

**Strategic Interactions in Corporate Finance: A Game-Theoretic Model of the
Principal-Agent Problem**

Yi Lun Li

A Thesis
in
The Department
of
Economics

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Arts (Economics) at
Concordia University
Montreal, Quebec, Canada

March 2026

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CONCORDIA UNIVERSITY
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Jorgen Hansen Chair
Chair's name

Ming Li Supervisor
Supervisor's name

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Abstract

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Yi Lun Li

This study explores the principal-agent problem in corporate finance through a game-theoretic framework, analyzing strategic interactions among shareholders, creditors, and managers. I used a sequential game to model the problem by incorporating asymmetric information and economic environment factors. The model examines managerial incentives, risk-taking behavior, and compensation structures. The findings highlight the impact of incentive misalignment on corporate decision-making and propose an optimized hybrid compensation model. The results offer insights for corporate governance, suggesting strategies to balance the manager, the shareholder and the creditor's interests, ultimately enhancing firm performance and financial stability.

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1 Introduction

In modern enterprises, an important problem worth digging into is the one of incentive misalignment between shareholders, creditors and professional managers, each with distinct objectives and strategies. While shareholders seek to maximize long-term firm value and returns, creditors prioritize financial stability and debt repayment, often opposing excessive risk-taking. Managers, as agents, are responsible for daily operations and strategic decision-making. They receive asymmetric information about external factors derived from their expertise and contribution to the market, yet they are influenced by compensation structures, reputation, and a preference for leisure, which may lead them to act in ways that do not fully align with the interests of shareholders or creditors.

What strategy should the principal employ to incentivize the agent to act in the best interest of the principal? The current tentative consensus is to align the agent's interest with that of the principal. This inquiry is at the heart of the principal-agent problem, a fundamental issue in corporate finance arising from the misalignment of incentives between those who own a business (principals) and those who manage it on their behalf (agents).

To analyze these dynamics with precision, this game-theoretic model simplifies the interaction to three distinct representative players, each embodying the collective interests and strategic options of their respective group. This allows for a structured examination of incentives, strategic choices, and potential governance improvements. This approach is an abstraction from reality, where each of these roles is often distributed among multiple individuals or entities—shareholders can range from institutional investors to retail stockholders, creditors include various banks and bondholders, and management consists of executive teams rather than a single decision-maker. Moreover, many individuals occupy multiple roles simultaneously. However, isolating these three players allows for analytical clarity while preserving the essential tensions of the corporate structure, adding a layer of complexity compared to other research while avoiding the intractability of models involving numerous heterogeneous actors. Lastly, the company's results have been simplified to only two situations and the game, to only one period.

The analysis of this model yields several critical findings. First, it demonstrates that standard equity-based and leveraged compensation structures often encourage excessive risk-taking,

particularly in favorable economic environments, but can lead to value destruction in adverse conditions. Second, the study identifies a persistent "Prisoner's Dilemma" between shareholders and creditors, where rational non-cooperative behavior leads to a suboptimal equilibrium characterized by restrictive covenants and inefficient compensation. Finally, the research proposes a solution in the form of a "Contractual Equilibrium." By utilizing a hybrid compensation model and embedding specific derivatives into debt contracts, the firm can settle on an outcome that Pareto dominates the Nash-Equilibrium outcome while also balancing the competing interests of the manager, the shareholder, and the creditor, ultimately enhancing firm performance and financial stability.

2 Literature Review

Mathematical and game-theoretic frameworks have recently expanded to capture the complexities of multi-principal dynamics in corporate governance. Hu, Ren, and Yang (2015) used these models to explore situations where multiple stakeholders compete for an agent's effort, finding that the "time inconsistency" problem in contract design often prevents principals from enforcing long-term incentives, leading to suboptimal decision-making. Expanding on the structural analysis of these interactions, Zhu (2022) modeled dynamic governance to highlight the role of shareholders, supervisory boards, and regulators, demonstrating how effective oversight mechanisms can mitigate agency conflicts. To address the specific mechanics of these interactions, Hyland, Gutierrez, and Wooldridge (2023) modeled multi-agent systems to focus on how contracts and observable actions influence player behavior, emphasizing the cost of observation. Furthermore, Gan, Han, Wu, and Xu (2024) used Bayesian models to demonstrate how moral hazard and adverse selection constraints must be incorporated into optimal contract design, particularly in environments where agents control information flows.

Despite these theoretical frameworks, empirical evidence suggests that executive compensation structures often incentivize excessive risk-taking behavior due to asymmetric payoff functions. Chesney, Stromberg, Wagner, and Wolff (2020) studied "Asset Vega" and "Asset Delta" during the 2007-2008 financial crisis, demonstrating how CEOs took on additional risk in adverse environments because their compensation packages disproportionately rewarded volatility while shielding them from downside losses. This asymmetry is further analyzed by Edmans and Gabaix (2015) and Garen (1994), who found that severance packages and limited liability protections often

weaken long-term accountability, allowing short-term profits to take precedence over sustainable growth. Mahzoon, Shourideh, and Zetlin-Jones (2023) added to this by finding clear incentives for the strategic manipulation of information, where agents influence contract outcomes by controlling the data principals receive.

Expanding the scope to the firm's financial architecture, research suggests that capital structure serves as a critical tool for managing these agency frictions. Harris and Raviv (1991) established that the choice between debt and equity acts as a strategic response to asymmetric information, where debt disciplines self-interested managers by reducing discretionary cash flow. Supporting this agency cost hypothesis, Margaritis and Psillaki (2010) demonstrated that higher leverage is positively correlated with improved firm efficiency, as the pressure of debt service forces managers to align their actions with shareholder interests. However, Ardalan (2017) challenged these purely functionalist models, arguing for a reconsideration of capital structure that accounts for the diverse social paradigms and stakeholder perspectives that influence how risk and value are perceived.

Clifford W. Smith's (1985) foundational work applies agency theory to analyze the inherent conflicts of interest between stockholders, managers, and creditors, arguing that these tensions diminish firm value and necessitate contractual mechanisms—such as debt covenants and incentive-based compensation—to align stakeholder interests. These conflicts are significantly exacerbated by macroeconomic uncertainty and business cycle fluctuations; notably, Shah (2014) found that short-termism amplifies these misalignments, leading to decisions that prioritize immediate returns and worsen economic volatility through poor capital allocation. To mitigate the impact of such fluctuations, Dogan, Shen, and Aswani (2023) explore the design of adaptive incentives in repeated games with imperfect knowledge as a means to improve alignment during periods of instability. Finally, the introduction of individual risk preferences further complicates this environment, as demonstrated by Chevalier and Ellison (1995), who found that mutual fund managers strategically adjust portfolio risk based on year-to-date performance to maximize personal investment inflows rather than investor returns.

3 Game-Theoretic Modeling of Principal-Agent Problem in Corporate Finance

The principal-agent problem is a fundamental issue in corporate finance, arising from the misalignment of incentives between those who own a business (principals) and those who manage it (agents). In modern enterprises, this problem manifests in the complex interactions between shareholders, creditors, and professional managers. This study addresses this challenge by structuring the interaction as a sequential, non-cooperative game.

The model simplifies the interaction to three distinct players—Shareholders (Principal), Creditors (Lender), and the Manager (Agent)—to maintain analytical clarity while capturing the core strategic tensions. These players make decisions that influence the firm's financial performance, which is further conditioned by an unobservable Economic Environment factor (E). This factor accounts for the complex external forces (macroeconomic conditions, industry competition) that affect firm outcomes.

A critical component of this model is information asymmetry. Only the Manager, through professional expertise, can retrieve and interpret information about the economic environment. The principals (Shareholders and Creditors) lack this privileged insight and must make their decisions based on ex-ante beliefs about expected returns.

The creditor makes its choice with no information, solely based on its speculation on both the shareholder's and manager's strategies. The choice made by the creditor will decide the ceiling of its share of the benefit. The creditor has first claim on the value of the company after the fixed portion of the salary has been paid. The shareholder then makes its choice based on the creditor's choice and its speculation on the shareholder's strategy. The shareholder decides on a compensation package for the manager composed of a fixed salary portion and a share-based portion. The residual claim on the value of the company, the remainder share of the company after paying for the fixed salary and the creditor's portion, is shared among the shareholder and the share-based portion of the manager's compensation. Lastly, the manager decides on its choice between aggressive and conservative knowing the economic environment, the creditor's choice and the shareholder's choice.

