Incentive Compensation for Risk Managers when Effort is Unobservable

by

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Abstract

In a stylized model of a financial intermediary, risk managers can expend effort to reduce loan PD and LGD, but effort is costly and unobservable. Incentive compensation (IC) can induce manager effort, but underwriting and loss mitigation managers require different IC contracts. When the intermediary uses subsidized insured deposit funding, the demand for risk management declines because effort decreases the insurance subsidy. Consequently, the principal may no longer offer risk manager IC. Regulatory policy should reinforce an insured depository's incentives to offer risk mangers appropriate IC contracts and yet existing regulatory guidance explicitly prohibits performance-linked IC for risk managers.

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1. Introduction

The financial crisis focused attention on the management compensation practices of large financial institutions. Institutions that participated in the Troubled Asset Relief Program (TARP) faced limits on the compensation for their most highly paid executives. The Office of the Special Master for TARP Executive Compensation (Special Master) was created and assigned responsibility for setting compensation levels for top executives and highly paid employees at companies receiving TARP assistance. The Special Master did not restrict salaries, but instead limited the magnitude of incentive compensation (IC) awards, required extended vesting periods for IC payments, introduced "clawback" provisions, and prohibited "golden parachute payments" to the most senior executives of TARP institutions.

In June 2010 the federal banking regulators[2] jointly issued guidance on IC policies. This guidance applied to executive and non-executive bank employees who have the ability to control or influence the risk profile of a financial institution. Concurrently, the U.S. Congress passed the Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA) which requires all federal financial regulators to issue formal rules to prevent covered financial institutions from writing IC agreements that expose an institution to inappropriate risks or material potential losses. In April 2011, the federal financial regulators issued a Notice of Proposed Rule Making[3] (NPR) on IC that is similar to the 2010 joint banking agency guidance.

Regulatory guidance on IC requires that compensation arrangements balance risk and financial results without encouraging employees to expose their organization to imprudent risks. The guidance and the April 2011 NPR recognize four methods to achieve this goal: (1) risk-adjusting IC awards based on quantitative or managerial judgment; (2) deferring IC significantly beyond the end of the performance period and adjusting it for interim losses; (3) basing IC on longer-horizon performance with perhaps a deferral component; and, (4) reducing IC's sensitivity to short term performance by structuring IC so that it is an increasing but strictly concave function of the performance measure.

[2] The banking agencies are, Federal Reserve Board, the Federal Deposit Insurance Corporation, and the Office of the Comptroller of the Currency.
[3] Federal Register, Vol. 76, No. 72, pp. 21169-21219.

The only specific guidance regarding IC for risk managers appears in the Federal Reserve Board's October 2011 horizontal review on incentive compensation practices. The report [19, p.22] argues that inappropriate risk manager IC can compromise risk management activities, and to ensure proper risk management, the institution should decouple the risk manager's IC performance target from the performance of the activities over which the risk manager exercises control:

"…a conflict of interest is created if the performance measures applied to them (risk managers), or the bonus pool from which awards are drawn, depend substantially on the financial results of the lines of business or business activities that such staff oversee. …Thus, risk management and control personnel should be compensated in a way that makes their incentives independent of the lines of business whose risk taking and incentives compensation they monitor and control."

The purpose of IC is to create an incentive for the risk manager to expend effort or otherwise exercise risk control judgments that are in the best interest of stakeholders when the effort and judgments of risk managers cannot be directly observed or are otherwise not contractible. The regulatory guidance regarding risk manager IC is particularly unsettling because it requires that risk manager IC be independent of performance of the specific activities risk managers control.

When shareholder interests diverge from those of regulator and deposit insurer stakeholders, risk manager IC should be structured to account for the regulator's interests, but the IC must still be based on the *ex post* performance of the activities under the risk manager's control. In the analysis that follows, I use a stylized model of risk management in a bank that benefits from a deposit insurance subsidy and show that the principal's unconstrained optimal contracting solution may short-change the risk management function. In order to reduce the risks faced by the regulator and deposit insurer, the regulator may have to require the principal to increase the amount of IC that is paid to some risk managers.

If a risk manager's IC performance is decoupled from the performance of the activities the risk manager is controlling–as the current regulations recommend–theory predicts that the contract will encourage weak risk management. In contrast to regulatory guidance, I show that in order to mitigate the risk-taking incentives created by mispriced deposit insurance, financial institutions must be required to link risk managers IC to the performance of the activities they oversee.

The weakness in existing regulatory guidance on IC is perhaps a reflection of the developmental stage of the underlying academic literature on compensation. To my knowledge, there is no academic literature on IC methods that might be used to design compensation for risk managers in financial institutions. The existing literature focuses for the most part on bank CEO compensation and its results are mostly aligned with the existing regulatory guidance.[4] The existing literature has little to say about the IC structures that are most appropriate for the non-CEO bank management functions including risk managers. In this paper I attempt to fill that gap by developing a model that focus on the characteristics of IC contracts that are likely to be useful to encourage risk control in deposit-taking intermediaries.

The paper is organized as follows. Section 2 introduces the basic model assumptions. Section 3 derives the optimal risk manager compensation contracts when effort is observable and contractible and the lending institution is funded with fairly priced debt and equity. Section 4 derives the optimal risk manager compensation contracts when effort is not observable but managers are risk neutral. Section 5 extends the theory to a bank that enjoys subsidized deposit financing and shows that introduction of mispriced government guarantees reduces the demand for risk manager effort. When risk manager effort is not observable and contractible, deposit insurance will reduce the principal's incentives to offer IC compensation to risk managers and encourage additional risk taking. Risk manager risk aversion compounds bank incentives to underinvest in risk management. Section 6 discusses policy implications and concludes.

2. A Model of Credit Risk Management in a Lending Institution

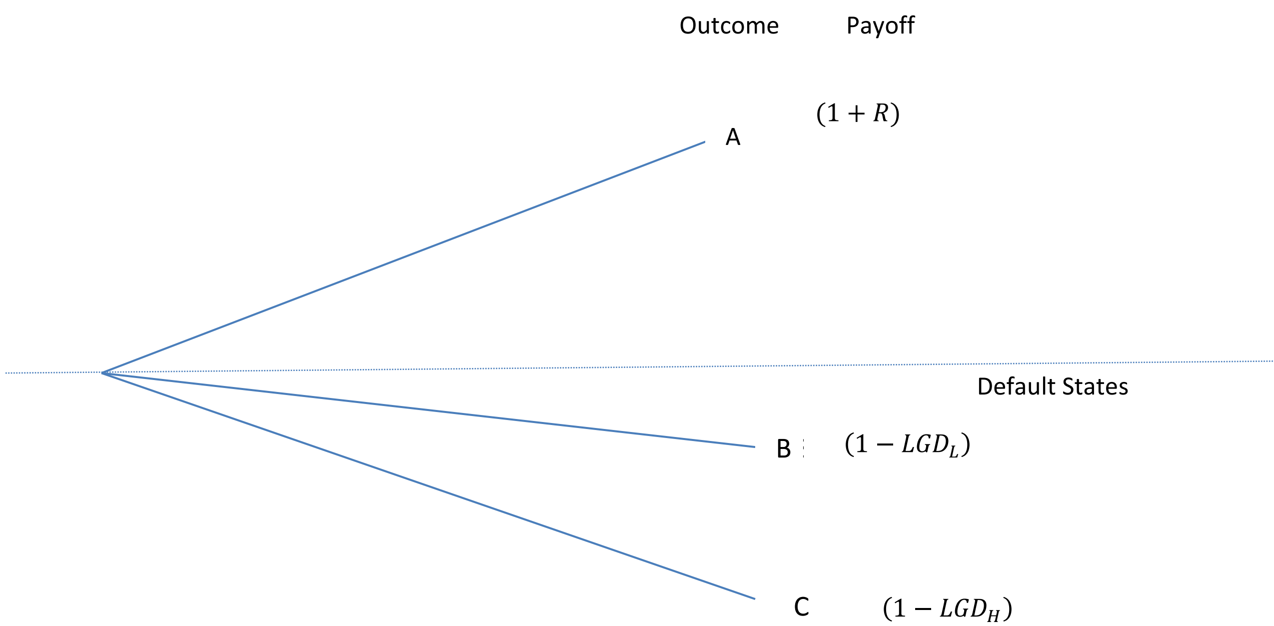
2.1 Simple Model of Loan Cash Flow Uncertainty

A principal can choose among many loan investment opportunities, each of which require an initial investment of 1, and promise to repay$(1 + R)$, R > 0, after a single period. These loan investments are risky and may default on their promised terminal payment. Should a loan default, the loan recovery value is uncertain. To simplify the exposition, I consider two possible recovery values, $1 > (1 - LGD_L) > (1 - LGD_H) \geq 0$, for, $0 < LGD_L < LGD_H < 1$. Under these assumptions, the realized loan maturity cash flows are represented by outcomes A, B and C in Figure 1.

