 5). When $m_1 = 0.5$, agency costs again become monotonically decreasing but the effect is small. This is due to the speed that manger's optimal investment decision converges to the Firm-Best one is small (Figure 4), while the difference of optimal coupon payment between Manager-Best and Firm-Best again is almost the same (Figure 5).

In Figure 7, we explore the optimal debt ratios where investment and financing decisions are chosen by manager and abandonment and bankruptcy decision are decided by shareholders when $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$ in the range $m_2 \in [0.001, 0.25]$. It can be observed that optimal debt ratios are decreasing as m_2 increases for all cases except that manager has no incentive to use debt financing. The sensitivity of optimal debt ratio to m_2 becomes less significant as m_2 is getting increasing. Figure 8 demonstrates the credit spreads where investment and financing decisions are chosen by manager and abandonment and bankruptcy decision are decided by shareholders when $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$ in the range $m_2 \in [0.001, 0.25]$. Credit spreads are consistently decreasing for all cases. This result is in accordance with the empirical findings of Duru et.al. (2005), asserting that earning-based compensation plays a role in reducing the credit spreads of debt.

3.4. Numerical results when manager's expected compensation wealth is fixed

The manager's wealth is composed of cash salary, ownership shares, and earning-based compensation after the project is initiated. To robustly address our results, we fix the expected managerial wealth ($M^L(P)$) to be \$1.2 to explore the combination of manager's compensation package given cash salary is fixed at \$0.04 while changing ownership shares and earning-based compensation.

Figure 9 investigates manager's optimal investment triggers, optimal debt ratios, credit spreads and agency costs given cash salary is fixed and changing ownership shares and earning-based compensation. All these contracts that yield the same level of expected managerial wealth correspond to varying optimal investment and financing decisions and hence to varying levels of optimal debt ratios, credit spreads and agency costs. For these range of m_1 and m_2, as we increase earning-based compensation, manager's investment trigger (financing decision) is affected by two consistent effects. Increased earning-based compensation induces deferring investment (lowering coupon) and decreased ownership shares also provide the same incentive for investment (financing), thereby leading to the upward (downward)-sloping (downward) line as m_2 increases, m_1 decreases and manager's compensation wealth is fixed. Accordingly, optimal debt ratios and credit spreads are also downward-sloping line as m_2 increases, m_1 decreases and manager's compensation wealth is fixed. Finally, agency costs are a upward-sloping line which results mainly from the upward-sloping line of manager's optimal investment trigger.

4. Conclusion

Earnings-based bonus and stock-based compensations are usually used to align manger’s incentive with shareholders’, but there are few studies to clarify whether these two compensations really offer the same incentives to manager. This paper employs a real-option framework develop by Mauer and Sarkar (2005) to investigate manager’s optimal investment and financing decisions where he/she is compensated for cash salary, ownership shares and earnings-based bonus, and abandonment and bankruptcy decisions are chosen by shareholders.

We find that even though ownership shares and earnings-based bonus provides almost the same incentive for manager’s optimal investment trigger, manager’s optimal financing decision is quite different when the compensation is offered by ownership shares or by earnings-based compensation. Manager compensated for ownership shares provides manager an incentive to issue debt to finance the investment project, whereas earnings-based compensation provides an exactly opposite incentive. Therefore, the optimal leverage ratios, credit spreads and agency costs, when manager is partly compensated for earnings-based bonus, behave dissimilarly when manager is only compensated for cash salary and ownership shares. In particular, Andrikopoulos (2009) showed that credit spreads are increasing as manager is compensated for more ownership shares, while credit spreads are decreasing as manager is compensated for more earnings-based bonus. In addition, the effects of earnings-based compensation on the manager’s investment and financing decisions and agency costs can vary according to different sizes of accompanying ownership shares compensation. We also investigate the effects of earnings-based compensation when the manager’s expected compensation value is fixed and find similar results.

There in one empirical implication. Since ownership shares and earnings-based bonus provide different incentives for manager to make financing decision, researcher should pay more attentions to manager’s compensation composition when analyzing the issue concerning a firm’s capital structure and manager’s compensation (John and John, 1993, Ortiz-Molina, 2007). In this research, only fixed salary, ownership shares and earning-based compensation are included in our analysis, while ignoring the executive stock-option compensation. The natural step to extend the paper is to include executive stock-option and reexamine relevant issues. Finally, our real options model is new market model and it is interesting to investigate the role of earnings-based bonus compensation in a real option model of corporate expansion (Mauer and Ott, 2000 and Kanagaretnam and Sarkar, 2011).

