Managerial Incentives, Financial Innovation, and Risk-Management Policy

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October 23, 2022

Motivation

$\exists$Many stories about:

- Risk-management (or cash-management) of an individual firm (e.g., failures to do proper risk-management)
- Each corporation's imprudent risk-taking contributes to the systemic risk of the financial market (Wall Street) and the Main Street economy
- The Global Financial Crisis (GFC) and the subsequent Great Recession

Bernanke (2009): "compensation practices at some banking organizations have led to misaligned incentives and excessive risk-taking, contributing to bank losses and financial instability"

- How do we operationalize his claim in relation to the agency literature?

Big Question (Main Topic)

Managerial incentive $\Longleftrightarrow$ the development of financial markets (e.g., derivative market) and risk-choices of corporations

Big Question (Main Topic)

How do innovations in financial markets affect the value of corporations?

Pros:

- Derivative instruments allow managers to HEDGE against hedgeable risks, thus eliminating the firm's original risk-exposures (which are unobserved by shareholders)

Cons:

- If managers SPECULATE (as in financial crises) instead of HEDGE in derivative markets, their compensation contracts must be altered to make them HEDGE

- The shareholders would incur additional agency cost in twisting the comps

Our contribution:

- A framework where incentive contracts, financial market innovations (e.g., introduction of derivative markets), and firms' risk-choices are intertwined, jointly affecting a value of corporation

Findings

When $\exists$effort and project-choice (non-hedgeable risk-choice) by managers

1. If $\exists$moral hazard only in effort (project-choice is observed)
    - Shareholders: generally prefers the project's risk$\downarrow$
    - Why?: risk$\downarrow$ means output is a sharper signal in inferring the hidden effort (agency cost$\downarrow$)
    - But risk$\downarrow$ implies average return$\downarrow$: usual risk-return trade-off
2. If $\exists$moral hazard in both effort and project-choice
    - The optimal contract rewards or punishes the output's sample variance
    - When shareholders want the manager to raise the project's risk$\uparrow$
        - Then output's sample variance$\uparrow$ $\longrightarrow$ comps$\uparrow$
    - When shareholders want the manager to lower the project's risk$\downarrow$
        - Then output's sample variance$\uparrow$ $\longrightarrow$ comps$\downarrow$

Findings

When $\exists$hedgeable risk-choice (in addition to action and project choice) by managers

1. Derivative market $\Longrightarrow$ informational benefit
   - When managers HEDGE and eliminate the firm's risk exposures voluntarily

2. When managers SPECULATE,
   - Shareholders must alter the manager's compensation contract to induce him to HEDGE instead of SPECULATE
   - $\exists$Additional agency cost from altering the contract
   - How shareholders change the comps to induce the manager toward HEDGING is a very tricky question we answer

3. Financial innovation thus <u>might</u> hurt the efficiency of the firm
   - When the additional agency cost (for inducing HEDGING) $>$ the informational gain from the introduction of derivative markets

Related prior theoretical and empirical works:
Hirshleifer and Suh (1992), Sung (1995), Guay (1999), Rajgopal and Shevlin (2002), Palomino and Prat (2003), DeMarzo et al. (2013), Makarov and Plantin (2015), Hébert (2018), Barron et al. (2020)

The Economic Environment

Single period agency setting: principal (shareholders) and agent (manager)

Actions: a_1 action, a_2 project choice, a_3 transaction in derivative market

$$\text{Output } x = \underbrace{\phi(a_1, a_2)}_{\text{Expected output}} + \underbrace{a_2\theta}_{\text{Project risk}} + \underbrace{(R - a_3)\eta}_{\text{Hedgeable risk}} \tag{1}$$

1. $\theta \sim N(0,1)$: NON-HEDGEABLE risk (project risk)
2. $\eta \sim N(0,1)$: HEDGEABLE risk (market's random variables: e.g., monetary policy, oil price, war, etc)
3. The contract can be written on **x** (output) and η (market variables)
4. R: firm's exposure to HEDGEABLE risks, only observable to manager
   - Information asymmetry between shareholders and the manager

Transaction in the derivative market: a_3

$$\text{Output } x = \underbrace{\phi(a_1, a_2)}_{\text{Expected output}} + \underbrace{a_2\theta}_{\text{Project risk}} + \underbrace{(R - a_3)\eta}_{\text{Hedgeable risk}} \qquad (2)$$

If $|R - a_3| < |R|$:

- The manager is HEDGING in the derivative market

If $|R - a_3| > |R|$:

- The manager is SPECULATING in the derivative market

Preference:

The manager is risk-averse with $u(\cdot)$, and shareholders are risk-neutral

Without Derivative Markets ($a_3 = 0$)

Then principal can write contract on $y = x - \underbrace{R}_{\text{Observed}} \quad \eta = \phi(a_1, a_2) + a_2\theta$

Fix actions a_1, a_2 and find optimal $w^P(y|a_1, a_2)$ that induces a_1 (given a_2)

$$\begin{aligned} \max_{a_1, a_2, w(\cdot)} \quad & \underbrace{\phi(a_1, a_2)}_{\text{Expected output}} - \underbrace{\int w(y) f(y|a_1, a_2) dy}_{\text{Payment to manager}} \\ & + \underbrace{\lambda}_{\text{Fixed weight}} \underbrace{\left[\int u(w(y)) f(y|a_1, a_2) dy - v(a_1)\right]}_{\text{Manager's utility}} \quad \text{s.t.} \end{aligned} \tag{3}$$

$$(i) \quad a_1 \in \arg\max_{a_1'} \int u(w(y)) f(y|a_1', a_2) dy - v(a_1'), \quad \forall a_1'$$

$$(ii) \quad w(y) \geq k, \quad \forall y,$$

$\rightarrow$ Respect (IC) for a_1 (NOT a_2) and (LL)

For the optimal contract $w^P(y|a_1^P, a_2^P)$, social welfare is defined:

$$SW^P(a_1^P, a_2^P) \equiv \phi(a_1^P, a_2^P) - \underbrace{C^P(a_1^P, a_2^P)}_{\text{Agency cost}} - \lambda v(a_1^P) \tag{4}$$

where:

$$C^P(a_1^P, a_2^P) \equiv \int \left[\boxed{w^P(y|a_1^P, a_2^P)} - \boxed{\lambda u(w^P(y|a_1^P, a_2^P))} \right] f(y|a_1^P, a_2^P)dy$$

Payment to the agent

Agent utility to SW

Benchmark: R is observed by principal and no derivative market ($a_3 = 0$) and a_2 is enforceable (no moral hazard in a_2)

Lemma (Agency Cost: Kim (1995))

$C^P(a_1, a_2^0) < C^P(a_1, a_2^1)$ for any given a_1 if $a_2^0 < a_2^1$.

Low a_2: value of signal $y\uparrow$

- $a_2\downarrow \rightarrow$ a sharper information of how a_1 affects y, thus $C(a_1, a_2)\downarrow$
- $a_2\downarrow \rightarrow \phi(a_1, a_2)\downarrow$ (risk-return tradeoff)

Therefore, $\exists$trade-off in $a_2\downarrow$

Benchmark: R is observed by principal and no derivative market ($a_3 = 0$) and a_2 is enforceable (no moral hazard in a_2)

Given $a_1^P, a_2^P, w^P(y|a_1^P, a_2^P)$: solution of (3)

Question ((IC) for a_2)

Given $w^P(y|a_1^P, a_2^P)$, would the manager choose $a_2 = a_2^P$ voluntarily if a_2 is NOT enforceable?

In other words, with

$$a_2^A(a_2^P) \in \arg\max_{a_2} \int u(w^P(y|a_1^P, a_2^P))f(y|a_1^P, a_2)dy - v(a_1^P) \quad (5)$$

Would we have $a_2^A(a_2^P) = a_2^P$?

$\Rightarrow$ Generically $\underline{a_2^A(a_2^P) \neq a_2^P}$

Then what happens if a_2 is NOT enforceable?: should consider (IC) for a_2

Benchmark: R is observed by principal and no derivative market ($a_3 = 0$) and a_2 is NOT enforceable (moral hazard in a_2)

Then shareholders solve the following problem:

$$\max_{a_1, a_2, w(\cdot)} \underbrace{\phi(a_1, a_2)}_{\text{Expected output}} - \underbrace{\int w(y) f(y|a_1, a_2) dy}_{\text{Payment to manager}}$$

$$+ \underbrace{\lambda}_{\text{Fixed weight}} \underbrace{\left[\int u(w(y)) f(y|a_1, a_2) dy - v(a_1)\right]}_{\text{Manager's utility}} \quad \text{s.t.} \tag{6}$$

$$(i) \quad a_1 \in \arg\max_{a_1'} \int u(w(y)) f(y|a_1', a_2) dy - v(a_1'), \quad \forall a_1'$$

$$(ii) \quad a_2 \in \arg\max_{a_2'} \int u(w(y)) f(y|a_1, a_2') dy - v(a_1), \quad \forall a_2'$$