[4] See for example [1], [2], [5], [6], [11], [12] or [13].

For simplicity, I assume the set of potential loan cash payments at maturity are identical for all potential borrowers in the pool of loan applicants from which the principal may select, but the probability associated with each of these loan maturity outcomes may differ among the applicants. While individual loan applicants may have different probabilities associated with the payoff outcomes, I assume the principal is unable to differentiate among individual loan applicants and assigns the unconditional probabilities, $\{P_A, (1 - P_A)P_B, (1 - P_A)(1 - P_B)\}$, to the payoff outcomes $\{A, B, C\}$ for any individual applicant. In this notation, P_A represents the probability of outcome A and P_B represents the probability of outcome B conditional on loan default. Consequently $(1 - P_A)P_B$ is the unconditional probability of outcome B and $(1 - P_A)(1 - P_B)$ is the unconditional probability of outcome C.

Figure 1: Payoff Outcomes for Risky Loan Investment



2.2 Loan Credit Risk Management Technology

I assume that the principal must hire risk managers to control two distinct functions: loan underwriting, and the loss mitigation collection processes used when loans default. When the principal can contract on risk manager effort, given the assumptions of this model, the contract terms are identical for both risk management functions. In the more interesting case when risk manager effort is unobservable and not contractible, the principal must offer each risk management function distinct contract terms to induce risk manager effort. As a consequence, I will model the contracting problem for the two functions separately.

I exogenously require the principal to hire managers for both risk management functions. In practice, the need to employ risk managers may arise for a number of reasons. For example, if the principal is managing a regulated financial intermediary, the regulatory authority may require the principal to employ staff to fulfill risk management functions as a minimum requirement to meet safety and soundness regulations.[5] Alternatively, the principal may hire risk managers as a means to protect his management tenure. The principal may decide to staff risk management functions as a signal to the board of directors, shareholders and creditors that he is satisfying his fiduciary responsibilities. Hiring risk managers may also provide an option to assign responsibility for loss realizations to the risk managers and thereby limit reputational damage to the principal. Regardless, I take the principal's need to hire risk managers as exogenous and study the conditions under which the principal will offer contract terms that encourage risk managers to expend effort to reduce the risk of the firm.

One risk management activity I consider is loan screening and underwriting. In this function, the risk manager expends effort to screen loan applicants in order to identify the counterparty that has the highest probability of fully performing on the loan contract terms. I assume that effort expended on screening activity can differentiate among individual applicants' probabilities of realizing outcome A [see Figure 1] and identify higher quality applicants with a full-performance probability, $\hat{P}_A$, that is higher than the unconditional pool average probability, P_A, $(\hat{P}_A > P_A)$.

A second form of risk mitigation I consider includes activities and processes that reduce loan losses when loans default. In this function a risk manager expends effort to increase the probability of receiving a high recovery value in the event of default. This may involve securing contingent legal rights to collateral at the time the loan is initiated as well as installing loss collection practices and designing covenant restrictions (or perhaps other specialized activities) that increase the probability of receiving a high recovery value in the event of default. I assume

[5] See for example Principles 15 and 16 in [18].

that successful loss mitigation requires that the principal contract for the loss mitigation risk manager before the loan is initiated (and cannot re-contract when default occurs) so that both risk managers must be under contract at the time of the initial loan investment.

I assume that risk managers can supply only two risk management effort levels, minimal effort and high effort. For simplicity I assume that the minimal effort level is 0. The level of effort expended on underwriting and screening is designated by $es \in \{0, es_H\}$. High underwriting effort can increase the probability that a loan fully performs. That is, $\mathrm{P}(A|es = 0) = P_A$, and $P(A|es = es_H) = \hat{P}_A > P_A$.

The technology through which the loss mitigation risk manager affects the loan payout probabilities differs slightly from the technology of the underwriter. Rather than assume that the loss mitigation risk manager can affect the unconditional payout probabilities, I assume that the loss mitigation manager can increase the probability of the high recovery state conditional on a default event. That is, I assume the loss mitigation risk manager can alter the conditional probabilities of the two recovery states without having any effect on the probability that the loan fully performs. The level of risk manager effort expended on loss mitigation activities is designated by, $elm \in \{0, elm_H\}$, with $P(B|default, elm = 0) = P_B$, and $P(B|default, elm = elm_H) = \hat{P}_B > P_B$.

I consider the optimal contract terms for both risk managers when the level of risk manager effort is observable and in the more interesting cases when the level of effort is unobservable. I assume the principal and any investors who provide the principal debt finance will evaluate investments as if they are risk neutral and evaluate outcomes based on the expected present value of cash flows.

I make the assumption that the loan investment is profitable for the principal when the risk managers are paid their reservation wages. I also assume that the market for risk managers does not differentiate between specialized underwriters or loss mitigation managers, but rather treats risk managers as fully capable of performing either the PD or LGD risk management function. I assume that the labor market conditions for risk managers sets a uniform risk manager reservation wage of $\ddot{w}$ for both risk management tasks.

The principal's expected profit after hiring both risk managers and paying the reservation wage is,

$$(1+R)P_A + (1-LGD_L)(1-P_A)P_B + (1-LGD_H)(1-P_B)(1-P_A) - 1 - 2\ddot{w}\,, \tag{1}$$

or,
$$R\,P_A - LGD_L(1-P_A)P_B - LGD_H(1-P_A-P_B+P_AP_B) - 2\ddot{w}. \tag{1a}$$

I assume that expression (1) is greater than or equal to R_f, the risk free rate of interest. To further simplify the model, I assume $R_f = 0$ because the risk free rate does not play a crucial role for the issues of interest in this paper.

3. Optimal Contracts for an Equity Financed Intermediary

In this section I consider a risk neutral principal's optimal contracting solutions for risk managers when the intermediary is financed with fairly priced equity. Under these assumptions, the principal will attempt to maximize the expected value of the profits that remain after he pays the risk managers their agreed upon wage and IC. Consistent with Modiglinai and Miller [15], it is also straight forward to show these actions will maximize the profits of a firm that is financed with equity and fairly-priced debt.

3.1 Risk Manager Utility

As is typical in the literature,[6] I assume that risk managers attempt to maximize the expected value of an indirect utility function that is separable between income and risk management effort,

$$U(w,e) = v(w) - g(e), e \in \{es, elm\} \tag{2}$$

$$v'(w) > 0, \qquad v''(w) \le 0, \qquad g(es_H) = g(elm_H) > g(0) = 0.$$

Expression (2) encompasses the case when risk managers are risk neutral (i.e., $v''(w) = 0$). A risk neutral manager has an indirect utility function of the form,

$v(w) = a_0 + a_1 w,\ a_0 \ge 0, a_1 > 0$. Without any loss of generality, when I subsequently analyze the contracting problem assuming risk neutral risk managers, I will make the simplifying assumption $a_0 = 0$ and, $a_1 = 1$. I also will assume that labor market conditions set both the screening and loss mitigation reservation wage at $\ddot{w}$.

[6] See for example, Chapter 14 in [16].

3.2 Optimal Risk Manager Contracts when Effort is Observable

The principal acts to maximize the expected profit that remains after paying the risk managers. When effort is observable and contractible, the principal will be willing to pay risk managers to exert a high effort if the incremental profit generated by the effort exceeds the additional pay the principal must offer to induce high effort. Because the effort level expended of one risk management can affect the profitability of high effort on the other risk management function, there are three contracting cases to consider: (1) low loss mitigation effort and high underwriting effort; (2) low underwriting effort and high loss mitigation effort; and, (3) high underwriting and loss mitigation effort. I will consider each of these cases in turn.

3.2.1 The Optimal Loan Underwriting Contracts when Loss Mitigation Effort is Low

Consider the principal's decision to offer only the loan underwriting risk manager a high-effort contract terms when the risk manager effort levels are observable and contractible. Let $N(w_s, es)$ be the underwriter's contract terms that specify the contract payment in state S, w_S, conditional on the risk manager's effort level, es. In order to get the risk manager to exert high effort, es_H, the contract terms must satisfy,

$$P(A|es = es_H)v[N(w_A, es_H)] + P(B|es = es_H)v[N(w_B, es_H)] + P(C|es = es_H)v[N(w_C, es_H)] - g(es_H) \geq v(\ddot{w}) \quad (3)$$

Expression (3) says that the risk manager's total expected utility from working and expending high effort must exceed (weakly) the utility from the reservation wage that the risk manager will receive if he expends no effort. If expression (3) holds as a strict inequality, the principal is over-paying to acquire the risk manager's services.

