Managerial Incentives, Financial Innovation, and Risk-Management Policy

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Motivation

Value of hedging:

- Frictionless with perfect information: zero (e.g., Modigliani and Miller (1958))
- The literature: focuses on roles of financial constraints (e.g., Rampini and Viswanathan (2010, 2013), Rampini et al. (2014)), usually assuming that a risk management choice is made by value-maximizing executives

Our viewpoint: managerial incentives on hidden efforts must be incorporated more seriously: e.g., Tufano (1996) and Bakke et al. (2016)

- Shareholders offer a compensation contract to induce the manager to expend efforts and proper risk choices
- The manager, not shareholders, decides whether to increase (i.e., speculation) or decrease (i.e., hedging) the firm's exposure to hedgeable risks
- Information asymmetry: only the manager observes the firm's initial exposure to hedgeable risks (shareholders observe its distribution)

Motivation

Value of hedging under moral hazard:

1. It eliminates shareholders' informational disadvantage about the firm's initial exposure to hedgeable risks, raising the efficiency of the optimal contract

   – similar intuition with managerial "ability" at the center: DeMarzo and Duffie (1991, 1995) and Breeden and Viswanathan (2016)

2. Negative cash flows can be amplified by feedback effects, e.g., bankruptcy, as in Smith and Stulz (1985). It eliminates the indeterminacy in our model

3. In some cases, it might be costly to write an optimal contract that "induces" hedging from the manager, in which case shareholders restricts the derivative market access

   > Our methodological contribution: deriving optimal contracts for hedging

Setting

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

Actions: a_1 effort, a_d transaction in derivative market

$$\underbrace{x}_{\text{Output}} = \underbrace{\phi(a_1)}_{\text{Expected output}} + \underbrace{\sigma\theta}_{\text{Non-hedgeable risk}} + \underbrace{(R - a_d)\eta}_{\text{Hedgeable risk}}$$

1. $\eta \sim N(0,1)$: hedgeable risks (e.g., monetary policy rates, oil prices) which derivatives can be written in ▸▸ Details

2. The incentive contract $w(\cdot)$ can be written on x (output) and η (market variables): $w(x, \eta)$

3. R: firm's initial exposure to hedgeable risks, only observable to manager – information asymmetry between shareholders and the manager

Benchmark*: R is observed by principal and no derivative market ($a_d \equiv 0$)

Then principal can write contract on

$$y = x - \underbrace{R}_{\text{Observed}}\eta = \phi(a_1) + \sigma\theta$$

For given a_1, the principal solves

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

$$+ \underbrace{\lambda}_{\text{Fixed weight}} \underbrace{\left[\int u(w(y)) f(y|a_1) dy - v(a_1)\right]}_{\text{Manager's utility}} - \underbrace{Pr[x \leq x_b | a_1, a_d = 0] D}_{\text{Financial stress cost}}$$

$$\text{s.t.} \quad (i) \quad a_1 \in \arg\max_{a_1'} \int u(w(y)) f(y|a_1') dy - v(a_1'), \quad \forall a_1'$$

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

Solution: $w^*(y|a_1)$, $a_1^* = \arg\max_{a_1} SW^*(a_1)$, $SW^* \equiv SW^*(a_1^*)$ Details

Second^N: with information asymmetry and no derivative market ($a_3 = 0$)

Two new issues:

- Now, the agent's effort depends on observed R: $a_1(R), \forall R$
- Contract cannot be written in $y = x - R\eta$ anymore. Now should be $w(x, \eta)$

Conditional distribution

The principal solves Details

$$\max_{a_1(\cdot), w(\cdot) \geq k} SW^N \equiv \int_R \left[\int_{x,\eta} (x - w(x,\eta)) \; g(x, \eta | a_1(R), R) \; dx d\eta \right] h(R) dR$$

$$+ \lambda \int_R \left(\int_{x,\eta} u(w(x,\eta)) g(x, \eta | a_1(R), R) dx d\eta - v(a_1(R)) \right) \; h(R) \; dR$$

$$- \int_R Pr[x \leq x_b | a_1(R), a_d = 0] D \cdot h(R) dR$$

Prior

$$\text{s.t.} \quad (i) \quad a_1(R) \in \arg\max_{a_1} \int_{x,\eta} u(w(x,\eta)) g(x, \eta | a_1, R) dx d\eta - v(a_1), \forall R$$