$$(iii) \quad w(y) \geq k, \quad \forall y,$$

$\rightarrow$ Now (ii) is (IC) for a_2

Optimum solution $(a_1^*, a_2^*, w^*(y))$ of (6) satisfies:

$$\frac{1}{u'(w^*(y))} = \lambda + \underbrace{(\mu_1^*\phi_1^* + \mu_2^*\phi_2^*)}_{>0} \underbrace{\boxed{\frac{y-\phi^*}{(a_2^*)^2}}}_{\text{Output mean}} + \underbrace{\mu_2^*}_{\lesseqgtr 0} \frac{1}{a_2^*} \left(\underbrace{\boxed{\frac{(y-\phi^*)^2}{(a_2^*)^2}}}_{\text{Output variance}} - 1 \right) \tag{7}$$

when $w^*(y) \geq k$, and otherwise $w^*(y) = k$

1. We can prove $\mu_1^*\phi_1^* + \mu_2^*\phi_2^* > 0$: incentive in a_1 (mean-shifting)
2. $\mu_2^* > 0$ or $\mu_2^* < 0$:
   - Depends on the relative indirect risk-preferences of principal and agent

Benchmark: R is observed by principal and no derivative market ($a_3 = 0$) and a_2 is NOT enforceable (moral hazard in a_2)

Proposition (Penalizing or Rewarding Risk through the Contract)

If $a_2^P < a_2^A(a_2^P)$, $w^*(y)$ penalizes the agent for having unusual output deviation from the expected level, i.e., $\mu_2^* < 0$. If $a_2^P > a_2^A(a_2^P)$, then $w^*(y)$ rewards the agent for having unusual output deviation, i.e., $\mu_2^* > 0$.

$a_2^P < a_2^A(a_2^P)$:

- The manager wants to raise the project risk ($a_2^A(a_2^P)$) from the stipulated level (a_2^P)
- Thus penalizing the sample output variance: i.e., $\mu_2^* < 0$

$a_2^P > a_2^A(a_2^P)$:

- The manager wants to reduce the project risk ($a_2^A(a_2^P)$) from the stipulated level (a_2^P)
- Thus rewarding the sample output variance: i.e., $\mu_2^* > 0$

For the optimal contract $w^*(y|a_1^*, a_2^*)$, social welfare is defined similarly:

$$SW^*(a_1^*, a_2^*) \equiv \phi(a_1^*, a_2^*) - \underbrace{C^*(a_1^*, a_2^*)}_{\text{Agency cost}} - \lambda v(a_1^*) \tag{9}$$

where:

$$C^*(a_1^*, a_2^*) \equiv \int \left[\boxed{w^*(y)} - \boxed{\lambda u(w^*(y))} \right] f(y|a_1^*, a_2^*) dy$$

Payment to the agent

Agent utility to SW

When R is NOT observed by principal and no derivative market ($a_3 = 0$) and a_2 is NOT enforceable (moral hazard in a_2)

Now, the contract $w(x,\eta)$ CANNOT depend on $y \equiv x - \underbrace{R}_{\text{Not observed}} \eta$

$$g(x,\eta|a_1,a_2,R) \equiv \text{conditional distribution of } (x,\eta) \text{ given } (a_1,a_2,R)$$

Principal knows the manager with different R chooses different $(a_1(R), a_2(R))$:

$$\max_{a_1(\cdot),a_2(\cdot),w(\cdot)} \mathbb{E}_R\left(\int_{x,\eta} (x - w(x,\eta))\, g(x,\eta|a_1(R),a_2(R),R)dxd\eta\right)$$
$$+ \lambda\mathbb{E}_R\left(\int_{x,\eta} u(w(x,\eta))g(x,\eta|a_1(R),a_2(R),R)dxd\eta - v(a_1(R))\right) \text{ s.t.}$$
$$(i) \quad a_1(R) \in \arg\max_{a_1} \int_{x,\eta} u(w(x,\eta))g(x,\eta|a_1,a_2(R),R)dxd\eta - v(a_1), \forall R,$$
$$(ii) \quad a_2(R) \in \arg\max_{a_2} \int_{x,\eta} u(w(x,\eta))g(x,\eta|a_1(R),a_2,R)dxd\eta, \forall R,$$
$$(iii) \quad w(x,\eta) \geq k, \quad \forall (x,\eta), \tag{10}$$

$\rightarrow$ (IC) for a_1 and (IC) for a_2 for all different Rs

When R is NOT observed by principal and no derivative market ($a_3 = 0$) and a_2 is NOT enforceable (moral hazard in a_2)