If the level of effort is observable and contractible, the principal can offer a fixed wage of ω, contingent on observing a high level of risk manager effort, such that

$$\omega = v^{-1}[v(\ddot{w}) + g(es_H)]. \quad (4)$$

The contract terms are, $N\left(w_{s,}es\right) = \{N(A, \omega, es_H), N(B, \omega, es_H), N(B, \omega, es_H)\}$.

Under this compensation contract, the principal's expected profit is,

$$\hat{P}_A(1 + R) + \left(1 - \hat{P}_A\right)[P_B(1 - LGD_L) + (1 - P_B)(1 - LGD_H)] - (\omega - \ddot{w}) - 2\ddot{w} - 1 \quad (5)$$

Hiring the underwriting risk manager is optimal provided,

$$(\hat{P}_A - P_A)\big(R + LGD_H - P_B(LGD_H - LGD_L)\big) - (\omega - \ddot{w}) \geq 0. \tag{6}$$

In expression (6), the risk manager's effort increases the probability of full loan payoff which reduces the overall probability of default and expected default loss. The contract is optimal provided the manager's effort increases the expected value of the loan proceeds by at least the required increase in wage payments, $(\omega - \dddot{w})$. The maximum wage the principal is willing to pay the underwriting risk manager, ω_S^{Max}, is

$$\omega_S^{Max} = \big(\hat{P}_A - P_A\big)[R + LGD_L\, P_B + LGD_H(1 - P_B)] + \ddot{w} \tag{6a}$$

3.2.2 The Optimal Loss Mitigation Contract when Underwriting Effort is Low

Consider the optimal contract terms needed to produce high loss mitigation effort when effort is observable and contractible and underwriter effort is low. It is optimal for the principal to offer a contract with a constant wage, $\omega = v^{-1}[v(\ddot{w}) + g(elm_H)]$, contingent on the loss mitigation risk manager expending high effort . The specific contract terms are $N\big(w_{lm,}elm\big) = \{N(A, \omega, elm_H), N(B, \omega, elm_H), N(C, \omega, elm_H)\}$. The principal will prefer this contract provided,

$$(1 - P_A)(\hat{P}_B - P_B)(LGD_H - LGD_L) - (\omega - \ddot{w}) \geq 0. \tag{7}$$

When the loss mitigation risk manager expends high effort, it increases the conditional probability of the high recovery state and thereby increases the expected value of the loan repayments in default. If the high effort risk mitigation activity increases the expected default recoveries by at least as much as the increase in the required wage payment, $(\omega - \ddot{w})$, then it will be optimal for the principal to offer this loss mitigation contract. The maximum wage for which the principal is willing to hire the loss mitigation risk manager, ω_{LM}^{Max}, is

$$\omega_{LM}^{Max} = (1 - P_A)\big(\hat{P}_B - P_B\big)(LGD_H - LGD_L) + \ddot{w} \tag{7a}$$

An interesting feature of expression (7) is that the value of high loss mitigation effort is reduced if the probability of full loan performance increases. When loans have a very high probability of full performance, the principal is less likely to expend additional resources to manage recovery risk.[7]

3.2.3 Contracts that Induce High Underwriting and Monitoring Effort

Consider the principal's contracting problem for securing high effort from both risk managers when risk manager effort is observable and contractible. To induce high effort, the principal must offer each risk manager a fixed wage of $\omega = v^{-1}[v(\ddot{w}) + g(es_H)] = v^{-1}[v(\ddot{w}) + g(elm_H)]$. It will be optimal to hire both risk managers under contracts that induce high effort provided,

$$\left(\hat{P}_A - P_A\right)(R + LGD_H) + \left[\hat{P}_B - P_B - \hat{P}_A\hat{P}_B + P_A P_B\right](LGD_H - LGD_L) - 2(\omega - \ddot{w}) \geq 0, \quad \text{(8a)}$$

$$(\hat{P}_A - P_A)\left(R + LGD_H - \hat{P}_B(LGD_H - LGD_L)\right) - (\omega - \ddot{w}) \geq 0, \quad \text{(8b)}$$

$$\left(1 - \hat{P}_A\right)\left\{(\hat{P}_B - P_B)(LGD_H - LGD_L)\right\} - (\omega - \ddot{w}) \geq 0. \quad \text{(8c)}$$

Expression (8a) is a necessary condition, but in addition it must be the case that the incremental profit generated by both risk managers' high effort levels adds value that exceeds the increase in the required wage payment needed to induce high effort when both are employed. These conditions are ensured when expressions (8b) and (8c) are satisfied. If condition (8b) is violated, it will be optimal for the principal to offer the underwriting risk manager a simple reservation wage contract, $\ddot{w}$, and a high effort contract to the loss mitigation risk manager provided expression (7) is also satisfied. Should condition (8c) be violated, the principal will offer the loss mitigation risk manager a simple reservation wage contract $\ddot{w}$ and the underwriting risk manager contract for high effort provided expression (6) is satisfied.

3.3 An Example when Effort is Observable and Contractible

To illustrate optimal contract solutions when effort is contractible, consider the loan maturity payoffs and associated probabilities in Table 1. Table 2 shows state-contingent loan payments conditional on different levels of risk manager effort.

[7] My own past bank supervisory experience is consistent with this finding. A typical successful sub-prime focused lender will have a large and experienced staff dedicated to the collection process whereas a lender focused on extending prime credit will typically dedicate few resources to the collection function.

Table 1: Risk Management Contract Stylized Example

Outcome	Outcome Payoff	Outcome Probability Conditional on Default	Outcome Unconditional Probability	Outcome Probability Conditional on Default and High Effort	Outcome Probability Conditional on High Effort
A	1.20		.80		.90
B	.95	.50	.10	.90	.09
C	.45	.50	.10	.10	.01

Table 2: Expected Loan Cash Flows as Function of Risk Manager Effort

Risk Manager Effort	Expected Loan Payment	Marginal Expected Payoff from High Loss Mitigation Effort	Marginal Expected Payoff from High Underwriting Effort
No Effort	1.10		
High Underwriting Effort	1.15		.05
High Loss Mitigation Effort	1.14	.04	
High Underwriting and Loss Mitigation Effort	1.17	.02	.03

The principal will offer both risk managers high effort contract terms provided each manager's effort generates additional profit at least as large as the required increase in the wage payment necessary to induce effort. Assume that risk managers are risk averse with utility functions that are separable among wages and the disutility of effort. I assume the managers have Bernoulli utility functions over wages given by,

$$v(w) = 1 - e^{-2w} \tag{9}$$

and disutility of effort given by, $g(es_H) = g(elm_H) = 0.02$. If risk managers have a reservation wage of $\ddot{w} = .02$, then the wage needed to induce a high effort from the underwriter is, $\omega \ni \left[1 - e^{-2\ddot{\omega}}\right] = [1 - e^{-2*\omega} - g(es_H)]$, or 0.030518. So the marginal cost of high effort is (0.030518-.02)=0.010518.

Table 3 shows the expected profit outcomes associated with alternative contracting solutions under the assumed risk managers' preferences. In this example, the highest expected profit outcome is for the principal to offer both risk managers high effort contracts. The additional expected loan proceeds generated by loss mitigation effort given high underwriter effort is 0.02. The additional expected proceed generated by high underwriting effort given high loss mitigation effort is 0.03. Both additions exceed the wage increment need to secure high effort from each manager (0.010518).

Table 3: Risk Manager Compensation and Principal's Profit as a Function of Risk Manager Effort when Effort is Observable and Contractible

Risk Manager Effort	Expected Loan Payments	Required Total Compensation	Principal Expected Profit
No Effort	1.10	0.04	0.06
High Underwriting Effort	1.15	0.050518	0.099482
High Loss Mitigation Effort	1.14	0.050518	.089482
High Underwriting and Loss Mitigation Effort	1.17	.061036	0.108964

If the labor market conditions for risk managers, or risk manager preferences differ from those in the prior example, the optimal solution may change and it may no longer be optimal for the principal to offer both managers high effort contracts. Consider an example with a higher disutility attached to risk manager effort: $g(es_H) = g(elm_H) = 0.04$. In this case, the risk managers must be offered a wage of 0.041262, and the marginal cost of inducing high effort is 0.021262. Under these risk manager preferences, the principal would only offer the underwriter a high effort contract.