Decisions in this game unfold sequentially in four steps:

1. Creditor's Choice: Creditor chooses the level of loan covenants, $d \in \{H, L\}$ (High or Low).
2. Shareholder's Choice: Shareholder designs the compensation, $c \in \{C_3, C_2, C_1, C_0\}$.
3. Environment State Determined: The economic environment is realized as either Good (G) or Bad (B), known only to by Manager at the time of its decision.
4. Manager's Choice: The Manager selects the operational level, $s \in \{A, C\}$ (Aggressive or Conservative), having observed the Environment, Creditor's choice of covenant, and Shareholder choice of compensation.

This model is kept within a static, single-period framework as shown in Figure 14. The firm's available cash value at the end of the period V is determined by the following variables: the cash at the beginning of the period $V_0 = 100$, the Economic Environment $E \in \{G, B\}$ and the Manager's Choice $M \in \{A, C\}$. Unlike short-term interactions, corporate debt agreements and executive compensation structures are generally pre-determined and remain unchanged for years. This static approach allows the model to mirror real-world corporate decision-making, where environmental and financial constraints as well as managerial incentives shape the manager decisions and where the value of the firm is a probabilistic pair of values (V) found in table 1, determined by the environmental factor, the creditor's decision on the covenant level and the manager's choice to use an aggressive or conservative strategy. The value (V) is distributed in full among each stakeholder in a way that is dependant on both the creditor and shareholder's strategy. The solution is found using backward induction.

3.1 Environmental Factor

The economic environment (E) is categorized into two possible states, Good (G) and Bad (B), to represent the spectrum of macroeconomic conditions. The environment state dictates the probability of success for any given operational strategy. Specifically, the probability of achieving a High Profit outcome (V_H) is:

Favorable conditions increase the likelihood of success is set to 0.55 to represent the probability of achieving good results regardless of the strategy being aggressive or conservative.

- In the Good Environment (G): $p_H = 0.55$

Adverse conditions reduce the likelihood of success, even for the same chosen strategy; the probability of success is set to 0.35.

- In the Bad Environment (B): $p_H = 0.35$.

3.2 The Creditor

Creditors represent entities (banks, bondholders) from whom the company has raised debt. Their claim is equivalent to the amount lent plus interest. As their payoff is capped at this pre-determined amount, Creditors are fundamentally risk-averse. Their primary interest is not in maximizing firm value but in prioritizing financial stability and ensuring debt repayment.

Creditor Strategies (d): The Creditor chooses between high or low covenants:

1. High Covenants (H): A restrictive strategy that limits managerial risk-taking, resulting in a lower debt payoff cap $D_{cap} = 85$ consisting of the principal amount and a lower interest.
2. Low Covenants (L): A flexible strategy that allows for higher managerial risk-taking, offering a slightly higher debt payoff cap $D_{cap} = 87$ due to higher interest due to higher risk.

Creditor Utility Function (U_D): Creditors are risk-neutral. Their utility is linear with respect to their payoff $D(V)$.

$$U_D = D(V)$$

3.3 The Shareholder

Shareholders are the residual claimants of the firm. By the nature of their payoff structure—an uncapped claim on all value remaining after debt obligations—they are the group most concerned with the performance of the company and are inherently risk-seeking. Their objective is to maximize long-term firm value and returns.

Shareholder Strategies (C): The Shareholder's strategy involves designing the optimal compensation package $c \in \{C_3, C_2, C_1, C_0\}$ to align the Manager's incentives with their own. These packages are defined by their Fixed Salary (F) components:

- C_3 : Fixed Salary $F = 3$
- C_2 : Fixed Salary $F = 2$
- C_1 : Fixed Salary $F = 1$
- C_0 : Fixed Salary $F = 0$

Each compensation package from C_0 to C_4 represent a compensation structure from C_0 being pure stock-based compensation to C_4 being fixed salary with no added compensation. C_4 , which should be $F = 4$, enough to motivate the manager to accept the position without additional compensation. C_4 has been overlooked for providing no alignment with the shareholder which would lead the manager to always choose the conservative option for the 0.2 boosted utility from leisure.

Each package consists of a Fixed Salary (F) and a Performance Share (α). All packages are constrained such that they satisfy the Manager's Participation Constraint ($\alpha \geq \alpha_{PC}$) to ensure the job is accepted, where α_{PC} represent the threshold under which the manager would not have accepted the position in the first place. The value of the threshold represents the compensation that is equal to the manager's opportunity cost.

Shareholder Utility Function (U_S): Shareholders are risk-neutral. Their utility is linear with respect to their residual payoff $S(V)$.

$$U_S = S(V)$$

3.4 The Manager

The Manager, as the agent, has the authority to make operational decisions and possesses private information about E. However, they do not bear the full consequences of their actions, which is well represented in the classic principal-agent problem.

Manager Utility Function (U_M): The Manager is risk-averse with a utility exponent of 0.8 on its compensation $M(V)$. The Conservative strategy provides an intrinsic utility gain (0.2), representing the benefit of lower effort/leisure.

$$U_M(V, M) = \begin{cases} (M(V))^{0.8} + 0.2. & \text{if } s = C \\ (M(V))^{0.8} & \text{if } s = A \end{cases}$$

Manager participation threshold ($U_{\{res\}}$): The Manager's opportunity cost is defined by a fixed income of 4:

$$U_{res} = (4)^{0.8} \approx 3.031$$

Manager Strategies (M): The Manager chooses one of two strategies:

1. Aggressive (A): A high-risk, high-reward strategy.
2. Conservative (C): A low-risk, low-effort strategy, plus, the manager gets a leisure bonus.

Manager Compensation $M(V)$: The Manager's total compensation consists of a Fixed Salary (F) and a Performance Share component (α):

$$M(V) = F + \alpha(V - D(V) - F)$$

Manager Expected Utility $E(U_M)$: The Manager chooses M^* that maximizes $E[U_M|D, C, E]$.

$$E[U_M] = p_H \cdot U_M(V_H, M) + (1 - p_H) \cdot U_M(V_L, M)$$

3.5 Payoff Waterfall and Priority

The available cash (V) as the end of the period is distributed according to the following priority structure:

1. Manager's Fixed Salary (F): Paid first.
2. Creditor Debt ($D(V)$): Paid from the profit remaining after F, up to the cap D_{cap} .

3. Residual Claimant (Manager Performance and Shareholder): Any remaining profit ($V - F - D_{cap}$) is split between the Manager (share α) and the Shareholder (share $1 - \alpha$).

3.6 Payoff Equations

Creditor Payoff ($S(V)$):

$$D(V) = \min(V - F, D_{cap})$$

Where $D(V)$ is the Creditor's payoff. It's the minimum between the ceiling (D_{cap}) and the business' value after paying for the fixed salary of the manager. The ceiling being 85 or 87 corresponding to high or low covenant being chosen respectively.

Manager Compensation ($M(V)$):

$$M(V) = F + \begin{cases} 0 & \text{if } V - F < D_{cap} \\ \alpha(V - F - D_{cap}). & \text{if } V - F \geq D_{cap} \end{cases}$$

Where $M(V)$ is the manager's compensation being the sum of a fixed salary portion and a share-based compensation portion. The fixed salary, F , is determined by the shareholder, while the stock-based portion is a fraction α of the company's value after paying for the fixed salary and the creditor's payoff, if any.

Shareholder Payoff ($S(V)$):

$$S(V) = \begin{cases} 0 & \text{if } V - F < D_{cap} \\ (1 - \alpha)(V - F - D_{cap}) & \text{if } V - F \geq D_{cap} \end{cases}$$

Where $S(V)$ is the shareholder's payoff. It's calculated from the remainder, if any, of the company's value after paying for the fixed salary and the creditor's payoff. While a portion α of the residual value is distributed to the manager, all the remainder portion, $(1 - \alpha)$, is owned by the shareholder.

