Self-Enforcing Clawback Provisions in Executive Compensation

There has been widespread public debate over the effectiveness of corporate governance practices in firms. One of the main concerns is that CEOs take advantage of accounting discretion to misreport financial information and to extract excess compensation (rents) from shareholders. Thus, the connection between CEO compensation and financial misstatements has received considerable attention. Due to these concerns, Section 304 of the Sarbanes-Oxley Act of 2002 (hereafter SOX) called for clawback provisions, which requires public company CEOs and CFOs to disgorge incentive-based compensation in the event of material noncompliance with financial reporting requirements. More recently, the U.S. Securities and Exchange Commission (SEC) changed Regulation S-K Item 402 (b) to require that compensation committees disclose their policies regarding bonus recovery in the event of errant financial statements. In response to Section 304 of the SOX, some, but not all, companies have voluntarily developed policies to incorporate clawback provisions in compensation contracts. Anecdotal evidence suggests that the introduction of clawback provisions has profound influence on corporate governance practices in several aspects. Regulators maintain that clawback provisions may mitigate the incentive of misreporting financial statements, thereby resulting in higher shareholders’ value. Opponents, in contrast, argue that provisions could make compensation contracts with clawback provisions less attractive and thus hiring and retaining managers more costly. In addition, clawback provisions would have unintended consequences: firms could try to circumvent clawback provisions by increasing base salaries, rather than tightening the links between pay and performance.

We examine why some, but not all, firms voluntarily adopt clawback provisions and how they affect the incentive alignments within a firm and the social efficiency. In this two-period adverse selection model, a CEO must submit a report on privately-observed fundamentals. In between two periods, a board of directors can observe a noisy financial signal that is correlated to the CEO’s private information. If the ex post financial signal suggests evidence of the CEO’s ex ante misreporting, the board may clawback the CEO’s first-period compensation and/or adjust the second-period revenue requirement and compensation. If successful, we will show that despite the information revelation of the financial signal, the CEO may benefit from and therefore willingly accept the clawback provisions; this occurs more likely when the financial signal is imprecise, and a priori the extent of information asymmetry is rather extreme. Moreover, the clawback provisions necessarily result in an upward adjustment of the revenue allocations, and may make the revenue allocations exceed the socially efficient levels. In light of this, the clawback provisions may sometimes be detrimental to the society. We also expect to provide empirical predictions of the economic consequences from adopting clawback provisions.
1 Motivation

There has been widespread public debate over the effectiveness of corporate governance practices in firms. One of the main concerns is that CEOs take advantage of accounting discretion to misreport financial information and to extract excess compensation (rents) from shareholders. Thus, the connection between CEO compensation and financial misstatements has received considerable attention. Due to these concerns, Section 304 of the Sarbanes-Oxley Act of 2002 (hereafter SOX) called for clawback provisions, which requires public company CEOs and CFOs to disgorge incentive-based compensation in the event of material noncompliance with financial reporting requirements. More recently, the U.S. Securities and Exchange Commission (SEC) changed Regulation S-K Item 402 (b) to require that compensation committees disclose their policies regarding bonus recovery in the event of errant financial statements. After the financial crisis of 2008, the Emergency Economic Stabilization Act of 2008 also included a standard clawback provision for all financial institutions that sell troubled assets to the Secretary of the Treasury. Moreover, the Dodd-Frank Wall Street Reform and Consumer Protection Act signed on July 21, 2010 further expands the reach of mandatory recoupment policies. Under the Act, the SEC will direct the national securities exchanges to amend their listing standard to require that listed company disclose and adopt a compensation clawback policy. But full details of the clawback requirements are still ambiguous and no deadline for the implementation is given yet.