4. Optimal Contracts when Effort is Unobservable and Risk Managers are Risk Neutral

If the risk manager's effort is unobservable and not contractible, theory suggests that it may be possible to construct a contract with IC that produces a first best outcome–the outcome when effort is contractible–if the risk manager is risk neutral. When effort is unobservable, to induce high effort, the principal must offer each risk manager a contract with an IC component that pays in states where the individual risk manager's effort contributes to improved performance.

4.1 Pure IC Contracts

Initially I consider contracts that include only incentive-based compensation. Such contracts offer no fixed wage component but only compensate risk managers in the states where their effort levels can improve performance. Pure IC contracts may induce optimal risk manager effort but they may also require payments that are infeasible. Contracts that include a fixed wage component in addition to IC can sometimes be used to overcome the feasibility constraint and replicate the principal's first best solution. However, in some situations, the addition of a fixed wage will not solve the contracting problem. The fixed wage component reduces the manager's incentive to work which can cause a violation of the incentive compatibility constraint.

The important conclusion from this section is that when effort is unobservable and not contractible, IC contracts that induce a high effort outcome must offer the underwriter and the loss mitigation risk manager different contract terms. Once effort is unobservable and contractible, each of the risk management functions must be compensated with distinctly different IC terms to induce high effort.

When the risk manager is risk neutral and effort is contractible, a high effort outcome can be achieved by contracts that offer both risk managers constant wages of $w_{RN} = \ddot{w} + g(es_H) = \ddot{w} + g(elm_H)$ conditional on observing high levels of effort. If these contracts are optimal, they are the first best contracting solutions for the principal. When risk managers are risk neutral, and effort is not observable, they will still need to be paid under a contract that provides them expected compensation of w_{RN}. There are three contracting cases that must be considered: (1) low loss mitigation effort and high underwriting effort; (2) low underwriting effort and high loss mitigation effort; and, (3) high underwriting and loss mitigation effort.

4.2 Pure IC Contracts for High Underwriting Effort when Loss Mitigation Effort is Low

When effort is unobservable, a risk neutral underwriting manager will be indifferent to expending a high level of effort under an IC only contract that pays, $w_{RN}(\hat{P}_A)^{-1}$ in state A, when the loan fully performs. In states B and C the contract pays the manager no compensation. The contract payment in state A must also be feasible, $w_{RN}(\hat{P}_A)^{-1} \leq (1+R)$, and the contract must be incentive compatible meaning the manager must also prefer to exert high effort instead of shirking and providing minimal effort.

The incentive compatibility constraint can be evaluated by introducing a wage rate 'slack variable,' s_U (underwriting wage slack).[8] The pure IC contract will be incentive compatible provided that $s_U \leq 0$, where s_U is defined implicitly by expression (10),

$$\hat{P}_A(w_{RN} + s_U)(\hat{P}_A)^{-1} - g(es_H) = P_A\, w_{RN}(\hat{P}_A)^{-1} \;, \tag{10}$$

or,

$$s_U = P_A(\hat{P}_A)^{-1}[\, g(es_H) + \ddot{w}] - \ddot{w} \leq 0. \tag{10a}$$

If $s_U \leq 0$, the contract is incentive compatible and the risk manager will expend high effort

[8] Introducing slack variables with corresponding inequality constraints is a method of insuring that the inequality optimization conditions are satisfied.

under the proposed contract terms.[9] If $s_U > 0$, the risk manager will accept the contract but shirk and put forth only minimal effort and the first best contracting solution for inducing high underwriting effort will not be attainable.

4.3 Pure IC Contracts for High Loss Mitigation Effort when Underwriting Effort is Low

Now consider the pure IC contract that will generate high loss mitigation effort from a risk neutral manager when underwriting effort is low. The loss mitigation manager will be indifferent to exerting high effort provided his contract pays, $w_{RN}\left[(1-P_A)\hat{P}_B\right]^{-1}$ when outcome B occurs. The contract makes no payment in states A or C. The contract is feasible provided, $w_{RN}\left[(1-P_A)\hat{P}_B\right]^{-1} \leq (1-LGD_L)$. It will be incentive compatible if,

$$(1-P_A)\hat{P}_B\, w_{RN}\left[(1-P_A)\hat{P}_B\right]^{-1} - g(elm_H) \geq (1-P_A)P_B\, w_{RN}\left[(1-P_A)\hat{P}_B\right]^{-1} \qquad (11)$$

I define a slack variable s_{LM} (loss mitigation compensation slack) implicitly in expression (12) to evaluate the incentive compatibility constraint for loss mitigation effort. Using the slack variable, the performance-linked contract will be incentive compatible when $s_{LM} \leq 0$,

$$(1-P_A)\,\hat{P}_B\,(w_{RN}+s_{LM})\left[(1-P_A)\hat{P}_B\right]^{-1} - g(elm_H) = (1-P_A)P_B w_{RN}\left[(1-P_A)\hat{P}_B\right]^{-1}$$

or,

$$s_{LM} = P_B\left(\hat{P}_B\right)^{-1}\left[g(elm) + \dddot{w}\right] - \grave{\dddot{w}} \leq 0. \qquad (12)$$

If the incentive compatibility constraint is not satisfied, $s_{LM} > 0$, the risk manager accepts the contract, but shirks and the first best contracting solution is not attainable. If $s_{LM} < 0$, the principal is paying more than is necessary to induce high effort.

4.4 Pure IC Contracts for High Loss Mitigation and Underwriting Effort

Now consider the pure IC contract design that produces high effort from both risk managers when they are risk neutral. To induce high effort, the underwriting risk manager must be offered a contract that satisfies the conditions in expression (10) and the loss mitigation risk

[9] If $s_U < 0$, i.e. the strict inequality held, the principal would be overpaying the risk manager and could reduce the state contingent payment by s_U.

manager should receive a contract that pays, $(w_{RN})\left[(1-\hat{P}_A)\ \hat{P}_B\right]^{-1}$, when outcome B is realized, and pays nothing in states A and C. These contracts will be optimal provided,[10]

$$\left(\hat{P}_A - P_A\right)(R + LGD_H) + \left[\hat{P}_B - P_B - \hat{P}_A\hat{P}_B + P_A P_B\right](LGD_H - LGD_L) - 2(w_{RN} - \ddot{w}) \geq 0, \quad \text{(12a)}$$

$$(\hat{P}_A - P_A)\left(R + LGD_H - \hat{P}_B(LGD_H - LGD_L)\right) - (w_{RN} - \ddot{w}) \geq 0, \quad \text{(12b)}$$

$$\left(1 - \hat{P}_A\right)\left\{\left(\hat{P}_B - P_B\right)(LGD_H - LGD_L)\right\} - (w_{RN} - \ddot{w}) \geq 0, \quad \text{(12c)}$$

$$s_U = \frac{P_A}{\hat{P_A}}\ [g(es_H) - \ddot{w}] - \ddot{w}\ ,\ s_{LM} = \frac{P_B}{\hat{P_B}}[g(elm) + \ddot{w}] - \ddot{\dot{w}}, \quad s_U \leq 0, s_{LM} \leq 0, \quad \text{(12d)}$$

$$w_{RN}\left[(1 - P_A)\hat{P}_B\right]^{-1} \leq (1 - LGD_L), \quad \text{(12e)}$$

$$w_{RN}\left(\hat{P}_A\right)^{-1} \leq (1 + R). \quad \text{(12f)}$$

Expression (12a) is a necessary condition that ensures that hiring both risk managers under high-effort contracts generates expected profits in excess of those the principal earns when the managers are paid their reservation wage. Condition (12b) ensures that the effort expended by the underwriting risk manager creates additional profits that exceed the extra expected wage costs required to induce effort when the loss mitigation manager is also expending high effort. Condition (12c) ensures that the risk mitigation manager's additional effort produces an increment to expected profit that exceeds the expected compensation premium he must be paid to induce effort when the underwriting risk manager is also expending high effort. Conditions (12d) are the incentive compatibility conditions that ensure that both risk managers choose to exert a high level of effort under their outcome-dependent contracts terms. Expression (12e) and (12f) are the contract feasibility conditions.

4.5 An Example of Pure IC Contracts when Effort is Unobservable

In this section, I consider a specific example in which risk managers are risk neutral and effort is unobservable. To establish a baseline for comparison, I first consider the optimal contract when effort is fully observable and contractible assuming manager's utility function satisfy $v(w) = w,\ g(es_H) = g(elm_H) = 0.0125,$ with a reservation wage rate, $\ddot{w}$=0.1. Under these assumptions, the optimal contract will pay each risk manager a fixed salary of 0.1125 conditional on observing high effort. The marginal cost of inducing high effort is .0125.