Table 1: Firm Profit Outcomes (Probabilities and Values)

| | | Good Economic Environment | | Bad Economic Environment | |
|------------------|--------------|---------------------------|-------|--------------------------|-------|
| | | Probability | Value | Probability | Value |
| High Covenant | Aggressive | 0.55 | 120 | 0.35 | 120 |
| | | 0.45 | 90 | 0.65 | 80 |
| | Conservative | 0.55 | 110 | 0.35 | 110 |
| | | 0.45 | 95 | 0.65 | 90 |
| Low Covenants | Aggressive | 0.55 | 150 | 0.35 | 130 |
| | | 0.45 | 80 | 0.65 | 70 |
| | Conservative | 0.55 | 110 | 0.35 | 110 |
| | | 0.45 | 95 | 0.65 | 90 |

4 Analysis: Backward Induction and Strategic Equilibrium

4.1 Manager's Participation Constraint and Strategy Set

This is a numerical exercise that demonstrates how the Creditor, Manager and Shareholder interaction works. In creating this model, a parameter wage of 4 has been chosen as the manager's opportunity cost in the market. The assumption is that the manager can get this fixed salary in the market if it chooses not to become the company's manager. The parameter 4 has been chosen arbitrarily as its very small compared to the company's final value, and can be used as reference to create different compensation package based on the amount of fixed salary the shareholder chooses. In this game, the shareholder's strategic choice C_i is a fixed pair (F, α) where α must be greater than or equal to the minimum α required for the Manager to accept the job (α_{PC}), where α is the manager's share of the company's residual value after paying for the fixed salary and the creditor's payoff. The compensation set excludes the hypothetical C_4 ($F = 4$) as it fails the incentive requirement. Through the Appendix's Calculation sets as well as figures 6 through 13, by using inequality, the best strategy under any value of α for each combination of C_i (compensation package) and D (covenant level). From there, the following list of equilibrium α for each situation was found. Furthermore, the figures 6 through 13 show the manager's optimal choice in each situation under both good and bad economic environment.

Table 2: Minimum Participation Shares (α_{PC}) by Fixed Salary (F)

| Package | Fixed Salary (F) | α_{PC} for d = H | α_{PC} for d = L |
|---------|------------------|-------------------------|-------------------------|
| C_3 | 3 | 0.05608178 | 0.04328604 |
| C_2 | 2 | 0.12959187 | 0.08950871 |
| C_1 | 1 | 0.19044494 | 0.13780678 |
| C_0 | 0 | 0.24543685 | 0.19717063 |

Manager's Optimal Strategy (s^*): Incentive Constraint

The Manager makes a choice s^* between Aggressive or Conservative :

- Under $d = H$: $s^* = A$ when $E = G$ (for $C_2 - C_0$); $s^* = C$ when $E = G$ (for C_3) and all $E = B$.
- Under $d = L$: $s^* = A$ for all $E = G$ and $E = B$ with pay package $(C_2 - C_0)$. $s^* = C$ when $E = B$ and pay package C_3 is chosen.

If the creditor chooses high covenant, the manager's optimal strategy is to only choose the aggressive strategy when the economic environment is good and a compensation package other than C_3 is chosen. In all other cases where the creditor chooses high covenant, the manager's optimal strategy is to choose the conservative strategy.

If the creditor chooses low covenant, the manager's optimal strategy is to only choose the conservative strategy when the economic environment is bad and the compensation package C_3 is chosen. In all other cases for low covenant, the manager's optimal strategy is to choose the aggressive strategy.

Expected Payoffs and Shareholder's Choice

The following table presents the Expected Payoffs (EP) for the Creditor and Shareholder. These payoffs reflect the raw outcome of the Manager's optimal response without any contractual transfers.

Table 3: Expected Payoffs (EP)

| Covenant Level | Package (c) | $D(V)$ | $S(V)$ | $M(V)$ |
|----------------|-------------|--------|--------|--------|
| High | C_3 | 85.000 | 11.445 | 3.031 |
| | C_2 | 85.000 | 12.838 | 3.031 |
| | C_1 | 85.000 | 12.750 | 3.031 |
| | C_0 | 85.000 | 12.639 | 3.031 |
| Low | C_3 | 85.875 | 19.134 | 3.031 |
| | C_2 | 79.925 | 21.806 | 3.031 |
| | C_1 | 80.475 | 21.038 | 3.031 |
| | C_0 | 81.025 | 19.950 | 3.031 |

Shareholder's Optimal Strategy (c^*):

- Under $d = H$: $c^* = C_2$ ($S(V) = 12.8385$).
- Under $d = L$: $c^* = C_2$ ($S(V) = 21.8063$).

The shareholder's optimal strategy, regardless of the creditor's decision to opt for high or low covenants is to offer the manager with a base salary of 2 and a share of the residual claim on the company's available cash. By doing so, the shareholder has an expected payoff equal to 12.8385 in case of high covenant and 21.8063 in case of low covenant.

Subgame Perfect Nash Equilibrium (SPNE)

The equilibrium of the game without any contractual modification is the SPNE: $d^* = H$ is chosen by the Creditor, anticipating the Shareholder choosing the dominant strategy of $c^* = C_2$. Because $c^* = C_2$ is a dominant of other strategies regardless of the Creditor's decision and assuming the Manager always chooses to maximize its expected utility.

$$\text{SPNE} = (d = H, c = C_2, s^*(E)) \quad \text{with payoffs } (D(V), S(V)) = (85.0000, 12.8385)$$

4.2 Pareto Efficient Solution and Contractual Mechanism

The Pareto Efficient Solution (PES) is the strategy profile ($\mathbf{d} = \mathbf{L}, \mathbf{c} = \mathbf{C}_3$) which yields the highest payoff for the Creditor and a high payoff for the Shareholder, making both parties strictly better off than the SPNE.

Table 4: Expected utility for 3 borrowers under SPNE and PDS

| Outcome | Strategy Profile | $D(V)$ | $S(V)$ | $M(V)$ |
|---------|--|--------|--------|--------|
| SPNE | $\mathbf{d} = \mathbf{H}, \mathbf{c} = \mathbf{C}_2$ | 85.000 | 12.838 | 3.031 |
| PDS | $\mathbf{d} = \mathbf{L}, \mathbf{c} = \mathbf{C}_3$ | 85.875 | 19.134 | 3.031 |

The Efficient Solution is not an equilibrium:

This Pareto Optimal strategy is not subgame perfect equilibrium. If the creditor chooses Low covenant, the shareholder has the incentive to divert to its dominant strategy to increase its payoff from 19.1343 to 21.8063 with no risk since the Shareholder decides after the Creditor and this is defined as a non-repetitive game although making this into a repetitive game would be an insightful thesis of its own. However since the pareto optimal strategy is superior to the SPNE, it would be valuable to find ways to achieve the pareto optimal strategy that is better or equally as good for all players.

Conditions to make Low Covenant Strategy an Equilibrium:

The Creditor's fear is that if they choose $d = L$, the Shareholder will defect to the individually maximizing strategy $c = C_2$, which yields the Creditor only $D(V) = 79.9250$. Let T be a compensation the Shareholder has to pay the Creditor in case of a divergence from C_3 . The minimum compensation required for the Creditor to agree to $d = L$ is $T = 85.0000 - 79.9250 = 5.0750$.

We can introduce a contractual transfer from the Shareholder to the Creditor as a penalty for when the Shareholder deviate from C_3 (i.e., C_0, C_1, C_2). The transfer's existence insures the Creditor's optimal choice is $d=L$.

Table 5: Adjusted Subgame Expected Payoffs (SEP) with Contractual Transfer

The transfer $T = 5.0750$ is applied to $d = L$ outcomes for C_0, C_1 , and C_2 .

| Covenant Level (d) | Package (c) | $D(V)$ | $S(V)$ | $M(V)$ |
|--------------------|-------------|-----------------------|------------------------|--------|
| High | C_3 | 85.000 | 11.445 | 3.031 |
| | C_2 | 85.000 | 12.838 | 3.031 |
| | C_1 | 85.000 | 12.750 | 3.031 |
| | C_0 | 85.000 | 12.639 | 3.031 |
| Low | C_3 | 85.875 | 19.134 | 3.031 |
| | C_2 | $79.925 + T = 85.000$ | $21.806 - T = 16.731$ | 3.031 |
| | C_1 | $80.475 + T = 85.550$ | $21.038 - T = 15.9625$ | 3.031 |
| | C_0 | $81.025 + T = 86.100$ | $19.950 - T = 14.875$ | 3.031 |

Contractual Equilibrium (SPNE^{**}):

The contractual mechanism fundamentally shifts the Shareholder's optimal choice and stabilizes the efficient outcome.

Shareholder's New Optimal Strategy (c) under $d = L$:** The Shareholder compares the net payoff under $d = L$: $C_3(19.1343)$ vs. $C_2(16.7313)$ vs. $C_1(15.9625)$ vs. $C_0(14.8753)$. The Shareholder's new optimal package is $c^{**} = C_3$.