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Figure 1. Manager's Optimal Investment Triggers When $m_1 = 0$ or $m_2 = 0$

In Firm-Best case, the investment decision is made by all stakeholders. In Manager-Best case, the investment decision is made by managers. Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

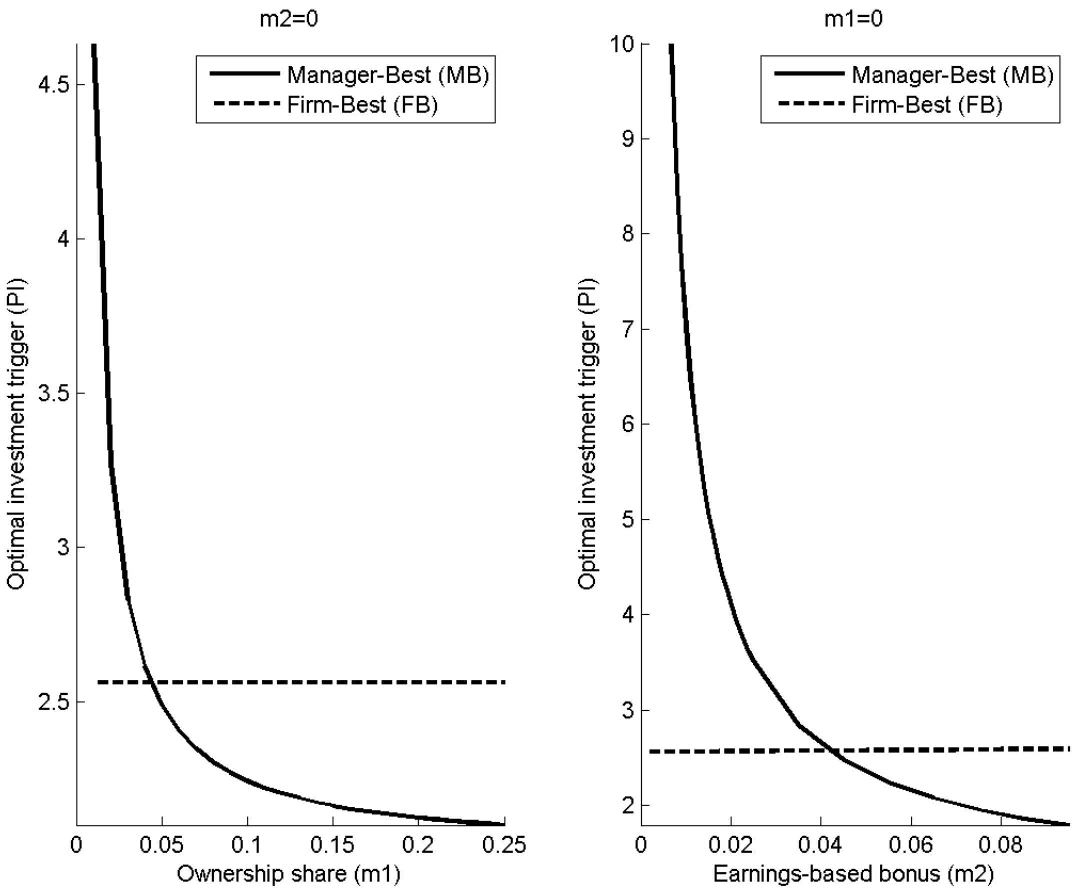

Figure 2. Manager's Optimal Coupon Payments When $m_1 = 0$ or $m_2 = 0$

In Firm-Best case, the financing decision is made by all stakeholders. In Manager-Best case, the financing decision is made by managers. Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