In response to Section 304 of the SOX, some, but not all, companies have voluntarily developed policies to incorporate clawback provisions in compensation contracts. Equilar, an executive-compensation advisory firm, reported that nearly three-quarters of Fortune 100 companies had such rules in 2009, up from about 18% in 2006 (Lublin (2010a)). In 2010, of the 100 largest public companies, 71 firms operate a clawback policy through which they can reclaim senior management’s compensation under certain circumstances (Thomas (2010)). Anecdotal evidence suggests that the introduction of clawback provisions has profound influence on corporate governance practices in several aspects. Regulators maintain that clawback provisions may mitigate the incentive of mis-reporting financial statements, thereby resulting in higher shareholders’ value (Lucchetti (2010)). Opponents, in contrast, argue that provisions could make compensation contracts with clawback provisions less attractive and thus hiring and retaining managers more costly. In addition, clawback provisions would have unintended consequences: firms could try to circumvent clawback provisions
by increasing base salaries, rather than tightening the links between pay and performance (Lublin (2010b)).

The aforementioned discrepancy gives rise to a number of intriguing questions:

1. What is the optimal dynamic executive compensation in the presence of financial signals?
2. Do clawback provisions indeed mitigate the possibility of financial misreporting?
3. How do clawback provisions affect the ex ante investment decisions and ex post revenue allocation?
4. Why do some firms voluntarily adopt clawback provisions?
5. How do clawback provisions affect the incentive alignments within a firm and the social efficiency?

To address these research questions, we construct a dynamic adverse selection model wherein a board of directors (principal) contracts with a CEO (agent) to generate sales revenue for two periods. Below, we describe the detailed model characteristics and some preliminary steps to tackle this problem.

2 Model

For ease of exposition, we hereby present a simplified two-type, two-signal setting. Our results are easily extendable to the more general setting with sophisticated type-signal compositions.

**Investment opportunity.** We consider a principal-agent model in which a board of directors (principal) hires a risk-neutral CEO (agent) for two periods. In each period \(i \in \{1, 2\}\), the CEO produces a net product revenue

\[
R = e - \theta,
\]

where \(\theta \in \{\theta_l, \theta_h\}\) (\(\theta_h > \theta_l > 0\)) is the uncollectible revenue and \(e \geq 0\) is the CEO’s effort. The CEO privately observes the uncollectible revenue \(\theta\) prior to the contracting stage, which is invariant across different periods. The board has a prior belief on \(\theta\) characterized by probability \(\alpha = \Pr(\theta = \theta_l)\). Upon exerting the costly effort to increase the product revenue, the CEO incurs a disutility (in monetary terms) of \(\psi(e)\). At the end of each period, the board can observe product revenue \(R\), but cannot verify the proportion of uncollectible revenue \(\theta\).
Financial signal. At the beginning of the second period, the board receives a financial signal $S \in \{S_G, S_B\}$ that could be used to mitigate the information asymmetry problem vis-a-vis the CEO (where the subscripts $G$ and $B$ denote good and bad news, respectively). This financial signal is informative in that it is correlated to the unobservable uncollectible revenue $\theta$. Let $\pi_{jk}$ denote the conditional probability that the financial signal $S_k$ is realized, conditional upon the realization of $\theta_j$. We assume the conditional probability $\pi_{jk}$ exhibits the following properties:

$$
\pi_{lG} = \Pr(S_G|\theta_l) = \lambda + \delta, \quad \text{and} \quad \pi_{lB} = \Pr(S_B|\theta_l) = 1 - \lambda - \delta,
$$

$$
\pi_{hG} = \Pr(S_G|\theta_h) = \delta, \quad \text{and} \quad \pi_{hB} = \Pr(S_B|\theta_h) = 1 - \delta,
$$

where $0 \leq \lambda \leq 1$ and $0 \leq \delta \leq 1 - \lambda$ are imposed to ensure that these conditional probabilities are well-behaved. The parameter $\lambda$ serves as a proxy of the informativeness of financial signal, as a higher $\lambda$ indicates a more informative signal (see Milgrom (1981)). The specification is consistent with the strict monotone likelihood ratio property (MLRP): $\frac{\pi_{lG}}{\pi_{hG}} > \frac{\pi_{lB}}{\pi_{hB}}$. Given the binary nature of the financial signal, MLRP is equivalent to the condition that the likelihood of obtaining the signal $S_G$ is higher when the state is $\theta_l$ than when the state is $\theta_h$, i.e., $\pi_{lG} > \pi_{hG}$. We define $\Delta \theta = \theta_h - \theta_l$ as a measure of the type differential.