For the optimal contract $w^N(x, \eta)$, social welfare is defined similarly:

$$SW^N \equiv \int_R \left[\phi(a_1^N(R), a_2^N(R)) - \underbrace{C^N(a_1^N(R), a_2^N(R))}_{\text{Agency cost for } \forall R} - \lambda v(a_1^N(R)) \right] h(R)dR \tag{11}$$

where:

$$C^N(a_1^N(R), a_2^N(R)) \equiv$$

$$\int_{x,\eta} \left[\boxed{w^N(x, \eta)} - \boxed{\lambda u(w^N(x, \eta))} \right] g(x, \eta | a_1^N(R), a_2^N(R), R) dx d\eta$$

Payment to the agent Agent utility to SW

With Derivative Markets (Free a_3)

Imagine principal designs a contract that is optimal in the absence of derivative market (i.e., (7)), with x instead of $y \equiv x - (R - a_3)\eta$

$$\frac{1}{u'(w^*(x))} = \lambda + \underbrace{(\mu_1^* \phi_1^* + \mu_2^* \phi_2^*)}_{>0} \underbrace{\boxed{\frac{x - \phi^*}{(a_2^*)^2}}}_{\text{Output mean}} + \underbrace{\mu_2^*}_{\lessgtr 0} \frac{1}{a_2^*} \left(\underbrace{\boxed{\frac{(x - \phi^*)^2}{(a_2^*)^2}}}_{\text{Output variance}} - 1 \right) \tag{12}$$

Lemma (HEDGING and SPECULATION depending on the sign of μ_2^*)

When $\mu_2^* < 0$, then manager voluntarily chooses $a_3 = R$ (complete HEDGING).
If $\mu_2^* > 0$, manager chooses $|R - a_3| = \infty$ (infinite SPECULATION).

With $\mu_2^* < 0$:

- The manager voluntarily eliminates $(R - a_3)\eta$ as he dislikes additional risk on output x
- Eliminates the information asymmetry about R: informational gain of financial market innovations
- The social welfare becomes $SW^*(a_1^*, a_2^*)$

With $\mu_2^* > 0$:

- Shareholders must alter the contract to ensure that the manager HEDGES (i.e., $a_3 = R$)
- Must change from $w^*(x)$ to $w^o(x, \underbrace{\eta}_{\text{Additional risk}})$
- To induce HEDGING, the new contract must depend on η. **How exactly?**

With $\mu_2^* > 0$, principal solves the following problem:

$$\max_{a_1, a_2, w(\cdot)} \underbrace{\phi(a_1, a_2)}_{\text{Expected output}} - \underbrace{\int w(x, \eta) g(x, \eta | a_1, a_2, a_3 = R) dx d\eta}_{\text{Payment to manager}}$$

$$+ \underbrace{\lambda}_{\text{Fixed weight}} \underbrace{\left[\int u(w(x, \eta)) g(x, \eta | a_1, a_2, a_3 = R) dx d\eta - v(a_1) \right]}_{\text{Manager's utility}} \quad \text{s.t.}$$

$$(i) \quad a_1 \in \arg\max_{a_1'} \int u(w(x, \eta)) g(x, \eta | a_1', a_2, a_3 = R) dx d\eta - v(a_1'), \quad \forall a_1'$$

$$(ii) \quad a_2 \in \arg\max_{a_2'} \int u(w(x, \eta)) g(x, \eta | a_1, a_2', a_3 = R) dx d\eta - v(a_1), \quad \forall a_2'$$

$$(iii) \quad R \in \arg\max_{a_3'} \int u(w(x, \eta)) g(x, \eta | a_1, a_2, a_3') dx d\eta - v(a_1), \quad \forall a_3'$$

$$(iv) \quad w(y) \geq k, \quad \forall y, \tag{13}$$

$\rightarrow$ Now we add (iii), (IC) for $a_3 = R$

Problem (The First-Order Approach)

Cannot rely on the famous first-order approach for (iii), (IC) for $a_3 = R$

Mathematical difficulty:

- The indirect value function becomes convex if we use the first-order approach about $a_3 = R$

Question (The First-Order Approach)

How can we solve the above optimization problem without relying on the first-order approach?