[10] The incentive compatibility constraint for the loss mitigation manager is dependent on the effort level expended by the underwriting risk manager.

Under the loan maturity payoff assumptions in Table 1, when effort is contractible, the principal will find it optimal to offer both risk managers a fixed salary of 0.1125 conditional on a observing a high level of effort. It is optimal to offer both risk managers high-effort contracts because, in each case, the marginal cost of inducing high effort (.0125) is less than or equal to the additional expected loan proceeds generated by each risk manager's additional effort.

When effort is unobservable and not contractible, the principal could offer the underwriter a pure IC contract that pays, $\frac{\overline{W_{RN}}}{\widehat{P_A}} = \frac{0.1125}{0.90} = 0.125$, when outcome A is realized and 0 states B and C. If the underwriter accepts the contract and expends high effort his utility is $0.9 * \frac{0.1125}{0.9} - .0125 = .1$. Should the underwriter accept the contract and exert no effort, his utility will be, $\frac{0.80*0.1125}{0.90}$=0.1, and so he is indifferent between exerting high effort and shirking. I assume (as is typical in this literature) that the manager exerts high effort in this case, and so the contract is incentive compatible.

When effort is unobservable and not contractible, the loss mitigation manager would be indifferent to exerting high effort under a pure IC contract that pays $\frac{\overline{W_{RN}}}{(1-\widehat{P_A})\widehat{P_B}} = \frac{0.1125}{(1-0.90)*0.75} = 1.5$, when outcome B is realized and 0 in states A and C. This pure IC contract is, however, not feasible (1.5 >0.95).

4.6 Optimal Contracts that Include a Fixed Wage and IC

I now consider contracts that offer the risk manager a fixed wage component in addition to targeted IC. The fixed wage component can reduce the size of the IC payments that are necessary to induce effort and make the contract feasible. However, offering a fixed wage component reduces the incentive to expend effort. The fixed wage may lead to a violation of the incentive compatibility condition and in these cases it will be impossible to replicate a first best solution using a feasible mixed IC contract.

Consider the optimal contract terms for the underwriting risk manager when the contract pays a fixed wage less than the reservation wage and IC compensation in state A. Let the contract's fixed wage be, $\ddot{w} - \varphi_s$, $0 \leq \varphi_s \leq \ddot{w}$. Let π_s represent the contact IC payment in state A. For the contract to be incentive compatible, the underwriter must be indifferent to expending high effort and shirking. The incentive compatible condition is,

$$\ddot{w} - \varphi_s + \hat{P}_A \pi_s - g(es_H) \geq \ddot{w} - \varphi_s + P_A \pi_s, \tag{13}$$

or, $\pi_s \geq \left(\hat{P}_A - P_A\right)^{-1} g(es_H)$.

The underwriter will be indifferent to taking the contract and providing high effort provided,

$$\ddot{w} - \varphi_s + \hat{P}_A \pi_s - g(es_H) = \ddot{w} \tag{14}$$

Solving (14) simultaneously with the minimum bonus payment that satisfies the incentive compatible condition, $\pi_s^* = \left(\hat{P}_A - P_A\right)^{-1} g(es_H)$, implies,

$$\varphi_s^* = g(es_H)\, P_A \left(\widehat{P_A} - P_A\right)^{-1} \tag{15}$$

Under the optimal contract terms, (φ_s^*, π_s^*), it can be shown that the underwriting risk manager will expend high effort and the principal's expected payment for underwriting services is $\ddot{w} + g(es_H)$. The contract will be feasible provided , $\varphi_s^* + \pi_s^* \leq (1+R)$, and $\varphi_s^* \leq (1 - LGD_H)$. If the contract (φ_s^*, π_s^*) is feasible, it will replicate the principal's first best solution for underwriting risk manager.

Now consider the optimal contract terms for the risk neutral loss mitigation risk manager. Let the contract's fixed wage be, $\ddot{w} - \varphi_{LM}$, $0 \leq \varphi_{LM} \leq \ddot{w}$. Let π_{LM} represent the contract's IC paid in state B. Assuming that the screening risk manager is expending high effort, the contract will be incentive compatible if the loss mitigation manager is indifferent between expending high effort and shirking. The incentive compatible condition is,

$$\ddot{w} - \varphi_{LM} + \left(1 - \hat{P}_A\right)\hat{P}_B \pi_{LM} - g(elm_H) \geq \ddot{w} - \varphi_{LM} + (1 - \hat{P}_A) P_B \pi_{LM}, \tag{16}$$

or, $\pi_{LM} \geq \left[\left(\hat{P}_B - P_B\right)\left(1 - \hat{P}_A\right)\right]^{-1} g(elm_H)$

The loss mitigation manager will be indifferent to expending high effort when,

$$\ddot{w} - \varphi_{LM} + \left(1 - \hat{P}_A\right)\hat{P}_B \pi_{LM} - g(elm_H) = \ddot{w} \tag{17}$$

Solving (17) simultaneously with the minimum bonus payment that satisfies the incentive compatible condition, $\pi_{LM}^* = \left[\left(\hat{P}_B - P_B\right)\left(1 - \hat{P}_A\right)\right]^{-1} g(elm_H)$, implies,

$$\varphi_{LM}^* = g(elm_H)\, P_B \left(\hat{P}_B - P_B\right)^{-1}. \tag{18}$$

This contract, $(\varphi_{LM}^*, \pi_{LM}^*)$, is feasible provided, $2\ddot{w} - \varphi_s^* - \varphi_{LM}^* \leq (1 - LGD_H)$, $2\ddot{w} - \varphi_s^* - \varphi_{LM}^* - \pi_{LM}^* \leq (1 - LGD_L)$, and $2\ddot{w} - \varphi_s^* - \varphi_{LM}^* - \pi_s^* \leq (1+R)$. If the contract terms are feasible, they will replicate the principal's first best solution.

Alternatively, if the underwriting risk manager expends only minimal effort $(es = 0)$, the optimal loss mitigation manager's optimal fixed wage payment is unchanged $(\ddot{w} - \varphi_{LM})$, but the optimal required incentive compensation is reduced,

$$(\pi_{LM}^{*}|\, es = 0) = \left[\left(\hat{P}_B - P_B\right)(1 - P_A)\right]^{-1} g(elm_H). \qquad (19)$$

The feasibility conditions for this contract are, $2\dddot{w} - \varphi_{LM}^{*} \leq (1 - LGD_H)$ and,

$2\dddot{w} - \varphi_{LM}^{*} - (\pi_{LM}^{*}|es = 0) \leq (1 - LGD_L)$. This contract will replicate the principal's first best solution provided the goal is to induce high effort from the loss mitigation manager alone.

4.7 An Example Contract with Wage and IC Components

Continuing with the assumptions of the prior example, when the optimal contract may include both a wage and an incentive compensation component, it is straight forward to show that the optimal contract terms are: $(\varphi_S^{*} = .1, \pi_S^{*} = .125)$, and, $(\varphi_{LM}^{*} = .015625, \pi_{LM}^{*} = .3125)$. Based on these wage and profit terms, the contracts promised state payments are: $\{N_s(A, 0.125, na), N_s(B, 0, na), N_s(C, 0, na)\}$, and, $\{N_{LM}(A, 0.084375, na), N_{LM}(B, 0.084375, .3125), C_{LM}(N, 0.084375, na)\}$.

In this example, the underwriting risk manager's contract must be entirely IC if it is to create a sufficiently strong incentive for high effort. If a fixed wage component is included as a partial substitute for IC, the manager will shirk and expend only minimal effort The loss mitigation manger's contract, in contrast, has both a large fixed wage component as well as a substantial IC payout in state B. The fixed wage component is necessary to make the size of the required IC payment feasible.

5. Optimal Risk Manager Contracts with Equity and Subsidized Insured Deposit Funding

5.1 Subsidized Deposit Insurance Funding

In this section I assume that the principal can use government-insured deposits to partially fund the loan investment. I assume that savers value insured deposits as if they are completely risk free and the government provides insurance without charge on deposits up to an exogenous limit (e.g., a maximum percentage of the value of the loan amount).