We focus on the setting in which the CEO exerts costly effort to increase the net sales revenue. When the uncollectible revenue is higher, the CEO needs to exert more costly effort in order to achieve a level of net revenue $R$. To reduce the disutility of effort, the manager then has an incentive to over-report the uncollectible revenue $\theta$. This setting thus captures the CEO’s incentives of over-reporting uncollectible revenue that we may observe in practice. Because of this incentive, the board considers the type-$\theta_l$ CEO as an efficient one. The direction of misreporting private information may change in a different setting; see, for instance, a capital budgeting model by Antle and Eppen (1985). However, the economic tradeoffs we will document herein are not sensitive to this assumption.

Dynamic allocation. We normalize the total length of the contracting period to 1; accordingly, the first period of production lasts for a time $\tau \in (0, 1)$, and the second period of production lasts for the remaining time $1 - \tau$. Upon observing the product revenues $R_1$ and $R_2$, the board’s expected payoff is given by

$$
V = \tau(v(R_1) - t_1) + (1 - \tau)(v(R_2) - t_2),
$$

where $v(\cdot)$ corresponds to the board’s value function, and $(t_1, t_2)$ are the compensation payments to the CEO for two periods. To facilitate the analysis, we assume that $v(R)$ is increasingly concave in $R$ (i.e., $v'(\cdot) > 0$ and $v''(\cdot) \leq 0$). On the other hand, a type-$j$ CEO’s payoff given $(R_1, R_2)$ is

$$
U_j = \tau(t_1 - \psi(R_1 + \theta_j)) + (1 - \tau)(t_2 - \psi(R_2 + \theta_j)).
$$
3 Problem formulations

Our primary goal is to examine how the financial signal influences the revenue allocation and the clawback provisions. To this end, we first consider two benchmark cases: the first-best scenario in which the CEO’s uncollectible revenue is publicly known, and the second-best scenario in which the CEO privately observes the uncollectible revenue and no clawback provision is implemented. Following this, we then introduce the financial signal and see how the clawback should be designed accordingly.

3.1 First-best and second-best scenarios

In the absence of financial signal, the game repeats for two periods; consequently, we drop the index of the period and simply use \( R_j \) to represent the revenue allocation, where the subscript \( j \) corresponds to the CEO’s type. Let us start with the first best scenario in which the board can observe the uncollectible revenue \( t_j \). In each period, the aggregate payoff for the board and the CEO is \( v(R_j) - \psi(R_j + \theta_j) \). The first-best effort, denoted by \( e_{fb}^j \), is determined by the first-order condition \( v'(R_j) - \psi'(R_j + \theta_j) = 0 \), where \( e_{fb}^j = R_{fb}^j + \theta_j \). Accordingly, the board’s expected payoff in each period is

\[
V_{fb} = \alpha[v(R_{fb}^l) - \psi(R_{fb}^l + \theta_l)] + (1 - \alpha)[v(R_{fb}^h) - \psi(R_{fb}^h + \theta_l)].
\]

Next, we consider the second-best scenario in the absence of financial signal. In such a scenario, the board faces the classical two-period adverse selection problem. The optimal contract design problem can be translated into a single-period one. According to the revelation principle, we can without loss of generality focus on the family of direct mechanisms in which the CEO is requested to report her type and the board determines the product revenue and the corresponding payment. The board’s objective function for both periods is to maximize

\[
\max_{\{R_j, t_j\}} \quad V^{sb} = \alpha[v(R_l) - t(\theta_l)] + (1 - \alpha)[v(R_h) - t(\theta_h)].
\]

The corresponding incentive compatibility (IC) and individual rationality (IR) constraints are:

\[
t(\theta_l) - \psi(R_l + \theta_l) \geq t(\theta_h) - \psi(R_h + \theta_l), \quad (IC-lh)
\]
\[
t(\theta_h) - \psi(R_h + \theta_h) \geq t(\theta_l) - \psi(R_l + \theta_h), \quad (IC-hl)
\]
\[
t(\theta_h) - \psi(R_h + \theta_h) \geq 0, \quad (IR-h)
\]
\[
t(\theta_l) - \psi(R_l + \theta_l) \geq 0, \quad (IR-l)
\]
which ensure that the CEO is willing to report her type truthfully and accept the board’s contract. By the standard arguments in the literature, only the constraints (IR-h) and (IC-lh) are binding. We can easily observe the standard economic trade-off under information asymmetry. The board induces the efficient (type-\(\theta_l\)) CEO to exert the first-best effort \(e^{fb}_l\), but the inefficient (type-\(\theta_h\)) CEO’s effort \(e^{sh}_h = R^{sh}_h + \theta_h\) is distorted downwards with \(v''(\cdot) \leq 0\).