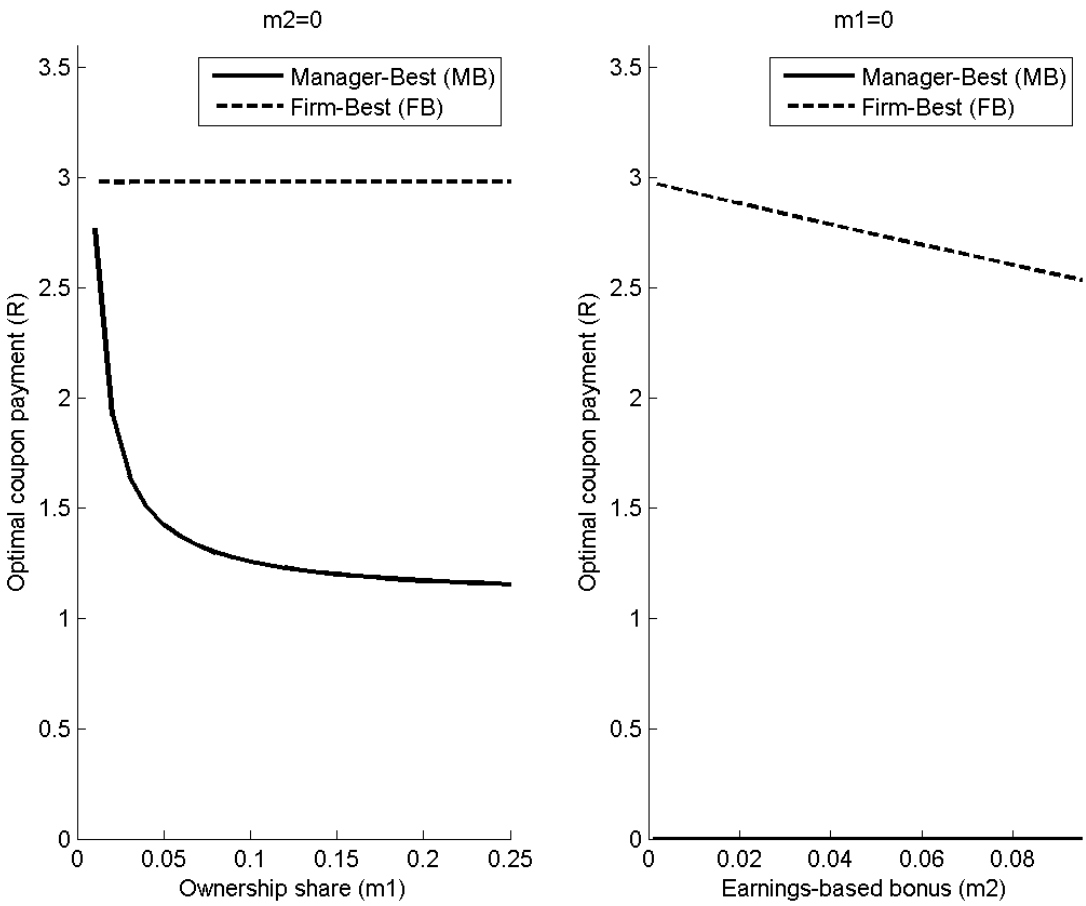

Figure 3. Agency Costs When $m_1 = 0$ or $m_2 = 0$

In Firm-Best case, the investment and financing decisions are made by all stakeholders. In Manager-Best case, the investment and financing decisions are made by managers. In both cases, the abandonment and bankruptcy decisions are chosen by shareholders Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