Proposition (Proposition 1)

$$SW^N < SW^*$$

Conditional distribution

Third^o: when managers can trade derivatives

The agent effectively chooses $b \equiv R - a_d$ given $w(x, \eta)$. Now principal solves

$$\max_{a_1, b, w(\cdot) \geq k} SW^o \equiv \int_{x,\eta} (x - w(x,\eta)) \; g(x, \eta | a_1, b) \; dxd\eta$$

$$+ \lambda \left[\int_{x,\eta} u(w(x,\eta)) g(x,\eta|a_1, b) dxd\eta - v(a_1) \right]$$

$$- \underbrace{Pr[x \leq x_b | a_1, b \equiv R - a_d] D}_{\text{Financial stress cost}}$$

$$\text{s.t.} \quad (i) \quad a_1 \in \arg\max_{a_1'} \int_{x,\eta} u(w(x,\eta)) g(x,\eta|a_1', b) dxd\eta - v(a_1'), \forall a_1'$$

$$(ii) \quad \underbrace{b \in \arg\max_{b'} \int_{x,\eta} u(w(x,\eta)) g(x,\eta|a_1, b') dxd\eta, \forall b'}_{\text{(IC) for b}}$$

$\rightarrow$ (IC) for hedging choice $b = R - a_d$ added

Conditional distribution

Third^o: when managers can trade derivatives

The agent effectively chooses $b \equiv R - a_d$ given $w(x, \eta)$. Now principal solves

$$\max_{a_1, b, w(\cdot)\geq k} SW^o \equiv \int_{x,\eta} (x - w(x,\eta)) \; g(x,\eta|a_1, b) \; dxd\eta$$

$$+ \lambda \left[\int_{x,\eta} u(w(x,\eta)) g(x,\eta|a_1, b) dxd\eta - v(a_1) \right]$$

$$- \underbrace{Pr[x \leq x_b | a_1, b \equiv R - a_d] D}_{\text{Financial stress cost}}$$

$$\text{s.t.} \quad (i) \quad a_1 \in \arg\max_{a_1'} \int_{x,\eta} u(w(x,\eta)) g(x,\eta|a_1', b) dxd\eta - v(a_1'), \forall a_1'$$

$$(ii) \quad \cancel{\underbrace{b \in \arg\max_{b'} \int_{x,\eta} u(w(x,\eta)) g(x,\eta|a_1, b') dxd\eta, \forall b'}_{\text{(IC) for b}}}$$

For now, ignore (IC) for b – then given any chosen $b = \hat{b}$

- Define $z(\hat{b}) \equiv x - \hat{b}\eta = \phi(a_1) + \sigma\theta$: the optimal contract for given $(a_1, \hat{b})$ becomes $w^*(z(\hat{b})|a_1)$
- If possible, the principal chooses $\hat{b} = 0$ (i.e., complete hedging) to minimize financial stress cost: then $z(0) = x$ and the optimal contract becomes $w^*(x|a_1^o)$ Details

Third^o: when managers can trade derivatives (hedging case)

Big Question ((IC) for b again)

Given $w^*(x|a_1^o)$, will the agent choose $a_d = R$ (or $b = 0$, i.e., complete hedging)?

Define the agent's "indirect" utility function:

$$V(x) \equiv u(w^*(x|a_1^o))$$

- If $V(\cdot)$ is **concave**, then the agent "voluntarily" chooses $a_d = R$ (i.e., $b = 0$)
- Usually, when the agent's (relative) risk aversion is high enough Details

Proposition (Voluntary hedging case)

When $V(x) \equiv u(w^*(x|a_1^o))$ is concave,

$$SW^N < SW^* < SW^o$$

- Voluntary hedging: (i) informational gain; (ii) reducing financial stress costs

Third^o: when managers can trade derivatives (speculation case)

When $V(x) \equiv u(w^*(x|a_1^o))$ is **convex**, the agent under $w^*(x|a_1^o)$ chooses $b = \pm\infty$ (i.e., infinite speculation)