3.2 Clawback provisions

In this section, we consider the case in which the board can observe an ex post financial signal regarding the uncollectible revenue. Based on the realized financial signal, the board implements clawback provisions by taking back the CEO’s first-period compensation and/or adjust the second-period compensation.

**Direct revelation mechanism.** We first formally define a direct revelation mechanism that incorporates the CEO’s reports and the clawback provisions. In this mechanism, the board first asks the CEO to report her type. Given the CEO’s report \(\hat{\theta}\) (which may not necessarily equal her true type), the board requests the CEO to generate the product revenue \(R_1(\hat{\theta})\) in the first period and compensate the CEO by \(t_1(\hat{\theta})\). Then the board observes the financial signal \(S\) at the end of period 1. The period-2 product revenue specifies the product revenue \(R_2(\hat{\theta}, S)\) and the compensation pay \(t_2(\hat{\theta}, S)\) to the CEO. Thus, essentially the board offers a menu of contracts \(\gamma = \{(\gamma_1(\hat{\theta}), \gamma_2(\hat{\theta}, S))\}\), where \(\gamma_1(\hat{\theta}) = (t_1(\hat{\theta}), R_1(\hat{\theta}))\) and \(\gamma_2(\hat{\theta}, S) = (t_2(\hat{\theta}, S), R_2(\hat{\theta}, S))\) for the CEO’s report \(\hat{\theta}\) and the accounting report \(S\).

**Clawback provisions.** Because the financial signal \(S\) is observed after the CEO’s report, the contract can be made conditional on both the CEO’s report \(\hat{\theta}\) and the observed financial signal that provides useful information on the true state of \(\theta\). In particular, if the ex post financial signal \(S\) indicates that the true uncollectible revenue is likely to differ from the CEO’s ex ante report \(\hat{\theta}\), the board would adjust the second-period compensation, labelled as the clawback provisions, to the CEO. The goal of this analysis to analyze the effect of the clawback provisions on the CEO’s incentive to misreport her private information.

**Timing.** The timing of the game is as follows. 1) At the beginning, the CEO privately observes the uncollectible revenue \(\theta\) (i.e., her type). 2) The board offers a menu of contracts which stipulates \(\{(\gamma_1(\hat{\theta}), \gamma_2(\hat{\theta}, S))\}\) for the CEO’s report \(\hat{\theta}\) and the accounting report \(S\). 3) The CEO generates the product revenue \(R_1(\hat{\theta})\) and receives corresponding transfer \(t_1(\hat{\theta})\) in the of period 1. 4) The accounting system reports a financial signal \(S\). 5) The second-period revenue is realized \(R_2(\hat{\theta}, S)\) and the CEO is compensated by \(t_2(\hat{\theta}, S)\).
Executive compensation. We next specify the CEO’s payoffs. The CEO observes her true type and plays the mechanism before the financial signal is realized. Thus, the CEO’s payoff must be written in expectation over the realization of $S$. The type-$\theta$ CEO’s payoff given her report $\hat{\theta}$ is

$$U(\theta|\hat{\theta}, S) = \tau \left[ t_1(\hat{\theta}) - \psi(R_1(\hat{\theta}) + \theta) \right] + (1 - \tau) \left[ t_2(\hat{\theta}, S) - \psi(R_2(\hat{\theta}, S) + \theta) \right],$$

where the two terms represent the period-1 and period-2 payoffs respectively. The CEO incurs a disutility of effort that depends on her true type $\theta$, her own report $\hat{\theta}$, and the realized financial signal $S$ (through the required product revenues $R_1(\hat{\theta})$ and $R_2(\hat{\theta}, S)$). Ex ante, a type-$\theta_j$ CEO receives a good accounting report $S_G$ with probability $\pi_{jG} = \Pr(S_G|\theta_j)$. Thus, the CEO’s ex ante expected payoff is specified as

$$\pi_{jG}U(\theta_j|\hat{\theta}, S_G) + (1 - \pi_{jG})U(\theta_j|\hat{\theta}, S_B).$$