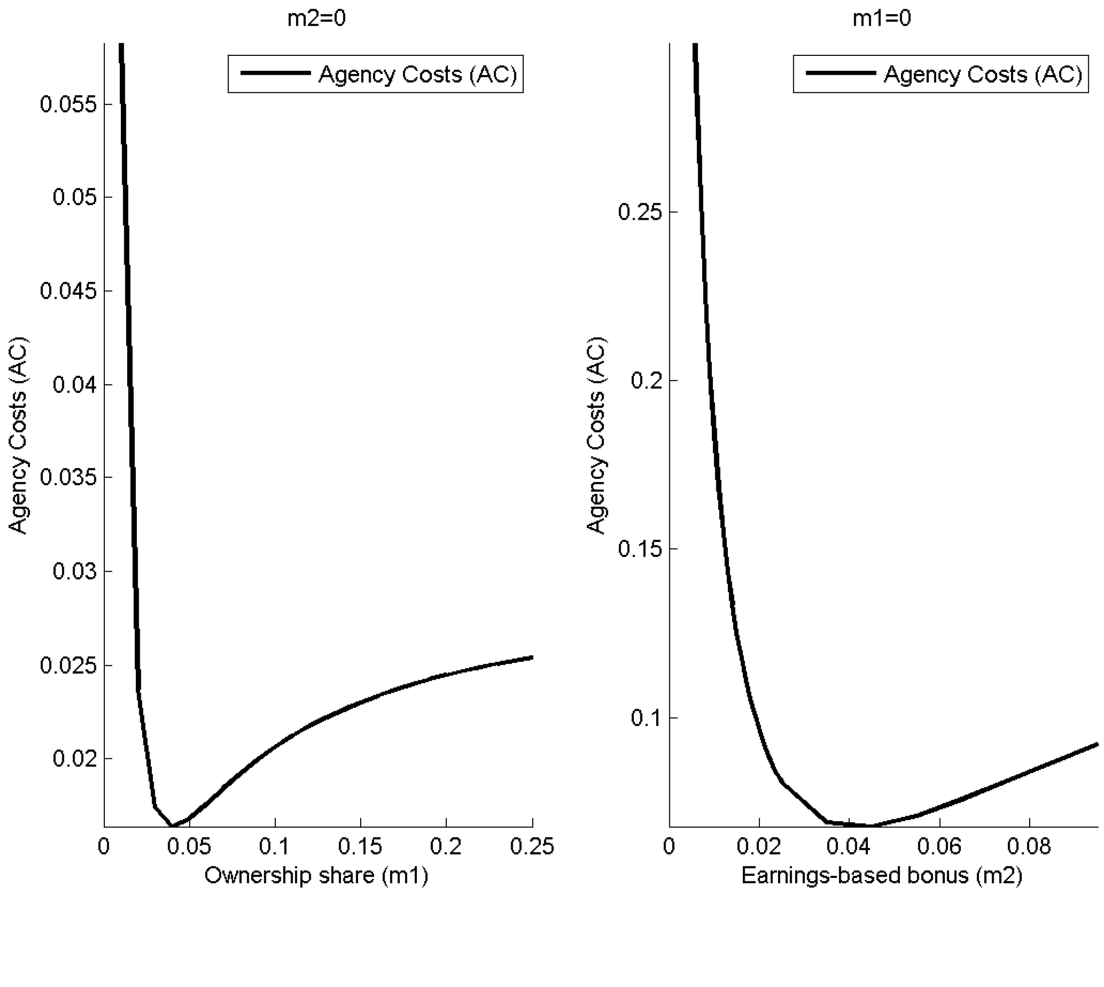

Figure 4. Manager's Optimal Investment Triggers When $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$

In Firm-Best case, the investment decision is made by all stakeholders. In Manager-Best case, the investment decision is made by managers. Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