A little more about the first-order approach:

$w^*(x)$ in (12): the optimal contract without (iii), which is (IC) for $a_3 = R$

- $w^*(x)$ does not include η as an argument

The manager's indirect utility given $w^*(x)$, as a function of a_3:

- Symmetric around $a_3 = R$
- Why? As $\eta \sim N(0,1)$ is symmetrically distributed around 0
- Remember $x = \phi(a_1, a_2) + a_2\theta + (R - a_3)\eta$

Thus for $w^*(x)$, we have:

$$\int u(w^*(x))g_3(x, \eta | a_1, a_2, a_3 = R)dxd\eta = 0 \tag{14}$$

$\rightarrow$ Under the first-order approach for (IC) for $a_3 = R$, we always get $w^*(x)$ as the optimal contract. It induces the manager to choose $|R - a_3| = \infty$ (infinite SPECULATION)

Proposition (The New Optimal Contract)

Optimal $w^o(x,\eta)$ satisfies:

1. $w^o(x,\eta) = w^o(x,-\eta)$ *for* $\forall x, \eta$
2. *It penalizes the manager for having any (both positive and negative) sample covariance between the output, x, and market observables, η, i.e., penalizing manager for having high realized $(x-\phi)^2\eta^2$*

Given η:

- Sample covariance^2=$\widehat{Cov}^2 \equiv (x-\phi)^2\eta^2 \uparrow \rightarrow w^o(x,\eta)\downarrow$

Given $(x-\phi)^2\eta^2$:

- $|\eta| \uparrow \rightarrow w^o(x,\eta)\uparrow$

Intuition:

$$R - a_3 = \mathbb{E}\left((x - \phi(a_1, a_2))\eta\right) = Cov(x, \eta)$$

To induce $a_3 = R$ (which leads to $Cov(x, \eta) = 0$):

Let's punish its SAMPLE version (SAMPLE COVARIANCE)$= |\widehat{Cov}|$

With $a_3 = R$:

- x is not correlated with η
- $w^o(x, \eta) = w^o(x, -\eta)$ to minimize risks imposed on risk-averse agent
- Given realized sample covariance $|\widehat{Cov}|$, the principal becomes more lenient when it is coming from a high η realization, since it's out of control of the manager, which explains

$$|\eta|\uparrow \rightarrow w^o(x, \eta)\uparrow$$

Welfare can go below SW^N in (11), the one when there is no derivative market

When $\sigma_R \to 0$ (Informational asymmetry $\to 0$)

1. No informational gain but still $\exists$incentive problem around a_3
2. Shareholders are better-off by shutting down any access to derivative markets

Financial innovation can hurt the efficiency!

The optimal contract $w^o(x,\eta)$:

$$\begin{aligned}\frac{1}{u'(w^o(x,\eta))} =&\lambda + (\mu_1^o\phi_1^o + \mu_2^o\phi_2^o)\frac{x-\phi(a_1^o,a_2^o)}{(a_2^o)^2} + \underbrace{\frac{\mu_2^o}{a_2^o}}_{>0}\left(\frac{(x-\phi(a_1^o,a_2^o))^2}{(a_2^o)^2} - 1\right) \\ & -2\underbrace{\sum_{k:\text{even}}^{\infty}\frac{1}{k!}\frac{1}{(a_2^o)^{2k}}\underbrace{\left(\int_{b\geq 0}\mu_4^o(b)b^k\exp\left(-\frac{b^2\eta^2}{2(a_2^o)^2}\right)db\right)}_{\equiv C_{k:\text{even}}(\eta)>0}}_{\equiv D_{k:\text{even}}(\eta)>0}\widehat{Cov}^k \\ & + \underbrace{\int \mu_4^o(b)db}_{>0}\end{aligned} \tag{15}$$

With sample covariance $\widehat{Cov} \equiv (x-\phi(a_1^o,a_2^o))\eta$

1. $\mu_4^o(b) \geq 0$: multiplier function for the following (IC) for $b = R - a_3$

$$\int u(w(x,\eta))[g(x,\eta|a_1^o,a_2^o,b=0) - g(x,\eta|a_1^o,a_2^o,b)]dxd\eta \geq 0 \tag{16}$$

2. μ_1^o and μ_2^o are multipliers for (IC) for a_1^o and a_2^o respectively

Costless communication

Question (Communication between shareholders and the manager)

What if manager can report his observation of R to shareholders?

Truth-telling mechanism is possible in the case where agent voluntarily does not like additional risk (making a side-bet to agent)

With $\mu_2^* < 0$:

- Truth-telling contract can substitute the derivative market (for informational gain)

Example:

- Risk management group at Disney would ask business unit heads to disclose all of their risks at the beginning of each quarter. Business unit profits were calculated assuming the risks were hedged, whether or not they actually were hedged

Big Question

Then what is the additional benefit financial innovations bring about?

With $\mu_2^* > 0$, again truth-telling contract becomes much more complicated