To simplify the notation, we define

$$U_j(\gamma_{jk}) = \tau \left[ t_1(\theta_j) - \psi(R_1(\theta_j) + \theta_j) \right] + (1 - \tau) \left[ t_2(\theta_j, S_k) - \psi(R_2(\theta_j, S_k) + \theta_j) \right],$$

$$U_j(\gamma_{-jk}) = \tau \left[ t_1(\theta_{-j}) - \psi(R_1(\theta_j) + \theta_j) \right] + (1 - \tau) \left[ t_2(\theta_{-j}, S_k) - \psi(R_2(\theta_{-j}, S_k) + \theta_j) \right],$$

where the subscript $j$ denotes the CEO’s true type, the first subscript of $\gamma$ corresponds to the CEO’s report, and $k$ indicates the financial signal $S_k$. In our two-type framework, the index $-j$ corresponds to the type other than $j$.

Incentive constraints. In line with the extant literature, the board needs to consider the following incentive compatibility and individual rationality constraints for the CEO. The incentive compatibility constraints ensure that a type-$\theta_j$ CEO truthfully reports her type as $\hat{\theta} = \theta_j$ and takes the offer $\gamma_{jk}$, instead of reporting $\theta_{-j}$ and taking the offer $\gamma_{-jk}$, that is, $U(\theta_j|\hat{\theta}, S) \geq U(\theta_{-j}|\hat{\theta}, S)$. Specifically, the incentive compatibility for a type-$\theta_j$ CEO is specified by

$$\pi_{jG}U_j(\gamma_{jG}) + (1 - \pi_{jG})U_j(\gamma_{jB}) \geq \pi_{jG}U_j(\gamma_{-jG}) + (1 - \pi_{jG})U_j(\gamma_{-jB}).$$

Moreover, a type-$\theta_j$ CEO’s individual rationality constraints must be satisfied:

$$U(\theta_j) = \pi_{jG}U_j(\gamma_{jG}) + (1 - \pi_{jG})U_j(\gamma_{jB}) \geq 0,$$

where the CEO’s reservation utility is normalized to zero.

Limited liability. We rule out the case of arbitrarily high punishment by assuming that the CEO is protected by limited liability:

$$\min\{t_1(\theta_j), t_2(\theta_j, S_k)\} \geq -L,$$
for any $\theta_j$ and $S_k$. The limited liability constraint is commonly adopted in the agency literature (e.g., Che and Gale (2000), Lewis and Sappington (2001), and Robert (1991)). When the CEO’s wealth is constrained, the board has limited ability to clawback compensation from the CEO over an exogenous limit (his given wealth $L \geq 0$).

**The board’s problem.** Given the CEO’s truthful report $\theta_j$ and the accounting report $S_k$, the board’s payoff for two periods is

$$V(\gamma_{jk}) \equiv \tau[v(R_1(\theta_j)) - t_1(\theta_j)] + (1 - \tau)[v(R_2(\theta_j, S_k)) - t_2(\theta_j, S_k)].$$

The board’s maximization problem for all $\theta_j \in \{\theta_l, \theta_h\}$ and $S_k \in \{S_G, S_B\}$ is given by

$$\textbf{(P)} \quad \max_{\gamma_{jk}} \quad U_o = \alpha[\pi_G V(\gamma_{IG}) + (1 - \pi_G) V(\gamma_{IB})] + (1 - \alpha)[\pi_H V(\gamma_{HG}) + (1 - \pi_H) V(\gamma_{HB})]$$

$$\text{s.t.} \quad (\text{IC}), (\text{IR}), \text{ and } (\text{LL}).$$

### 3.3 Preliminary results and possible implications

**Two regimes.** It is readily observable from (P) that the optimal solution for the CEO’s compensation critically depends on the limited liability constraint (LL). If the limited liability constraint is not binding, the board can essentially extract the entire surplus from the CEO irrespective of her type. This is labelled as “no limited liability” regime. On the other hand, under the “revenue distortion regime,” the CEO is wealth-constrained and the board distorts downwards the inefficient (type-$\theta_h$) CEO’s revenue allocation in order to induce truth-telling. We expect to characterize the equilibria in detail.