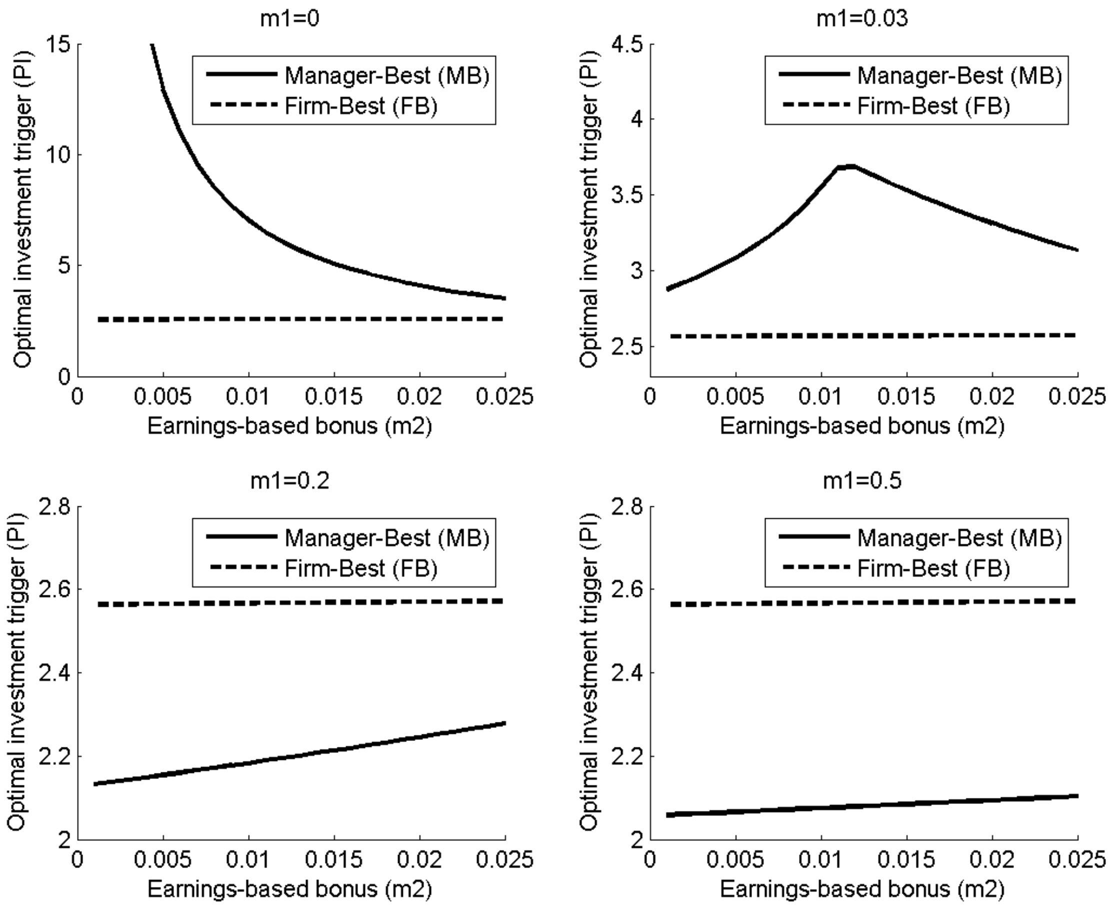

Figure 5. Manager's Optimal Coupon Payments When $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ **and** $m_1 = 0.5$

In Firm-Best case, the financing decision is made by all stakeholders. In Manager-Best case, the financing decision is made by managers. Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