Conditional distribution

The principal redesigns $w^o(x,\eta)$, solving

$$\max_{w(\cdot)\geq k} SW^o \equiv \int_{x,\eta} (x - w(x,\eta)) \; g(x,\eta|a_1^o, b=0) \; dxd\eta$$
$$+\lambda\left[\int_{x,\eta} u(w(x,\eta))g(x,\eta|a_1^o, b=0)dxd\eta - v(a_1^o)\right]$$
$$-\underbrace{Pr[x \leq x_b|a_1^o, b=0]\cdot D}_{\text{Financial stress cost}}$$

$$\text{s.t.} \quad (i) \quad \int_{x,\eta} u(w(x,\eta))g_1(x,\eta|a_1^o, b=0)dxd\eta - v'(a_1^o) = 0,$$
$$(ii) \quad \underbrace{b = 0 \in \arg\max_{b} \int_{x,\eta} u(w(x,\eta))g(x,\eta|a_1^o, b)dxd\eta, \forall b}_{\text{(IC) for } b=0}$$

- One technical issue: cannot use the first-order approach for (IC) for $b = 0$ Details

Third^o: when managers can trade derivatives (speculation case)

Proposition (Proposition 3)

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

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 a high realization of $(x - \phi(a_1^o))^2\eta^2$
   - Given x and $(x - \phi(a_1^o))^2\eta^2$, pays more for a higher η^2

From population relation:

$$b \equiv R - a_d = \mathbb{E}\left((x - \phi(a_1^o))\eta\right) = \underbrace{Cov(x, \eta)}_{\text{Unobserved}}$$

In a single-period setting:

$$\underbrace{\widehat{Cov}^2}_{\text{Sample covariance}^2} \equiv (x - \phi(a_1^o))^2\eta^2 \uparrow \longrightarrow w^o(x, \eta) \downarrow$$

Given x and $(x - \phi(a_1^o))^2\eta^2$:

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

Third^o: when managers can trade derivatives (speculation case)

Proposition (Proposition 4)

When $V(x) \equiv u(w^*(x|a_1^o))$ is convex, it is possible that

$$SW^o < SW^N < SW^*$$

- *When σ_R^2 and R levels are small*

When $\sigma_R \to 0$ (i.e., information asymmetry $\to 0$)

- Little informational gain but still $\exists$incentive problem around b (or a_d)

When $R \to 0$

- Then, the direct hedging benefit of reducing financial stress costs $\to 0$

Shareholders are better-off by shutting down any access to derivative markets

Costless communication

Big Question (Communication between shareholders and the manager)

What if manager can report his observation of R to shareholders (reported value is r)?

When $V(x) \equiv u(w^*(x|a_1^*))$ is concave:

- The principal constructs the following signal

Reported value

$$y_r \equiv x - r\,\eta = \phi(a_1) + \sigma\theta + (R - r)\eta$$

- Truth-telling mechanism is efficient and implementable

Similar to a_d

Example:

- The risk management group at Disney asks 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

Thank you very much!

(Appendix)

Setting: hedging vs. speculation

Transaction in the derivative market: a_d

$$\underbrace{x}_{\text{Output}} = \underbrace{\phi(a_1)}_{\text{Expected output}} + \underbrace{\sigma\theta}_{\text{Non-hedgeable risk}} + \underbrace{(R - a_d)\eta}_{\text{Hedgeable risk}}$$

<u>If $|R - a_d| < |R|$</u>:

- The manager is hedging in the derivative market
- If $a_d = R$, complete hedging (completely eliminates information asymmetry)

<u>If $|R - a_d| > |R|$</u>:

- The manager is speculating in the derivative market

Go back

Benchmark*: R is observed by principal and no derivative market ($a_d \equiv 0$)