Recognizing the required payment of risk managers' reservation wages, the principal's ability to issue risk free deposit funding without government insurance support is, $(1 - LGD_H -$

$2\ddot{w}$). If the principal issues up to $(1 - LGD_H - 2\ddot{w})$ in deposits, the firm will be financed with equity and risk free debt and the expected cash flows to the principal are identical to expression (1a).[11]

When insured deposits exceed, $(1 - \mathrm{LGD_H} - 2\ddot{w})$, there is risk that the deposits cannot be a repaid from the loan investment proceeds. I assume that any shortfalls are paid by the deposit insurer. Because investors treat deposits as risk free, the principal will always choose to issue the maximum amount of insured deposits allowed by government in this stylized model.

Let h be the balance of deposits that are insured by the government without cost to the principal. Figure 2 illustrates the issuance of insured deposits up to a limit set by the value h. Because insured deposits offer a subsidy, the principal will maximize their use and issue deposits in amount, $(1 - LGD_H - 2\ddot{w} + h)$. In practice, the value of h is determined implicitly by regulatory capital requirements which are taken as exogenous in this analysis.

Since all deposits are treated as risk free by depositors, if the firm initially raises $\left(1 - LGD_H - 2\dddot{w} + h\right)$ in deposits, the terminal value of these deposits will be $(1 + LGD_H - 2\ddot{w} + h)$, where the shortfall in revenues necessary to pay deposits (h) will be paid by the deposit insurer in state C.[12] Without insurance, the initial fair market value of these deposits would be, $\left(1 - LGD_H - 2\dddot{w}\right) + (P_A + P_B - P_A P_B)h$. The difference between these two values is the value of the deposit insurance subsidy to the principal, $[1 - P_A - P_B + P_A P_B]\ h$.

If the principal pays both risk managers the reservation wage, the principal's expected profit when funding with insured deposits is,

$$P_A(R + LGD_H - h) + (1 - P_A)P_B(LGD_H - LGD_L - h) - LGD_H + h - 2\ddot{w}. \tag{20}$$

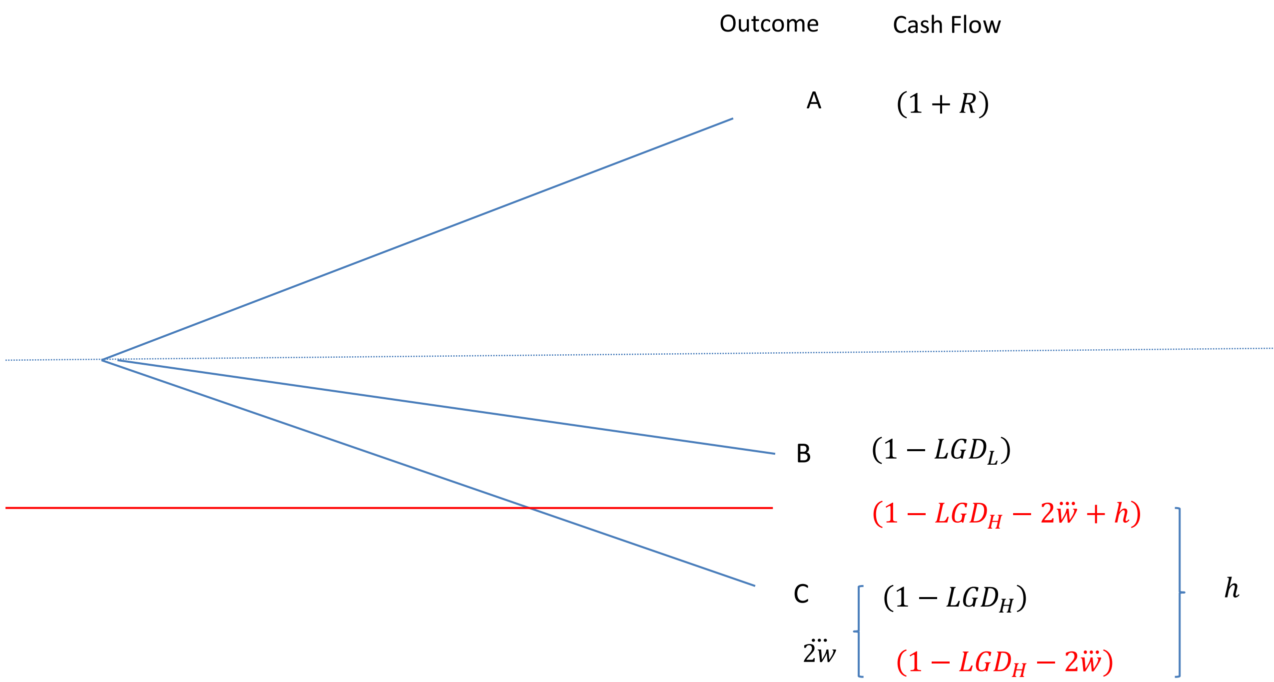
Expression (20) can be rewritten to isolate the value of the deposit insurance subsidy,

$$R\ P_A - LGD_L(1 - P_A)P_B - LGD_H(1 - P_A - P_B + P_A P_B) + [1 - P_A - P_B + P_A P_B]\ h - 2\ddot{w}. \tag{20a}$$

In expression (20a), the term, $[1 - P_A - P_B + P_A P_B]h$, is the value of the subsidy generated by mispriced deposit insurance and so the value of the principal's profit is the value of the unlevered firm's profit (expression (1a)) plus the value of the insured deposit subsidy.

[11] This is consistent with the Modigliani-Miller theorem [15].
[12] Recall the risk free rate is assumed to be 0.

Figure 2: Payoff Outcomes with Insured Deposit Funding



5.2 Optimal Risk Manager Compensation when Effort is Contractible

5.2.1 Optimal Contract for High Loss Mitigation Effort with Deposit Insurance

If the level of effort is observable and contractible, the principal can offer a fixed wage, ω, contingent on observing a high level of effort. Consider the principal's option of offering only the loss mitigation manager a high-effort contract. The condition for this strategy to be profitable is,

$$\begin{aligned}&(LGD_H - LGD_L)\big(\hat{P}_B - P_B\big)(1 - P_A)\\ &-(\omega - \ddot{w})\left(P_A + \hat{P}_B(1 - P_A)\right) - h\big(\hat{P}_B - P_B\big)(1 - P_A) \geq 0\,. \end{aligned} \tag{21}$$

Expression (21) differs from expression (7) in two ways. In expression (21), the principal gains an additional benefit from the deposit insurer because in state C the wage increment required to produce high effort is at risk and will be paid by the deposit insurer.[13] In other words, the risk manager effort premium $(\omega - \ddot{w})$ is partially subsidized by the deposit insurer and so the

[13] The increment above the reservation wage cannot be paid by the loan maturity cash flow realized in state C.

principal's expected wage bill is reduced by, $(\omega - \ddot{w})\left((1-\hat{P}_B)(1-P_A)\right)$. The second source of difference between expression (7) and (21) is the loss mitigation risk manager's effort lowers the value of the deposit insurance subsidy by $h(\hat{P}_B - P_B)(1-P_A)$.

The highest wage the principal is willing to pay the loss mitigation manager for high effort can be derived by solving for high effort wage that makes expression (21) an equality. Defining this wage level as , $\omega(ins)_{LM}^{Max}$,

$$\omega(ins)_{LM}^{Max} = \frac{(1-P_A)(\hat{P}_B - P_B)}{P_A + \hat{P}_B(1-P_A)}(LGD_H - LGD_L - h) + \ddot{w} \tag{21a}$$

Comparing the maximum willingness to pay for loss mitigation effort for a fully equity financed firm (7a) and one that receives a deposit insurance subsidy (21a), the difference is,

$$\omega_{LM}^{Max} - \omega(ins)_{LM}^{Max} =$$

$$\left(P_A + \hat{P}_B(1-P_A)\right)^{-1}\left[h + (LGD_H - LGD_L)\left(1 - (1-P_A)(\hat{P}_B - P_B)\right)\right]. \tag{22}$$

This difference (22) is always greater than 0 and increasing in h. Depending on the premium required to secure high effort, the principal may still decide to offer a high-effort loss mitigation contract with subsidized deposit insurance, but this outcome becomes increasingly unlikely as, h, the allowable amount of subsidized insured deposit funding increases. There is an effort wage premium threshold, above which, the principal will forgo contracting for high loss mitigation effort in the deposit insurance case even though the principal would choose a high-effort contract if the loan was funded with fairly priced debt and equity. This result establishes that, other things equal, the deposit insurance subsidy weakens the principal's demand for risk mitigation effort. A similar result holds when the principal offers the loss mitigation manager a high-effort contract while the underwriter is also being offered a high-effort contract.[14]

5.2.2 Optimal Contract for High Underwriting Effort with Deposit Insurance

Consider the principal's option of offering only the underwriting risk manager high-effort contracts terms. The optimality condition for this strategy is,