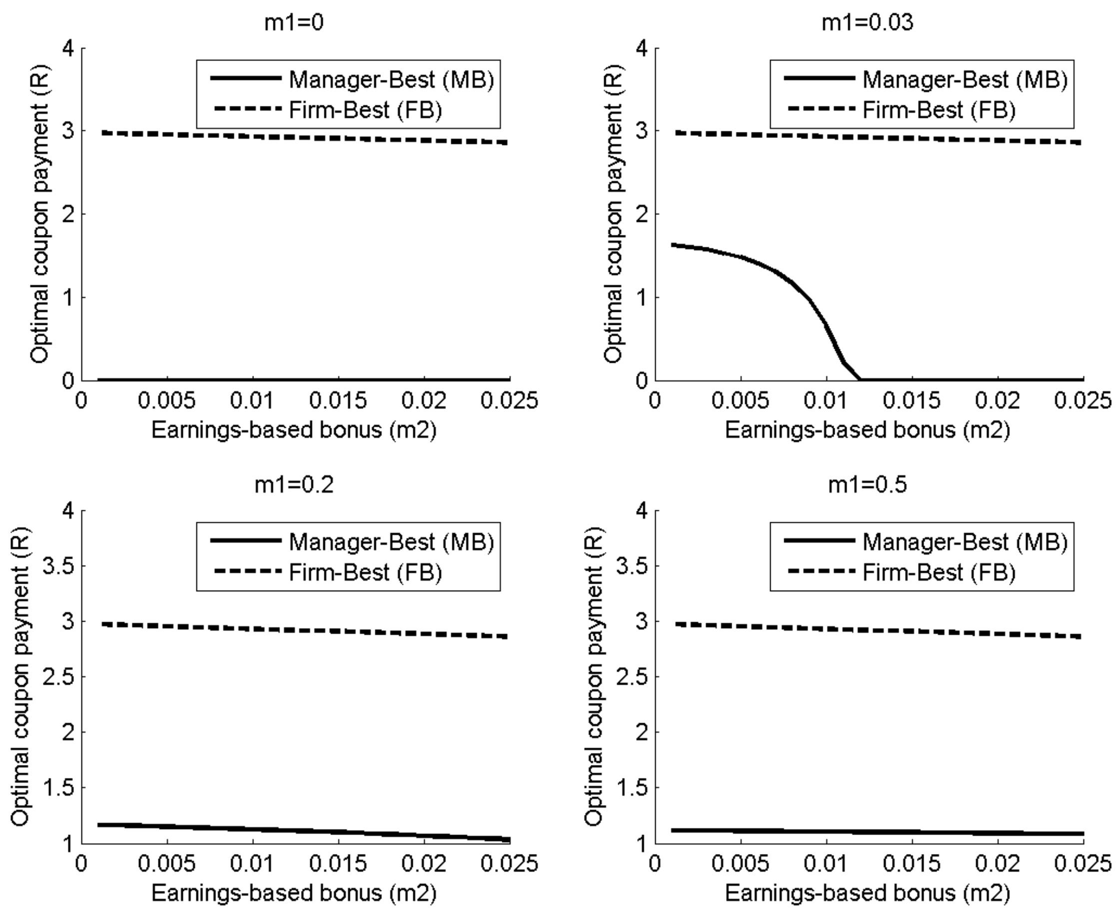

Figure 6. Agency Costs When $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ and $m_1 = 0.5$

In Firm-Best case, the investment and financing decisions are made by all stakeholders. In Manager-Best case, the investment and financing decisions are made by managers. In both cases, the abandonment and bankruptcy decisions are chosen by shareholders Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

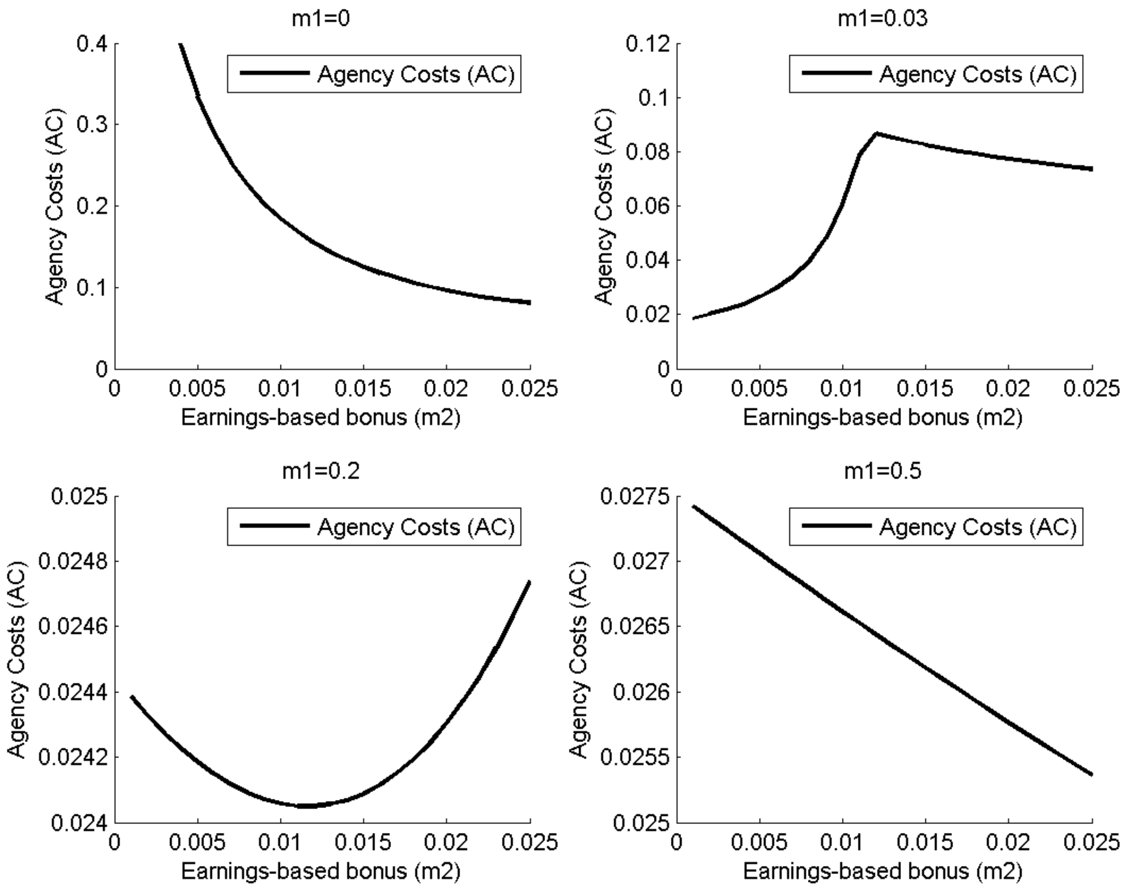

Figure 7. Optimal Debt Ratios When $m_1 = 0$, $m_1 = 0.03$, $m_1 = 0.2$ **and** $m_1 = 0.5$