Creditor's New Optimal Strategy (d):** The Creditor compares $E[D(V|d = H)] = 85.0000$ versus $E[D(V | d = L, c^{**} = C_3)] = 85.8750$. The Creditor chooses $d^{**} = L$.

The SPNE equilibrium is the Pareto Dominating Solution:

$$\text{SPNE}^{**} = (d = L, c = C_3, s^*(E)) \quad \text{with payoffs } D(V), S(V) = (85.8750, 19.1343)$$

5 Contractual Transfer Analysis and Realistic Application

The analysis in Section 4.2 demonstrates the theoretical utility of an expected value transfer T to stabilize the Pareto-efficient outcome. However, there are difficulties in implementing it in a real-world application.

The core issue is that the transfer $T = 5.0750$ is only possible if the Shareholder's realized payoff is greater than or equal to T . The Creditor's expected payoff $D(V)$ drops in the defection scenarios

(e.g., $d = L, C_2$) precisely because of the high probability of low-profit states (e.g., $V_L = 70$ in the Bad Environment). In these states, the firm's profit is insufficient to cover the Creditor's cap, resulting in a Shareholder payoff $S(V) = 0$. If the Shareholder has no payoff, they cannot pay the transfer T . The Creditor, anticipating this, recognizes the simple transfer as a non-credible commitment.

As a result, a more feasible mechanism to transfer this value is required, one that is state-contingent. This can be achieved through embedded derivatives in the Creditor's debt contract.

A way to approach this contractual transfer is by embedding a derivative (such as a warrant or equity kicker) in the Creditor's contract that is exercisable only if the Shareholder chooses a compensation package other than the mutually beneficial C_3 . This mechanism acts as an ex-ante deterrent to the Shareholder's strategic defection.

Upon exercise, this derivative would grant the Creditor a share, θ , of the Shareholder's residual profit stream. The new payoff waterfall in this defection scenario (where $C \neq C_3$) would be:

Manager (Fixed): F

Creditor (Debt): $D(V) = \min(V - F, D_{cap})$

Manager (Performance): $\alpha(V - F - D_{cap})$

Creditor (Derivative Payoff): $\theta(1 - \alpha)(V - F - D_{cap})$

Shareholder (Net Residual): $(1 - \theta)(1 - \alpha)(V - F - D_{cap})$

The goal is to find a θ that, when applied to the non-cooperative packages (C_2, C_1, C_0) under $d = L$, guarantees the Creditor an expected total payoff of at least their SPNE baseline of 85.0000. This value transfer compensates the Creditor for the risk of insolvency in the low-profit states.

For this specific game, $\theta = 0.2327$ is the minimum required value to make $d = L$ the optimal outcome against all defection strategies.

By embedding this "defection penalty" into the debt contract, the Creditor is insured against the Shareholder's moral hazard. The Shareholder, now facing a significant loss of their residual claim (θ) if they defect to C_2 , will find it optimal to choose the cooperative package C_3 . This mechanism design successfully re-aligns the Shareholder's incentives, making the efficient Contractual Equilibrium (*SPNE***) stable.

6 Conclusion

In this study, I set up a game to provide an in-depth analysis of the strategic interactions among shareholders, creditors, and professional managers within a firm using a game-theoretic framework. By modeling their decision-making processes under different environmental conditions. Multiple incentives and constraints imposed by the creditor and the shareholder shape the manager's behavior and ultimately determine the equilibrium outcomes. The results offer significant insights into the design of compensation. Although the result is highly dependent on the values and the utility functions of each player, the results from the above analysis can provide guidance on one of many possible scenarios. As an example, in the analysis, the exponent of 0.8 on the manager's utility function is set to reflect the preferences of a slightly risk averse manager. This constant could be altered to anything greater or equal to 0 to represent different preferences, however 0 being a preference that is indifferent of the income and only values the added utility from leisure and 1 or greater being a preference that is risk neutral to risk loving are not common preferences regarding income. Variations in the chosen constants have the potential to impact the results and analyses. For example, the impact of picking a value different from 0.8 would be a shift to a more aggressive or passive strategy moving the inflexion points 6 through 13 to the right for values higher than 0.8 and to the left for values lower than 0.8.

The game theoretic model demonstrates that the decisions of shareholders, creditors, and managers are deeply intertwined, each affecting the potential payoffs and risks for the others. A key insight is that the compensation package decided by the shareholder plays a crucial role in shaping managerial behavior. When creditors enforce high covenants, they effectively limit the firm's risk-taking potential, leading to more conservative managerial decisions and reduced profit variability. Conversely, low covenants allow for greater managerial flexibility but also introduce the

possibility of excessive risk-taking, which, while potentially rewarding for the shareholder and the manager, increases default risk for creditors.

This game highlights stock-based and leveraged compensation structures encourage risk-taking, as managers stand to benefit disproportionately from successful high-risk projects. The model shows that in a good economic environment, a riskier compensation structure can be beneficial for shareholders and even for managers themselves. However, in a poor economic environment, such incentives may lead to aggressive strategies that can harm the firm's financial stability potentially leading to default on debt and bankruptcy of the company on extreme cases. Fixed salary-based compensation package on the other hand tends to incentivize managers toward risk-averse strategies, aligning them more closely with creditors' interests.

The results of the game theoretical analysis offer several recommendations for corporate governance and financial policy. First, the findings emphasize the importance of designing an optimal managerial compensation package that aligns the interest of the manager better with that of the shareholder. Another conclusion from the game is that aligning the manager's interest with that of the shareholder might not be optimal. In the game above, the pareto optimal solution, although it is not SPNE, the shareholder has incentive to defer from C_3 . It provides a better potential payoff for both the shareholder and the creditor under an unknown economic condition.

The findings emphasize the importance of designing an optimal managerial compensation package that aligns with both shareholder and creditor interests. A hybrid approach—incorporating a balanced mix of fixed salary, stock-based incentives, and performance-linked bonuses—can help mitigate extreme risk-taking while still motivating managerial effort. To further examine the manager's strategy and the shareholder's optimal strategy among infinitely many compensation packages, it would be helpful to fix the Creditor's strategy. By doing so, it would simplify the game by examining 2 two players subgames where the Creditor has already chosen its strategy.

The principal-agent problem remains a fundamental challenge in corporate finance, especially in the complex dynamics among shareholders, creditors, and managers. By applying game theory, this study has provided valuable insights into how incentives, constraints, and asymmetric information shape decision-making in modern enterprises. While perfect alignment of interests may be unattainable or too costly, carefully structured compensation mechanisms, dynamic

covenant requirements, and diversified strategy and economic environment can significantly improve corporate governance outcomes. As financial markets continue to evolve, further research in this domain will be crucial to develop more effective and generalized strategies for solving the principal-agent conflict in the business environment. In future research in this field, modifying the game to become a repetitive game or doing analysis using more real-life data can be beneficial in getting closer to reality, potentially yielding more conclusive and generalized results.

7 Use of Generative AI and AI-assisted tools

During the preparation of this thesis, Generative AI was employed as an assistive tool to enhance the clarity and organization of the research. Its use was primarily focused on streamlining the presentation of conceptual ideas, formatting the formal game-theoretic setting, and structuring the systematic presentation of quantitative calculations and analytical findings. The underlying economic model, all numerical computations, and the final interpretations and conclusions are the original work of the author. The author has reviewed, edited, and validated all AI-assisted content and takes full responsibility for the final integrity and arguments presented in this thesis.