Based on the first-order approach for (IC) for a_1:

$$SW^*(a_1) \equiv \max_{w(\cdot)\geq k} \underbrace{\phi(a_1)}_{\text{Expected output}} - \underbrace{\int w(y) f(y|a_1) dy}_{\text{Payment to manager}}$$

$$+ \underbrace{\lambda}_{\text{Fixed weight}} \underbrace{\left[\int u(w(y)) f(y|a_1) dy - v(a_1)\right]}_{\text{Manager's utility}} - \underbrace{Pr[x \leq x_b | a_1, a_d = 0] D}_{\text{Financial stress cost}}$$

$$\text{s.t.} \quad (i) \quad \int u(w(y)) f_1(y|a_1) dy - v'(a_1) = 0$$

Optimal contract given a_1:

$$\frac{1}{u'(w^*(y|a_1))} = \max\left\{\lambda + \mu_1^*(a_1) \underbrace{\frac{y - \phi(a_1)}{\sigma^2}}_{\text{Likelihood ratio}} \phi_1(a_1) \;,\; \frac{1}{u'(k)}\right\}$$

Go back

Benchmark*: R is observed by principal and no derivative market ($a_d \equiv 0$)

Agency cost

Rewrite social welfare as

$$SW^*(a_1) = \underbrace{\phi(a_1) - \color{red}{C^*(a_1)} - \lambda v(a_1)}_{\equiv EAR^*(a_1)} - Pr[x \leq x_b | a_1, a_d = 0]D$$

where

$$C^*(a_1) \equiv \int \left(w^*(y|a_1) - \lambda u(w^*(y|a_1))\right) f(y|a_1) dy$$

- $EAR^*(a_1)$: represents the firm's efficiency purely from the agency relation

Go back

Second^N: with information asymmetry and no derivative market ($a_3 = 0$)

The optimal solution: $\left(a_1^N(R), w^N(x,\eta)\right)$ satisfies

$$\frac{1}{u'(w^N(x,\eta))} = \max\left\{\lambda + \int_R \mu_1(R)\left[\frac{g_1(x,\eta|a_1^N(R),R)}{\int_{R'} g(x,\eta|a_1^N(R'),R')h(R')dR'}\right] h(R)\; dR, \frac{1}{u'(k)}\right\}$$

Probability-weighted likelihood ratio

Social welfare is given by

$$SW^N \equiv \int_R \left[\phi(a_1^N(R)) - C^N(a_1^N(R)) - \lambda v(a_1^N(R)) - Pr[x \leq x_b | a_1^N(R), a_d = 0]D\right] h(R)dR$$

where

$$C^N(a_1^N(R)) \equiv \int_{x,\eta} [w^N(x,\eta) - \lambda u(w^N(x,\eta))]g(x,\eta|a_1^N(R),R)dxd\eta$$

Go back

Agency cost for R

Third^o: when managers can trade derivatives

Lagrange multiplier for (IC) for a_1

Optimal $w^*(z(\hat{b})|a_1)$ (without (IC) for $b = \hat{b}$) satisfies

$$\frac{1}{u'(w^*(z(\hat{b})|a_1))} = \max\left\{\lambda + \mu_1(a_1|\hat{b})\frac{z(\hat{b}) - \phi(a_1)}{\sigma^2}\phi_1(a_1), \frac{1}{u'(k)}\right\} \tag{1}$$

Social welfare given $(a_1, \hat{b})$ is given by

$$SW^o(a_1, \hat{b}) = EAR^o(a_1, \hat{b}) - Pr[x \leq x_b|a_1, \hat{b}]D, \tag{2}$$

where the efficiency of the agency relation

$$\begin{aligned} EAR^o(a_1, \hat{b}) \equiv & \int_{x,\eta}(x - w^*(z(\hat{b})|a_1))g(x, \eta|a_1, \hat{b})dxd\eta \\ & + \lambda\left[\int_{x,\eta} u(w^*(z(\hat{b})|a_1))g(x, \eta|a_1, \hat{b})dxd\eta - v(a_1)\right], \end{aligned} \tag{3}$$

is independent of $\hat{b}$

The principal chooses $\hat{b} = 0$ in this case, when not considering (IC) for b, with

$$a_1^o \in \arg\max_{a_1} SW^o(a_1, \hat{b} = 0)$$

Go back

Third^o: when managers can trade derivatives (hedging case)