In Firm-Best case, the investment and financing decisions are made by all stakeholders. In Manager-Best case, the investment and financing decisions are made by managers. In both cases, the abandonment and bankruptcy decisions are chosen by shareholders Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

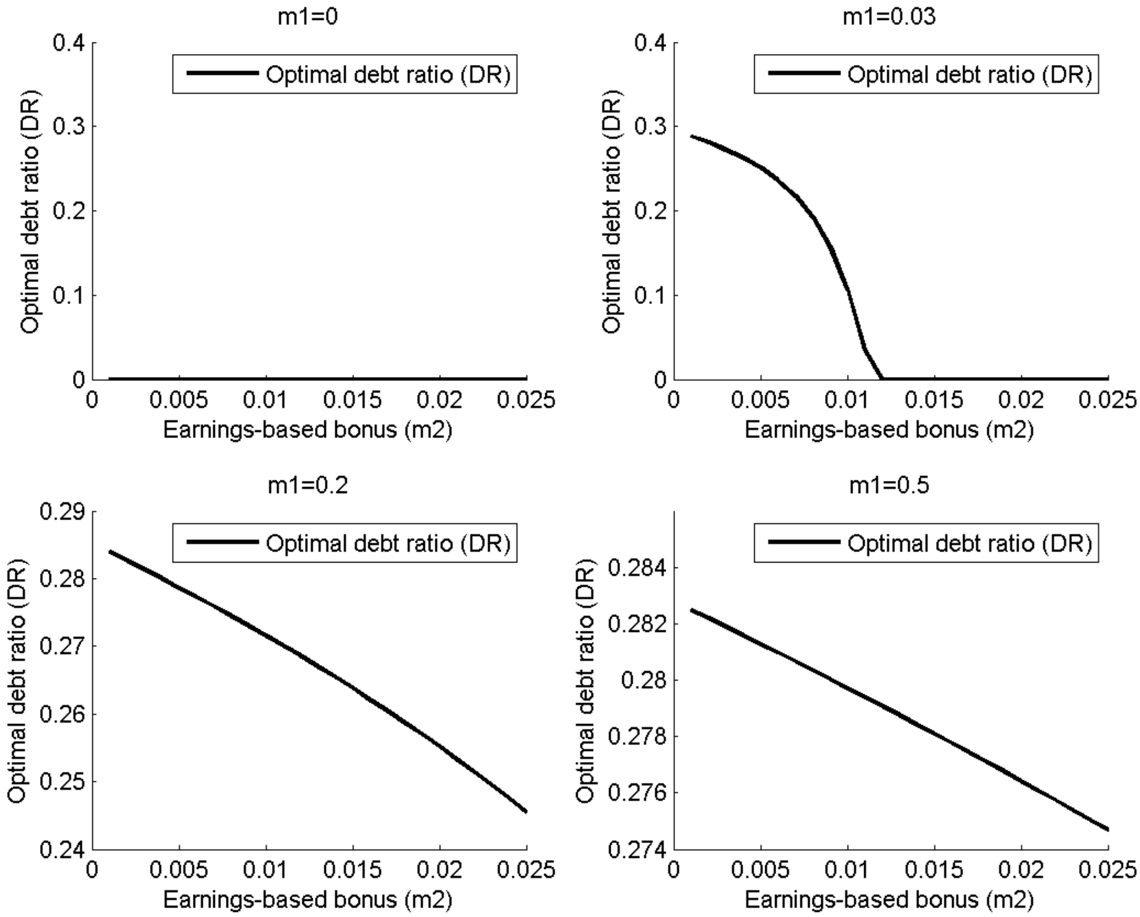

Figure 8. Credit Spreads When $m_1 = 0$**,** $m_1 = 0.03$**,** $m_1 = 0.2$ **and** $m_1 = 0.5$

In Firm-Best case, the investment and financing decisions are made by all stakeholders. In Manager-Best case, the investment and financing decisions are made by managers. In both cases, the abandonment and bankruptcy decisions are chosen by shareholders Parameters of this figure are given as follows: the initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04, where m_1 is a faction of ownership shares and m_2 is a fraction of earnings-based bonus that manager holds.