8 Appendix

Calculation set 1: Manager's payoff functions

The manager's payoff functions are according to the shareholder's strategy as below:

$$\begin{aligned}
 M(V) &= 0.24543685 * (V - F - D) & F= 0, \text{ high covenant} \\
 M(V) &= 0.19717063 * (V - F - D) & F = 0, \text{ low covenant} \\
 M(V) &= M_{fixed} + 0.19044494 * (V - F - D) & F = 1, \text{ high covenant} \\
 M(V) &= M_{fixed} + 0.13780678 * (V - F - D) & F = 1, \text{ low covenant} \\
 M(V) &= M_{fixed} + 0.12959187 * (V - F - D) & F = 2, \text{ high covenant} \\
 M(V) &= M_{fixed} + 0.08950871 * (V - F - D) & F = 2, \text{ low covenant} \\
 M(V) &= M_{fixed} + 0.05608178 * (V - F - D) & F= 3, \text{ high covenant} \\
 M(V) &= M_{fixed} + 0.04328604 * (V - F - D) & F = 3, \text{ low covenant}
 \end{aligned}$$

The shareholder received all the residual value, therefore:

$$S(V) = V - D(V) - M(V) \quad \text{which is always true.}$$

Calculation Set 2: Salary = 0

High Covenants

Good Economic Environment

$$0.55 * (35x)^{0.8} + 0.45 * (5x)^{0.8} = 0.55 * (25x)^{0.8} + 0.45 * (10x)^{0.8} + 0.2$$

$$x = 0.130075$$

Bad Economic Environment

$$0.35 * (35x)^{0.8} = 0.35 * (25x)^{0.8} + 0.65 * (5x)^{0.8} + 0.2$$

$$x = \emptyset$$

Low Covenants

Good Economic Environment

$$0.55 * (63x)^{0.8} = 0.55 * (33x)^{0.8} + 0.45 * (3x)^{0.8} + 0.2$$

$$x = 0.0177692$$

Bad Economic Environment

$$0.35 * (43x)^{0.8} = 0.35 * (23x)^{0.8} + 0.65 * (3x)^{0.8} + 0.2$$

$$x = 0.103459$$

High Covenant

$$U(x) = \begin{cases} 0 \leq x \leq 0.130075, \\ 0.130075 < x \leq 1, \end{cases}$$

Low Covenant

$$U(x) = \begin{cases} 0 \leq x \leq 0.0177692, \\ 0.0177692 < x \leq 0.103459, \\ 0.103459 \leq x \leq 1, \end{cases}$$

$$\begin{aligned}
 & \frac{0.45 * (10x)^{0.8} + 0.9 * (25x)^{0.8} + 0.65 * (5x)^{0.8} + 0.4}{2} \\
 & \frac{0.55 * (35x)^{0.8} + 0.35 * (25x)^{0.8} + 1.1 * (5x)^{0.8} + 0.2}{2} \\
 & \frac{0.55 * (33x)^{0.8} + 0.35 * (23x)^{0.8} + 1.1 * (3x)^{0.8} + 0.4}{2} \\
 & \frac{0.55 * (63x)^{0.8} + 0.35 * (23x)^{0.8} + 0.65 * (3x)^{0.8} + 0.2}{2} \\
 & \frac{0.55 * (63x)^{0.8} + 0.35 * (43x)^{0.8}}{2}
 \end{aligned}$$

Figure 6: Salary = 0, High Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,C) under (G,B) environment respectively.

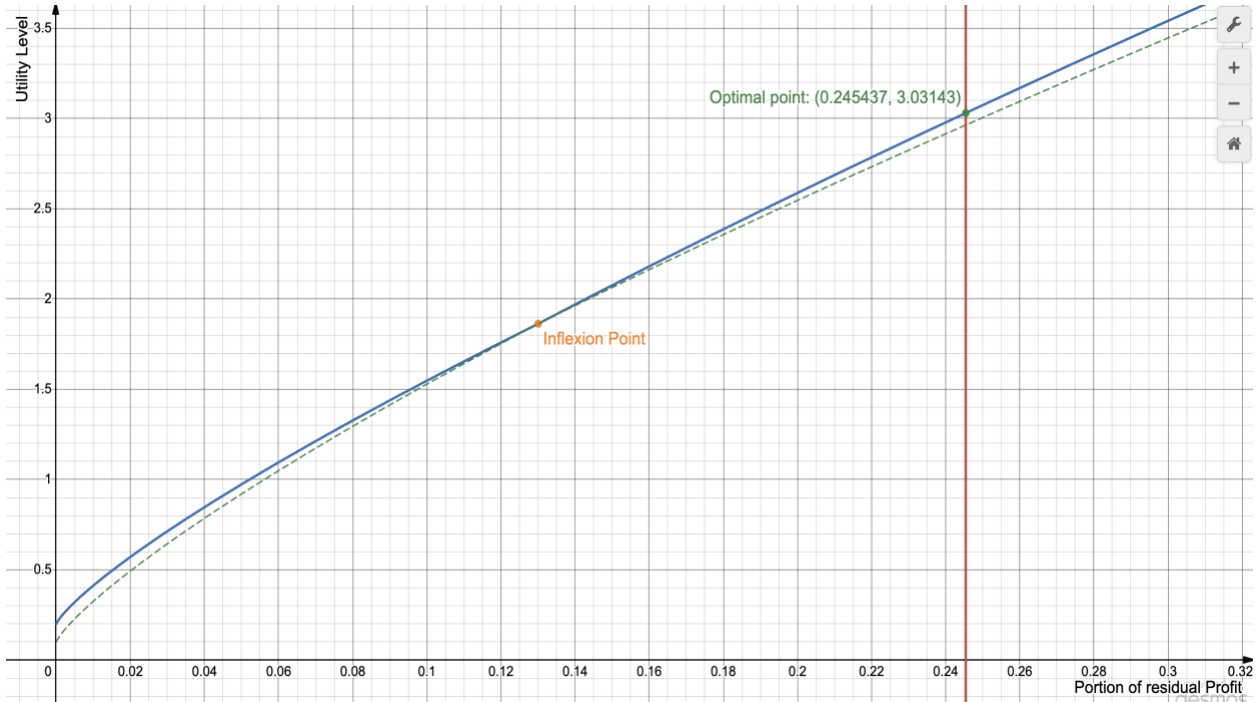
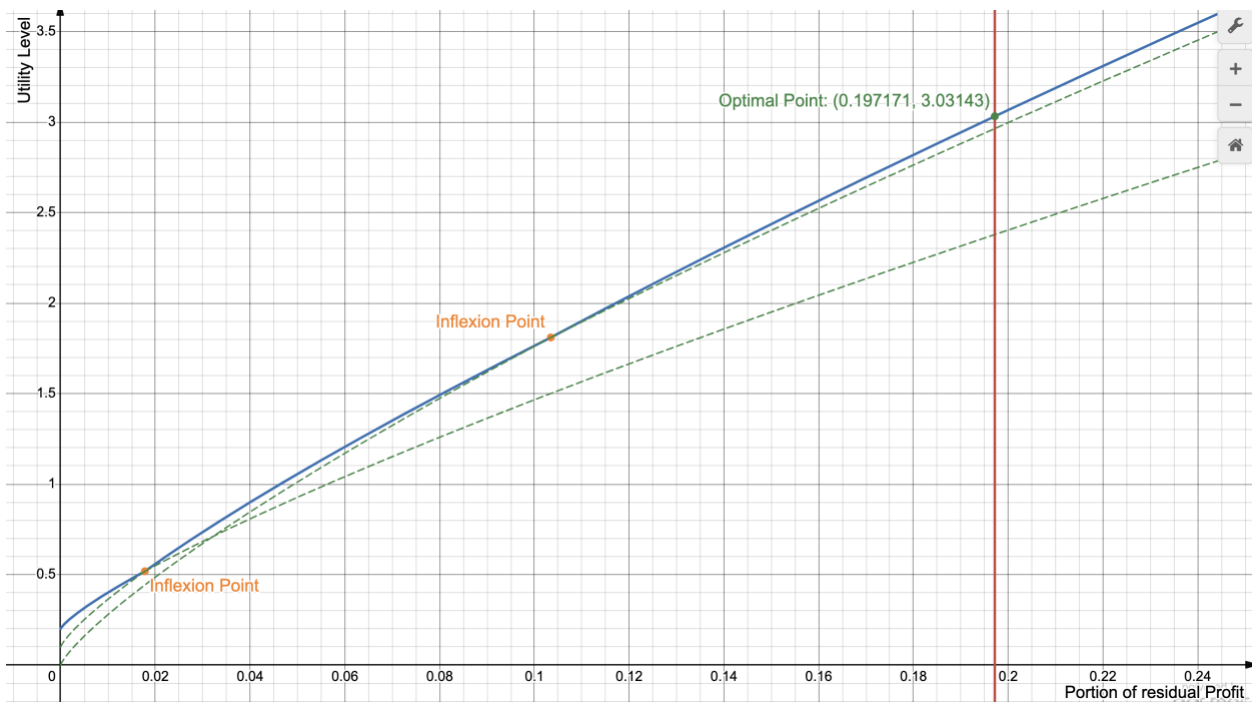


Figure 7: Salary = 0, Low Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,A) under (G,B) environment respectively