With constant relative risk aversion (CRRA) utility $u(w) = \frac{1}{t} w^t$ with (very) low k:[1]

$$w^*(x|a_1^o) = \left(\lambda + \mu_1^*(a_1^o)\left(\frac{x - \phi(a_1^o)}{\sigma^2}\right)\phi_1(a_1^o)\right)^{\frac{1}{1-t}},$$

and

$$V(x) \equiv u(w^*(x|a_1^o)) = \frac{1}{t}\left(\lambda + \mu_1^*(a_1^o)\left(\frac{x - \phi(a_1^o)}{\sigma^2}\right)\phi_1(a_1^o)\right)^{\frac{t}{1-t}}$$

1. With $t < \frac{1}{2}$, i.e., $1 - t > \frac{1}{2}$ (high risk aversion), $V(\cdot)$ becomes concave
2. With $t > \frac{1}{2}$, i.e., $1 - t < \frac{1}{2}$ (low risk aversion), $V(\cdot)$ becomes convex

Go back

[1] The relative risk aversion measure is given by $1 - t$.

Third^o: when managers can trade derivatives (speculation case)

Problem (The First-Order Approach)

Cannot rely on the famous first-order approach for (IC) for $b = 0$

$w^*(x|a_1^o)$, the optimal contract without (IC) for $b = 0$, does not include η as an argument (with $b = 0$)

The manager's expected monetary utility given $w^*(x|a_1^o)$, as a function of b

$$\int u(w^*(x|a_1^o))g(x, \eta|a_1^o, b)dxd\eta$$

- Symmetric around $b = 0$. Why?
- As $\eta \sim N(0, 1)$ is symmetrically distributed around 0 and $x = \phi(a_1) + \sigma\theta + b\eta$

Thus, we have:

$$\int u(w^*(x|a_1^o))g_b(x, \eta|a_1^o, b = 0)dxd\eta = 0$$

$\rightarrow$ Under the first-order approach for (IC) for $b = 0$, we always get $w^*(x|a_1^o)$ as the optimal contract. It induces the agent to choose $|R - a_3| = \infty$

Go back

Third^o: when managers can trade derivatives (speculation case)

Conditional distribution

The principal redesigns $w^o(x,\eta)$, solving

$$\max_{w(\cdot)\geq k} SW^o \equiv \int_{x,\eta} (x - w(x,\eta))\ g(x,\eta|a_1^o, b=0)\ dxd\eta$$
$$+\lambda\left[\int_{x,\eta} u(w(x,\eta))g(x,\eta|a_1^o, b=0)dxd\eta - v(a_1^o)\right]$$
$$-\underbrace{Pr[x \leq x_b|a_1^o, b=0]\cdot D}_{\text{Financial stress cost}}$$

$$\text{s.t.}\quad (i)\quad \int_{x,\eta} u(w(x,\eta))g_1(x,\eta|a_1^o, b=0)dxd\eta - v'(a_1^o) = 0,$$
$$(ii)\quad \underbrace{\int_{x,\eta} u(w(x,\eta))(g(x,\eta|a_1^o, b=0) - g(x,\eta|a_1^o, b))dxd\eta \geq 0,\ \forall b}_{\text{(IC) for } b=0}$$

- Following Grossman and Hart (1983), we use the direct (IC) for $b = 0$

Go back

Third^o: when managers can trade derivatives (speculation case)

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

$$\frac{1}{u'(w^o(x,\eta))} = \lambda + \mu_1^o \frac{x-\phi(a_1^o)}{\sigma^2}\phi_1(a_1^o) + \underbrace{\int \mu_4^o(b)db}_{>0}$$

$$\underbrace{-2\sum_{k:\text{even}}^{\infty}\frac{1}{k!}\frac{1}{\sigma^{2k}}\underbrace{\left(\int_{b\geq 0}\mu_4^o(b)b^k \exp\left(-\frac{b^2\eta^2}{2\sigma^2}\right)db\right)}_{\equiv C_{k:\text{even}}(\eta)>0}}_{\equiv D_{k:\text{even}}(\eta)>0}\widehat{Cov}^k$$

when $w^o(x,\eta)\geq k$ and $w^o(x,\eta)=k$ otherwise

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

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

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

2. μ_1^o is the Lagrange multiplier for (IC) for a_1^o

Go back