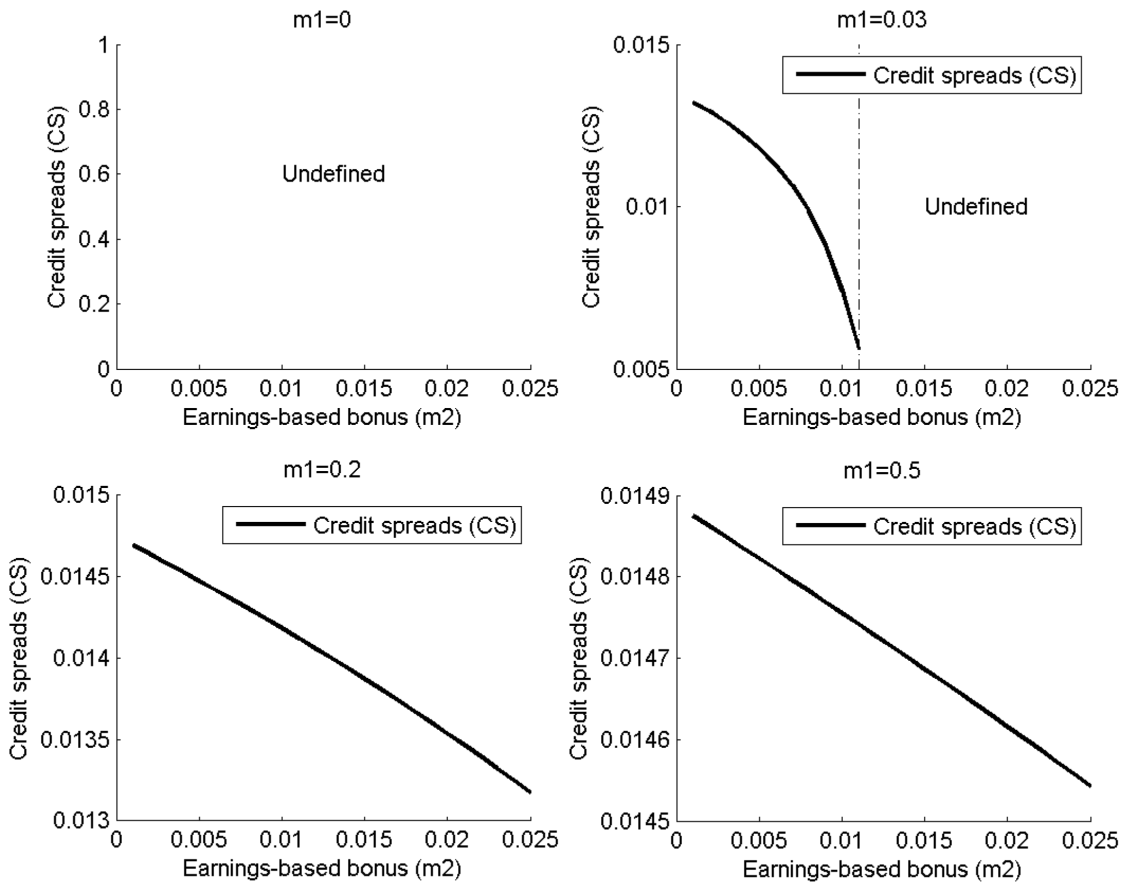

Figure 8. Manager's Optimal Investment Triggers, Optimal Debt Ratios, Credit Spreads and Agency Costs When Manager's Compensation Wealth Is Fixed

We fixed the manager's expected wealth to be \$1.2 and change the combination of ownership shares m_1 and earning-based compensation m_2. The initial output price, P, is \$1.0 per unit; production costs, C, are \$0.75 per unit; the cost of exercising the investment option, I, is \$10; the volatility of the output price, σ, is 30% per year; the convenience yield of the output price, δ, is 2% per year; the risk-free rate, r, is 4% per year; the corporate tax rate, τ, is 20%; and bankruptcy costs, α, are 35% of the value of unlevered assets at the time of bankruptcy. The salary of original job, PI, is \$1.5; the salary of the new job, RI, is \$1.5; the initial cash salary, m_0, is \$0.04.