Calculation Set 3: Salary = 1

High Covenants

Good Economic Environment

$$0.55 * (34x + 1)^{0.8} + 0.45 * (4x + 1)^{0.8} = 0.55 * (24x + 1)^{0.8} + 0.45 * (9x + 1)^{0.8} + 0.2$$

$$x = 0.120955$$

Bad Economic Environment

$$0.35 * (34x + 1)^{0.8} + 0.65 = 0.35 * (24x + 1)^{0.8} + 0.65 * (4x + 1)^{0.8} + 0.2$$

$$x = \emptyset$$

Low Covenants

Good Economic Environment

$$0.55 * (62x + 1)^{0.8} + 0.45 = 0.55 * (32x + 1)^{0.8} + 0.45 * (2x + 1)^{0.8} + 0.2$$

$$x = 0.018257$$

Bad Economic Environment

$$0.35 * (42x + 1)^{0.8} + 0.65 = 0.35 * (22x + 1)^{0.8} + 0.65 * (2x + 1)^{0.8} + 0.2$$

$$x = 0.056612$$

High Covenants

$$U(x) = \begin{cases} 0 \leq x \leq 0.120955, \\ 0.120955 < x \leq 1, \end{cases}$$

$$\frac{0.9 * (24x + 1)^{0.8} + 0.45 * (9x + 1)^{0.8} + 0.65 * (4x + 1)^{0.8} + 0.4}{2}$$

$$\frac{0.55 * (34x + 1)^{0.8} + 0.35 * (24x + 1)^{0.8} + 1.1 * (4x + 1)^{0.8} + 0.2}{2}$$

$$\frac{0.55 * (32x + 1)^{0.8} + 0.35 * (22x + 1)^{0.8} + 1.1 * (2x + 1)^{0.8} + 0.4}{2}$$

$$\frac{0.55 * (62x + 1)^{0.8} + 0.35 * (22x + 1)^{0.8} + 0.65 * (2x + 1)^{0.8} + 0.65}{2}$$

$$\frac{0.55 * (62x + 1)^{0.8} + 0.35 * (42x + 1)^{0.8} + 1.1}{2}$$

Low Covenants

$$U(x) = \begin{cases} 0 \leq x \leq 0.018257, \\ 0.018257 < x \leq 0.056612, \\ 0.056612 < x \leq 1, \end{cases}$$

Figure 8: Salary = 1, High Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,C) under (G,B) environment respectively

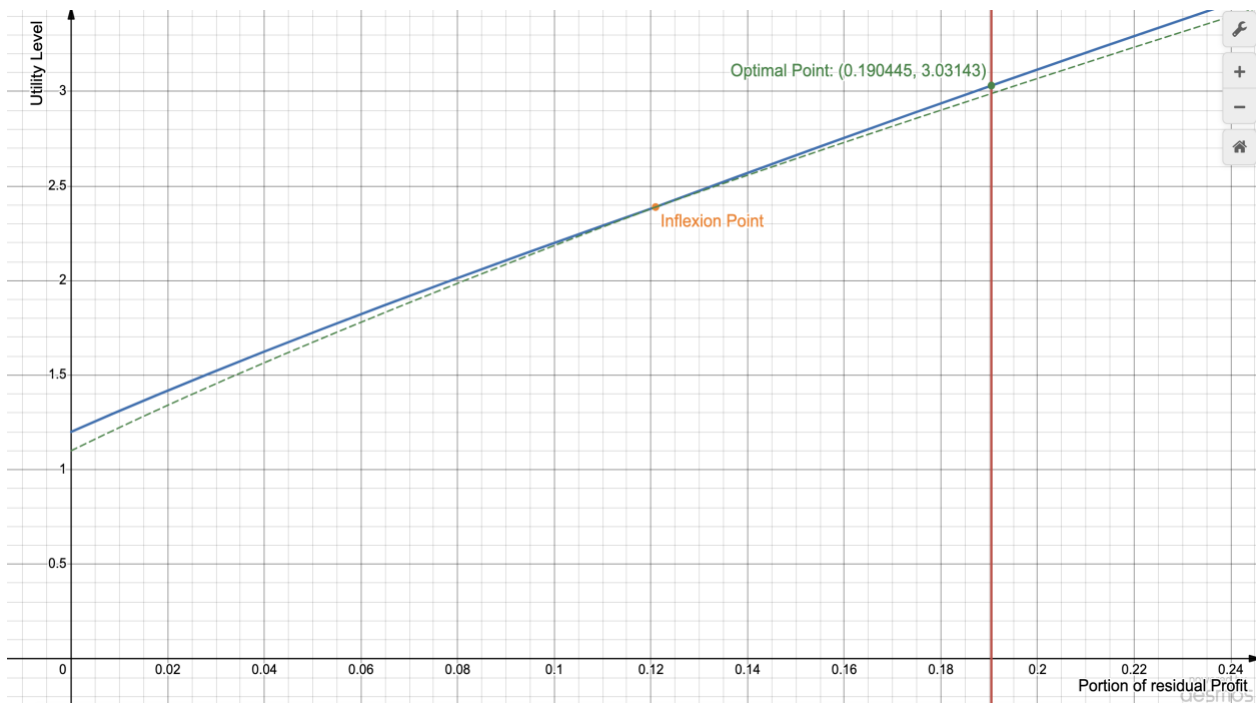
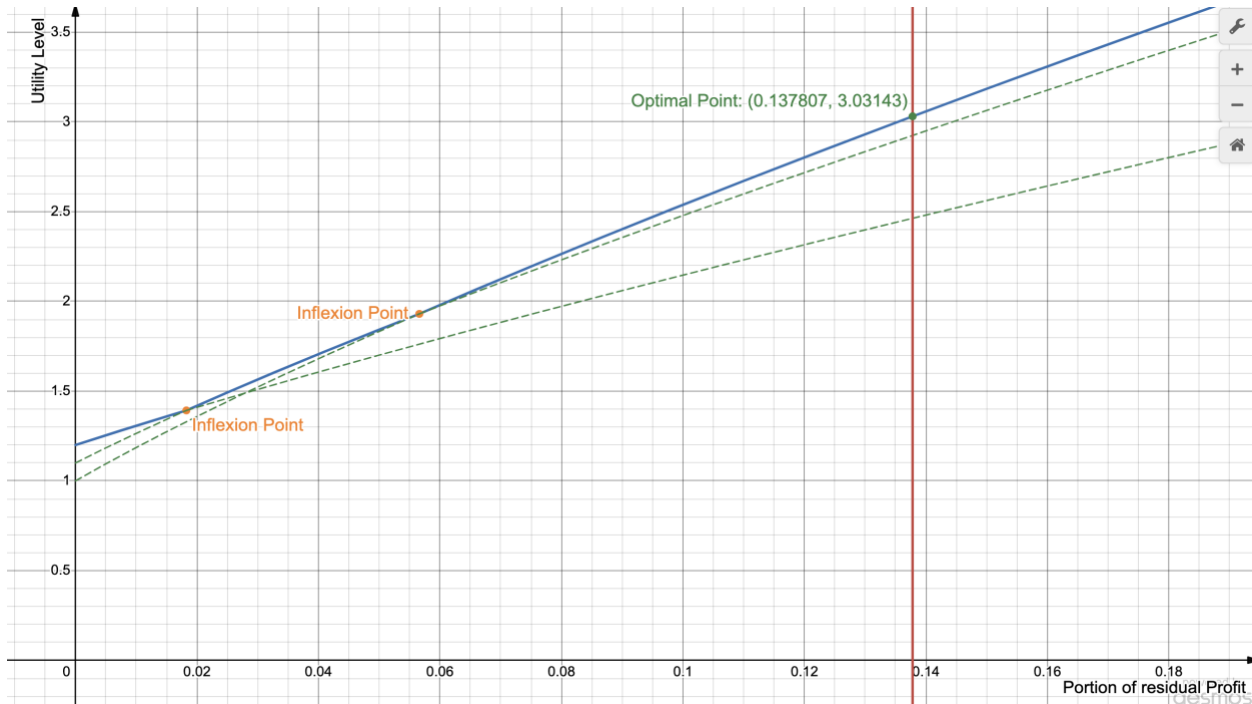


Figure 9: Salary = 1, Low Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,A) under (G,B) environment respectively