[14] In this case, the difference in maximum willingness to pay for loss mitigation effort is $\left(\hat{P}_A + \hat{P}_B(1-\hat{P}_A)\right)^{-1}\left[h + (LGD_H - LGD_L)\left(1 - (1-\hat{P}_A)(\hat{P}_B - P_B)\right)\right] > 0$.

$$\left(\hat{P}_A - P_A\right)[R + LGD_H - P_B(LGD_H - LGD_L) - h(1 - P_B)]$$
$$-(\omega - \ddot{w})\left(\hat{P}_A + \left(1 - \hat{P}_A\right)P_B\right) \geq 0. \tag{22}$$

Expression (22) differs from expression (6) because effort alters the subsidy value of the insured deposits. The direct reduction in the deposit insurance subsidy generated by high underwriter effort is, $-\left(\hat{P}_A - P_A\right)(1 - P_B)\ h < 0$, for $h > 0$. There is an additional impact because the extra effort reduces the probability that the deposit insurer will have to pay the additional cost of high effort in state C. The expected cost of high effort in expression (22) is $(\omega - \ddot{w})\left(\hat{P}_A + \left(1 - \hat{P}_A\right)P_B\right)$ which is reduced compared to $(\omega - \ddot{w})$ in expression (8) because the deposit insurer pays the effort premium in state C.

The maximum value the principal is willing pay for high effort when the investment is funded with insured deposits is, $\omega(ins)_S^{Max}$,

$$\omega(ins)_S^{Max} = \beta\left(\hat{P}_A - P_A\right)[\alpha - h(1 - P_B)] + \ddot{w}\ , \tag{23}$$

where, $\alpha = R + LGD_H - P_B(LGD_H - LGD_L)$, and $\beta = \left(\hat{P}_A + \left(1 - \hat{P}_A\right)P_B\right)^{-1}$.

Expression (23) can be compared to expression (6a), the maximum high-effort wage (ω_S^{Max}) the principal will be willing to offer when the firm's debt and equity is fairly priced. The difference between expression (6a) and expression (23) represents the difference in the maximum willingness to pay for high underwriting effort that is induced by subsidized deposit funding,

$$\omega_S^{Max} - \omega(ins)_S^{Max} = \left(\hat{P}_A - P_A\right)[\alpha(1 - B) + h\beta(1 - P_B)]. \tag{24}$$

It can be shown that,

$$\omega_S^{Max} - \omega(ins)_S^{Max} \geq 0 \Leftrightarrow h \geq \left(\frac{1-\hat{P}_A}{\hat{P}_A - P_A}\right)(\omega_S^{max} - \ddot{w}) \tag{25}$$

Expression (25) says that the principal's willingness to pay for high underwriting effort will decline under subsidized deposit insurance provided that the amount of deposits at risk is large enough.

The intuition behind expression (25) is as follows. When h is positive, the firm cannot pay its depositors and the risk manager from the proceeds of the loan in state C. So the deposit insurer takes ownership and makes the payments. So the principal does not make the promised contract payment to the underwriter in state C.

When h is very small, the primary source of the subsidy from deposit insurance is that insurer's pays the underwriter's effort premium $(\omega - \ddot{w})$ in state C. So when h is very small, the biggest effect of deposit insurance is a subsidy for underwriting effort, and the principal may actually be willing to pay more for underwriting risk management for small values of h because the wage subsidy for high effort is larger than the high effort impact on a diminished deposit insurance subsidy on h. A case like this only happens when the amount of subsidized deposits are small relative to the maximum effort premium that might be offered in the absence of deposit insurance. In reality, the subsidization of the risk manager wage rate in default states is unlikely to the primary distortion caused by mispriced deposit insurance, and so I will focus on cases in which the amount of insured deposits at risk are sufficiently large so that that the insurance funding subsidy drives the principal's incentives.

5.2.4 Optimal High-Effort Risk Manager Contracts with Deposit Insurance

Taken together, expressions (21) and (25) show that mispriced deposit insurance reduces the principal's incentives to offer high-effort contracts to either risk manager even when effort is fully observable and contractible. With insured deposit funding, there are circumstances under which the principal will not offer a high-effort contract to either the underwriter or the loss mitigation risk manager (or perhaps not to both) when the principal would find it optimal to offer high effort contracts in the absence of the deposit insurance subsidy. These results are consistent with well-known findings in the literature that mispriced deposit insurance creates incentives for banks to increase their asset risk in order to maximize the value of the deposit insurance subsidy.[15]

The following optimality conditions must hold for the principal to find it optimal to offer both risk managers high effort contracts when the investment is funded with insured deposits and effort is observable and contractible:

$$\left(\hat{P}_A - P_A\right)(R + LGD_H - h) + \left[\left(1 - \hat{P}_A\right)\hat{P}_B - (1 - P_A)P_B\right](LGD_H - LGD_L - h) - 2\gamma \geq 0, \quad \text{(26a)}$$

$$\left(\hat{P}_A - P_A\right)\left[R + LGD_H - \hat{P}_B(LGD_H - LGD_L) - h\left(1 - \hat{P}_B\right)\right] - \gamma \geq 0, \quad \text{(26b)}$$

$$(LGD_H - LGL_L - h)\left(\hat{P}_B - P_B\right)\left(1 - \hat{P}_A\right) - \gamma \geq 0, \quad \text{(26c)}$$

[15] See, for example [3], [4], [7], [11], [12], or [13].

where, $\gamma = (\omega - \ddot{w})(\hat{P}_A + (1 - \hat{P}_A)\hat{P}_B)$. Condition (26a) ensures that hiring both managers using high-effort contracts produces a profit gain over the no effort contracting solution. Condition (26b) ensures that the added profit from hiring the underwriter under a high effort contract conditional on high loss mitigation effort exceeds the compensation necessary to produce the effort. Condition (26c) ensures that paying the loss mitigation manager for high effort conditional on high underwriting effort produces an expected profit.

5.3 Example of Risk Manager Contracts with Deposit Insurance when Risk Manager Effort is Observable and Contractible

In this example, I repeat the assumptions of example 1 and add the additional assumption that the firm funds itself with insured deposits up to the limit, $h = 0.30$. Effort is observable and conrtactible. As in the first example, the loan maturity payoffs are given in Table 1 and risk managers are risk averse with separable Bernoulli utility functions over wages given by, $v(w) = 1 - e^{-2w}$, and the disutility of effort given by, $g(es_H) = g(elm_H) = 0.02$. As in the first example, the reservation wage is $\ddot{w} = 0.02$, then the wage needed to induce a high level of effort is, $\omega = 0.030518$. With $h = 0.30$, the bank will fund itself with 0.71 of insured deposits. Table 4 summarizes all the critical values needed to determine the optimal contracting solution when the principal can make use of subsidized deposit insurance funding.

Table 4: Expected Principal Profit as Function of Risk Manager Effort

Risk Manager Effort	Expected Loan Payments	Expected Profit to Principal	Deposit Insurance Subsidy	Expected Profit w/o deposit Insurance
No Effort	1.10	.09	.03	.06
High Underwriting Effort Only	1.15	0.115008	.015526	.099482
High Loss Mitigation Effort Only	1.14	.095692	.00621	.089482
High Underwriting and Loss Mitigation Effort	1.17	.112174	.00321	.108964

Among the possible contracting options available to the principal, expected profit is maximized by offering the underwriting risk manager a high-effort contract, the loss mitigation risk manager the reservation wage, and funding the project with 0.71 of insured deposits (.30 of which are at risk without the insurance guarantee). If the principal only used fairly priced equity and debt to fund the investment, example 1 in Section 3.3 shows that profit would be maximized by offering both risk managers high-effort contracts. With deposit insurance, by reducing risk management costs and maximizing the deposit insurance subsidy, the principal increases investment risk and increases his expected profit by 0.006044. A comparison of this outcome to the optimal outcome in example 1 demonstrates how the deposit insurance subsidy can create incentives for the principal to reduce beneficial risk management activities that he would choose to undertake in the absence of subsidized deposit insurance.

5.4 Optimal Compensation with Deposit Insurance when Effort is Unobservable

When risk manager effort is not observable and contractible, the principal will have to offer IC to induce risk managers to exert high effort. In an earlier example in Section 4.7, I showed that, when managers are risk neutral, the feasibility constraint required the principal to offer the loss mitigation risk manager a mixed contract that included both wage and IC components. The optimal underwriter contract was entirely IC as introducing any wage component into that contract would violate the underwriter incentive compatibility constraint.