Calculation Set 4: Salary = 2

High Covenants

Good Economic Environment

$$0.55 * (33x + 2)^{0.8} + 0.45 * (3x + 2)^{0.8} = 0.55 * (23x + 2)^{0.8} + 0.45 * (8x + 2)^{0.8} + 0.2$$

$$x = 0.120086$$

Bad Economic Environment

$$0.35 * (33x + 2)^{0.8} + 0.65 * 2^{0.8} = 0.35 * (23x + 2)^{0.8} + 0.65 * (3x + 2)^{0.8} + 0.2$$

$$x = \emptyset$$

Low Covenants

Good Economic Environment

$$0.55 * (61x + 2)^{0.8} + 0.45 * 2^{0.8} = 0.55 * (31x + 2)^{0.8} + 0.45 * (x + 2)^{0.8} + 0.2$$

$$x = 0.0192885$$

Bad Economic Environment

$$0.35 * (41x + 2)^{0.8} + 0.65 * (2)^{0.8} = 0.35 * (21x + 2)^{0.8} + 0.65 * (x + 2)^{0.8} + 0.2$$

$$x = 0.051444$$

High Covenants

$$U(x) = \begin{cases} 0 \leq x \leq 0.120086, & \frac{0.9 * (23x + 2)^{0.8} + 0.45 * (8x + 2)^{0.8} + 0.65 * (3x + 2)^{0.8} + 0.4}{2} \\ 0.120086 < x \leq 1, & \frac{0.55 * (33x + 2)^{0.8} + 0.35 * (23x + 2)^{0.8} + 1.1 * (3x + 2)^{0.8} + 0.2}{2} \end{cases}$$

Low Covenants

$$U(x) = \begin{cases} 0 \leq x \leq 0.0192885, & \frac{0.55 * (31x + 2)^{0.8} + 0.35 * (21x + 2)^{0.8} + 1.1 * (x + 2)^{0.8} + 0.4}{2} \\ 0.0192885 < x \leq 0.051444, & \frac{0.55 * (61x + 2)^{0.8} + 0.45 * 2^{0.8} + 0.35 * (21x + 2)^{0.8} + 0.65 * (x + 2)^{0.8} + 0.2}{2} \\ 0.051444 < x \leq 1, & \frac{0.55 * (61x + 2)^{0.8} + 1.1 * 2^{0.8} + 0.35 * (41x + 2)^{0.8}}{2} \end{cases}$$

Figure 10: Salary = 2, High Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,C) under (G,B) environment respectively

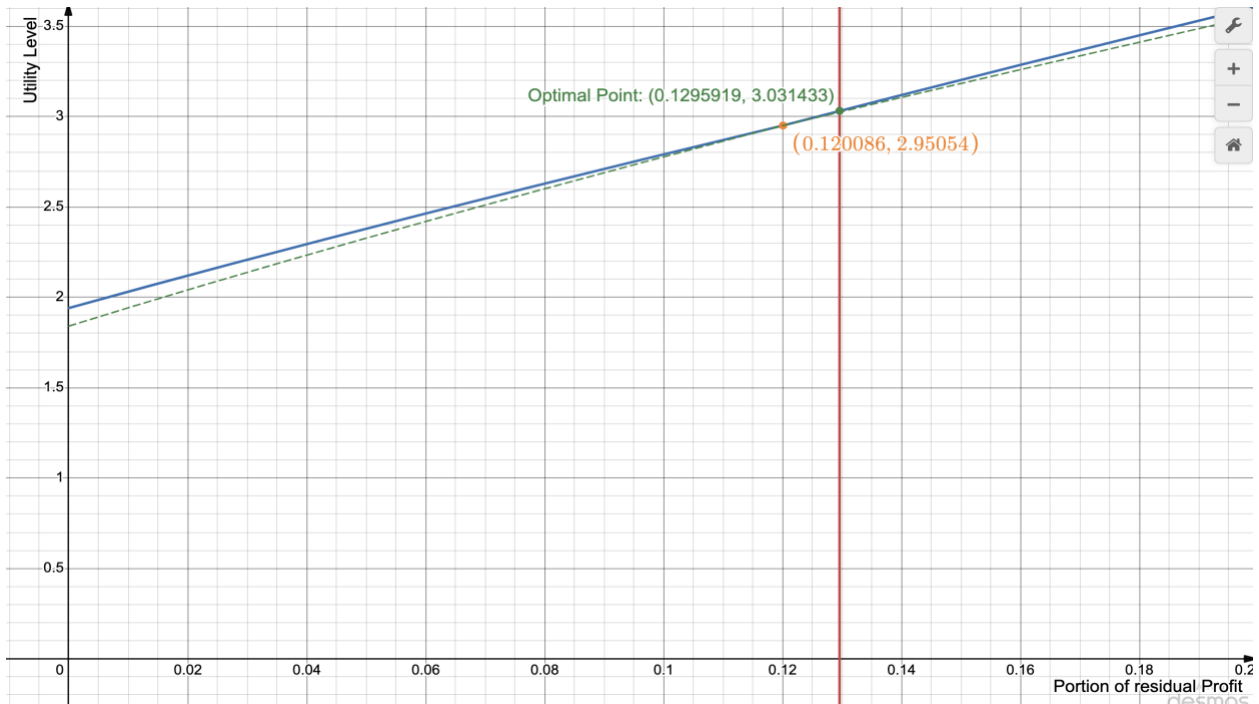
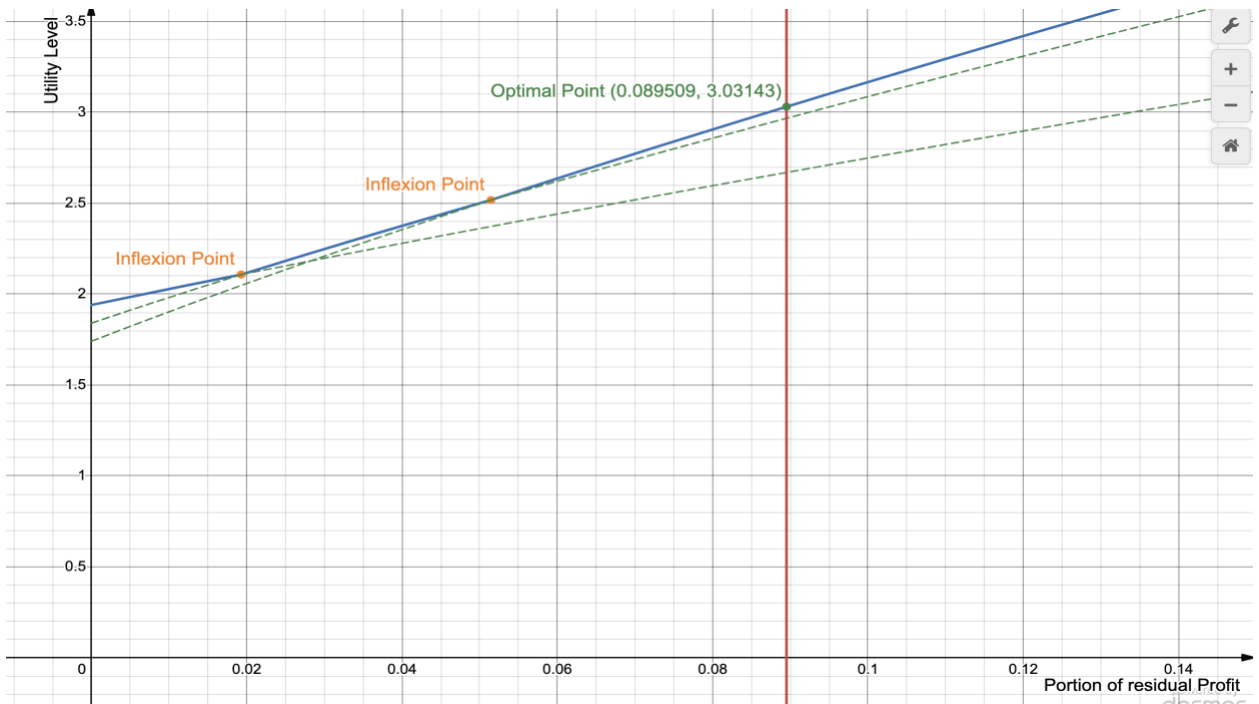


Figure 11: Salary = 2, Low Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,A) under (G,B) environment respectively



Calculation Set 5: Salary = 3

High Covenants

Good Economic Environment

$$0.55 * (32x + 3)^{0.8} + 0.45 * (2x + 3)^{0.8} = 0.55 * (22x + 3)^{0.8} + 0.45 * (7x + 3)^{0.8} + 0.2$$

$$x = 0.121133$$

Bad Economic Environment

$$0.35 * (32x + 3)^{0.8} + 0.65 * 3^{0.8} = 0.35 * (22x + 3)^{0.8} + 0.65 * (2x + 3)^{0.8} + 0.2$$

$$x = 0.198431$$

Low Covenants

Good Economic Environment

$$0.55 * (60x + 3)^{0.8} = 0.55 * (30x + 3)^{0.8} + 0.2$$

$$x = 0.019881$$

Bad Economic Environment

$$0.35 * (40x + 3)^{0.8} + 0.65 * (3)^{0.8} = 0.35 * (20x + 3)^{0.8} + 0.65 * (3)^{0.8} + 0.2$$

$$x = 0.0481033$$

High Covenants

$$U(x) = \begin{cases} 0 \leq x \leq 0.121133, & \frac{0.45 * (7x + 3)^{0.8} + 0.9 * (22x + 3)^{0.8} + 0.65 * (2x + 3)^{0.8} + 0.4}{2} \\ 0.121133 < x \leq 0.198431, & \frac{0.55 * (32x + 3)^{0.8} + 0.35 * (22x + 3)^{0.8} + 1.1 * (2x + 3)^{0.8} + 0.2}{2} \\ 0.198431 < x \leq 1, & \frac{0.9 * (32x + 3)^{0.8} + 0.45 * (2x + 3)^{0.8} + 0.65 * (3)^{0.8}}{2} \end{cases}$$

Low Covenants

$$U(x) = \begin{cases} 0 \leq x \leq 0.019881, & \frac{0.55 * (30x + 3)^{0.8} + 0.35 * (20x + 3)^{0.8} + 0.65 * (3)^{0.8} + 0.4}{2} \\ 0.019881 \leq x \leq 0.0481033, & \frac{0.55 * (60x + 3)^{0.8} + 0.35 * (20x + 3)^{0.8} + 0.65 * (3)^{0.8} + 0.2}{2} \\ 0.0481033 \leq x \leq 1, & \frac{0.55 * (60x + 3)^{0.8} + 0.35 * (40x + 3)^{0.8} + 0.65 * (3)^{0.8}}{2} \end{cases}$$

Figure 12: Salary = 3, High Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (C,C) under (G,B) environment respectively

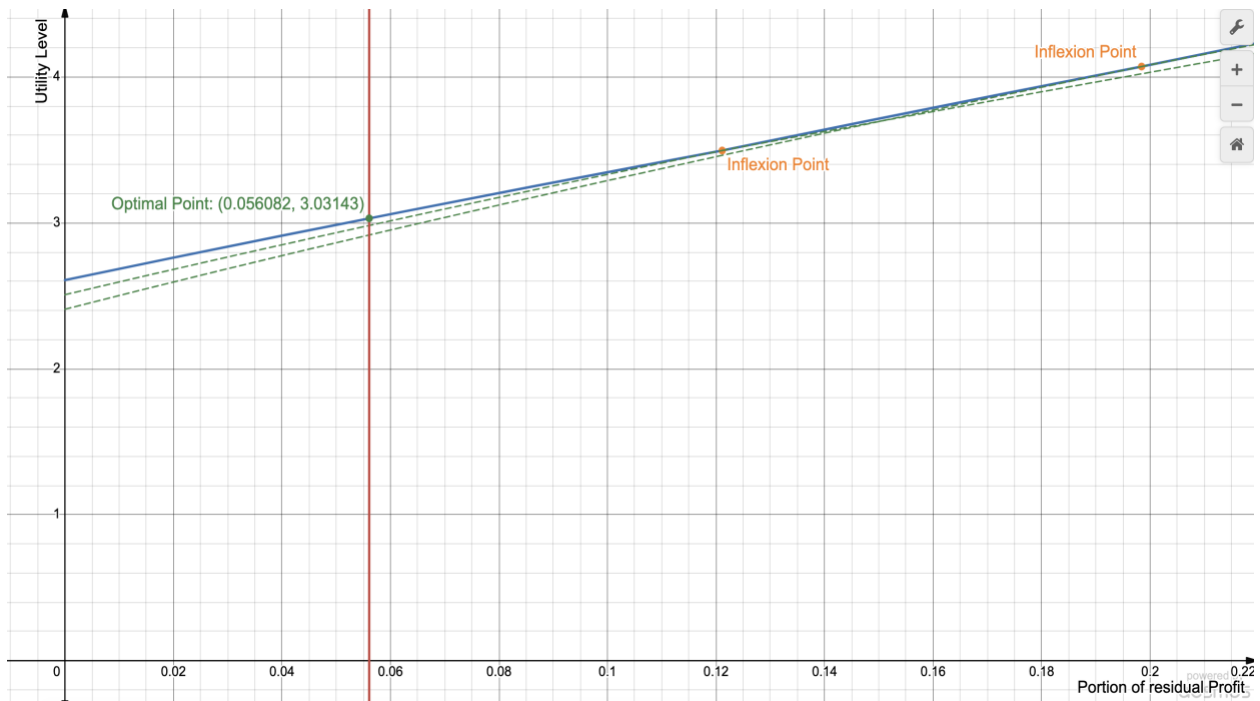
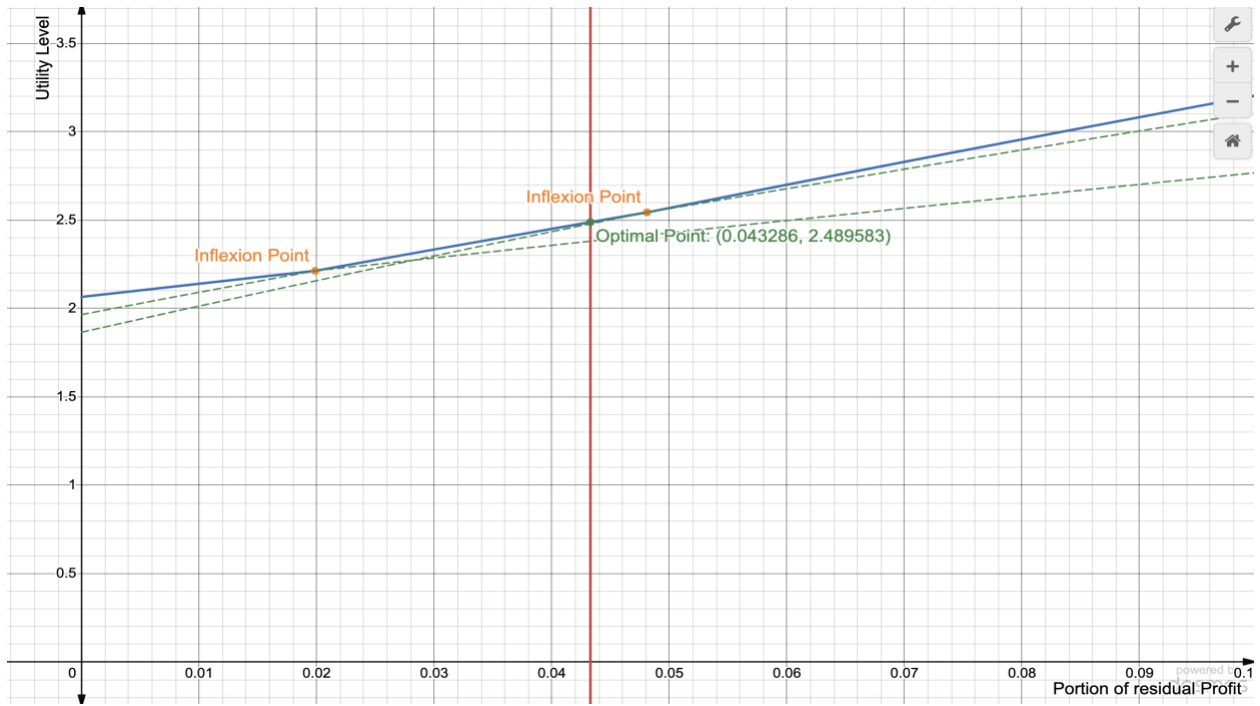


Figure 13: Salary = 3, Low Covenants, Orange being inflexion point, green is optimal, the blue line is the manager's best strategy; the manager chooses (A,C) under (G,B) environment respectively



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