With deposit insurance, the situation could potentially change. For example, if the deposit insurer fully honored risk manager contract terms including a risk manager's IC payments when a firm defaults, then the feasibility constraint might no longer bind. If this were true, and risk managers are risk neutral, the principal would then face strong incentives to move as much IC as possible into the high-loss default state so that risk managers' compensation cost would be transferred to the deposit insurer.

In practice, the deposit insurer (the FDIC) has the power to abrogate many contracts that are deemed inappropriate when a bank is taken into receivership. Wage payments are generally honored and paid with priority but management IC compensation agreements are typically abrogated. In the remainder I will assume that contract wage payments are given priority (essentially guaranteed) by the FDIC, but IC components of compensation are not paid when the bank defaults. I also assume that risk managers fully understand this priority convention.

5.4.1 Optimal Contract for High Loss Mitigation Effort when Effort is Unobservable, the Firm is Funded with Insured Deposits, and the Risk Manager is Risk Neutral

Consider the wage-IC contract that might induce high effort from a risk-neutral loss mitigation manager when the firm is funded in part with subsidized insured deposits and underwriting effort is low. The prior analysis demonstrated that, provided the manager is risk neutral, to induce high effort and satisfy the incentive compatibility constraint, the contract terms must satisfy,

$\pi_{LM}^{*} = \left[\left(\hat{P}_B - P_B\right)(1 - P_A)\right]^{-1} g(elm_H)$, and, $\varphi_{LM}^{*} = g(elm_H)\, P_B \left(\hat{P}_B - P_B\right)^{-1}$.

Offering the loss mitigation manager a high-effort contract will be optimal for the principal provided,[16]

$$(1 - P_A)\left(\hat{P}_B - P_B\right)(LGD_H - LGD_L - h) + \varphi_{LM}^{*}\left(P_A + (1 - P_A)\hat{P}_B\right) - \pi_{LM}^{*}(1 - P_A)\hat{P}_B \geq 0. \quad (27)$$

This optimality conditions differs from the optimality condition when effort is observable and contractible [expression (21)] because when effort is contractible, more of the risk manager's expected compensation is paid by the deposit insurer. The expected effort premium paid by the principal when effort is unobservable and IC is required is,

$$\pi_{LM}^{*}(1 - P_A) - \varphi_{LM}^{*}\left(P_A + (1 - P_A)\hat{P}_B\right)\hat{P}_B, \quad (28)$$

whereas, the expected wage premium paid when effort is observable and contractible is,

$$(\omega - \ddot{w})\left(P_A + (1 - P_A)\hat{P}_B\right)\hat{P}_B. \quad (29)$$

The difference between expression (28) and (29) is positive,

$$g(elm_H)\left(P_A + (1 - P_A)\hat{P}_B\right) + g(elm_H)\left(1 - \left(P_A + (1 - P_A)\hat{P}_B\right)\right) > 0. \quad (30)$$

The need to offer IC moves some of the additional compensation required to secure high effort from state C, where it is paid by the deposit insurer, into state B, where it is paid by the principal.

Expression (30) establishes that, when there is subsidized deposit insurance, the change from contractible effort to non-contractible effort increases the principal's expected cost of securing high effort from the loss mitigation manager because less of the expected incremental cost needed to generate effort is borne by the deposit insurer. The increased cost of effort will create cases in which the principal may forgo a high loss mitigation effort contract when effort is not contractible even though the principal would have preferred a high-effort contract if effort were observable and contractible.

[16] The principal's optimality conditions for offering a high-effort loss mitigation contract, conditional on high underwriting effort, are identical to conditions (28) to (31) after substituting $\hat{P}_A$ for P_A.

5.4.1 Optimal Contract for High Underwriting Effort when Effort is Unobservable, the Firm is Funded with Insured Deposits, and the Risk Manager is Risk Neutral

Consider, next, the optimality conditions for offering a high-effort contract to the underwriting risk manager. Earlier analysis demonstrated that the incentive pay and wage adjustments necessary to generate high effort and satisfy incentive compatibility constraints are, $\pi_S^* = \left(\hat{P}_A - P_A\right)^{-1} g(es_H)$, and $\varphi_S^* = g(es_H)\, P_A \left(\widehat{P_A} - P_A\right)^{-1}$. Offering the underwriter a high-effort contract will be optimal for the principal provided, [17]

$$\left(\hat{P}_A - P_A\right)[R + LGD_H - P_B(LGD_H - LGD_L) - h(1 - P_B)] + \varphi_S^*\left(\hat{P}_A + (1 - \hat{P}_A)P_B\right) - \pi_S^* \hat{P}_A \geq 0. \tag{31}$$

Expression (31) differs from expression (22) because the principal's expected cost of high effort is altered by deposit insurance. When effort is unobservable, the required incentive compensation contract will shift the cost of effort from state C to state A and the deposit insurer will subsidize a smaller share of this costs. The difference in the principal's expected cost of inducing high underwriting effort when effort is unobservable, relative to the case when effort is contractible is,

$$g(es_H) 2P_A \left(\hat{P}_A - P_A\right)^{-1} D - g(es_H)\, \hat{P}_A \left(\hat{P}_A - P_A\right)^{-1} (D - 1) > 0, \tag{32}$$

where, $D = (\hat{P}_A + \left(1 - \hat{P}_A\right)P_B,\ 0 < D < 1.$ Because the deposit insurer subsidizes less of the cost of generating high underwriting effort, there will be cases in which the principal will choose to contract for high under writing effort when effort is observable, and choose a reservation wage contract when effort is not contractible.

5.5 Risk Averse Risk Managers

The contracting analysis this far has developed IC solutions when effort is unobservable assuming that risk managers have risk neutral utility functions over their income. When risk managers are risk averse, they will require an additional risk premium when contract terms include IC. The additional required risk premium generally makes it impossible to replicate the first based contracting solution (contractible effort) because the principal's cost of securing high effort will increase. Since the risk premium will be incorporated into the risk manager's IC, there are additional ramifications when the bank is funded with subsidized insured deposits.

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[17] The optimality condition when the loss mitigation risk manager is expending high effort is identical to expression (32) after replacing P_B with $\hat{P}_B$.

Because IC must be paid in states in which the bank does not default (or it will not be paid), the required risk premium will be borne by the principal and not by the deposit insurer. When managers are risk averse, the higher cost of inducing effort will attenuate the principal's demand for a high risk management effort contract compared to the case of observable/contractible effort.

6. Regulatory Policy Implications and Conclusions

Notwithstanding the simplicity of the stylized model developed in this paper, the analysis has identified some very important features that should be considered when designing bank regulatory compensation policies. The existence of mispriced deposit insurance conveys a subsidy to financial institutions. It is well-known that unless insurance pricing is sensitive to a bank's risk, the value of the bank's insurance subsidy is endogenous and can be increased by the bank by merely increasing the riskiness of its investment portfolio. Incentives to increase the insurance subsidy counteract the bank's natural incentive to spend resources on risk management in the absence of a deposit insurance subsidy. Underpriced deposit insurance will reduce the bank's willingness to pay risk managers to reduce the riskiness of the bank's investments.

Since risk management compensation requires IC when risk management effort is unobservable, banks funded with insured deposits may be especially willing to forgo risk manager IC because doing so may be fully aligned with the bank's incentive to increase asset risk. In addition to the negative effects of risk manager effort on the value of the bank's deposit insurance subsidy, the IC a bank must offer to induce effort must be paid in states when the bank is solvent otherwise the deposit insurer will abrogate these payments. When IC compensation is required, it shifts risk managers compensation from wage costs—part of which will be paid by the deposit insurer in the default state, to IC compensation which will be paid by the principal. When effort is unobservable, the IC payments required to induce high effort shift the increased cost of risk manager compensation from the deposit insurer to the principal. Overall, the ability of the bank to fund itself with insured deposits reduces a bank's incentives to provide risk managers with appropriate IC. Left to their own choices, banks benefiting from the deposit insurance safety net are likely to offer too little IC to their risk managers.

The analysis in this paper clearly recommends that bank regulatory policies should be designed to encourage banks to offer adequate and appropriately targeted IC payments to their risk management staff. Moreover, these IC payments must be linked to the performance of the activities that the risk managers' control. In contrast, current regulatory guidance appears to prohibit performance-linked IC payments to risk managers. Should current regulatory policy on risk manager IC be widely enforced it is unlikely that bankers will complain because a prohibition against risk manager IC both saves banks risk management costs and helps secure banks valuable deposit insurance subsidies. The current regulatory guidance directs banks to under allocate resources to socially productive risk management activities. Contract theory suggests that current risk manager IC regulations are badly misguided and should be amended.

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