**Take-away messages.** It is intuitive that the standard trade-off between allocative efficiency and rent extraction shall be moderated by the clawback provisions. One may conjecture that the board can mitigate the incentive of misreporting by punishing the CEO when the realized financial signal $S$ is different from the CEO’s report $\hat{\theta}$. In addition, as the financial signal provides valuable information regarding the uncollectible revenue, the revenue efficiency is unambiguously improved. As a result, if the clawback provisions are implemented, the CEO’s expected payoff is strictly lower and the board’s expected payoff is strictly higher. If successful, we will demonstrate that *neither of the above conventional wisdom holds universally*. Specifically, we will show that under certain conditions, both the board and the CEO are benefited from implementing the clawback provisions; furthermore, the clawback provisions based on the financial signal may result in excessive revenue distortion.

**Empirical implications.** If successful, this research has important policy and empirical implications. A strongly held belief among regulators is that ex post clawback provisions may
alleviate a CEO’s ex ante incentive to misreport financial information. The Dodd-Frank Wall Street Reform and Consumer Protection Act signed on July 21, 2010 requires that all public-listed companies disclose and adopt a compensation clawback policy. However, we show that when the clawback provisions are implemented, the board may need to distort revenue above the first-best level, thereby decreasing the social welfare. For those firms having adopted clawback provisions, we provide empirical predictions of how the reported accounting measures in executive compensation may be related to some exogenous factors (such as the precision of the accounting signals, the extent of information asymmetry, and the clauses of legal penalties). To our knowledge, these empirical implications have not been explored in the literature.

**Proposed extensions.** In this study, we assume that the board, without any cost, can observe the unbiased accounting signals ex post. An extension would be to endogenize the accounting signals by introducing the role of accountants. In such a scenario, the accountant may not truthfully report unless she is offered appropriate incentives from the board. For example, the CEO may bribe the accountant, who then will issue an audit report to the investor that the CEO prefers. As a result, the clawback provisions become less effective in alleviating the cost of information asymmetry. To avoid such collusion, the accountant must be rewarded more than possible bribes from the CEO so that honest reporting is preferable. This may consequently affect the choices of the clawback provisions and revenue efficiency.

Another extension would be to allow for the possibility that the CEO can manipulate the accounting signals to some extent. In this case, the CEO now must balance the cost of manipulation against the benefit of increasing information rent. On one hand, the information content of the accounting signals would be lower owing to the possibility of manipulation, which consequently increases the CEO’s information rent. On the other hand, the CEO’s manipulation may reduce the possibility of triggering the clawback provisions. One interesting implication from this study is that the CEO may not necessarily have an incentive to manipulate the accounting signals even though such manipulations are costless. Moreover, it is possible that the CEO’s manipulation may be rewarded rather than punished in the sense of Maggi and Rodriguez-Clare (1995) and Dutta and Gigler (2002).

4 Related literature

This research is related to the literature on earnings management and performance evaluation. In an influential paper, Arya et al. (1998) consider an extreme form of clawback provisions: In a two-period relationship, an owner may select to dismiss the manager at the end of period 1. They
show that earnings management may be beneficial, because it helps the owner commit to firing the manager less frequently. Arya and Glover (2008) further show that despite the agent’s incentive to cherry-pick, the principal may allow to the agent to decide which performance measures to appeal mistakes in the initial measurement of two performance measures. Surprisingly, in the presence of measurement errors, the agent is incentivized by increased opportunities for cherry-picking that arise if he chooses between the right and wrong acts.

Moreover, Dutta and Gigler (2002) study the association between earnings management and voluntary management forecasts in an agency setting. Interestingly, they illustrate that voluntary forecasts may help prevent the manager from misreporting financial information and that shareholders may not find it optimal to prohibit earnings management. Evans and Sridhar (1996) consider a two-period model in which a manager privately observes both economic earnings and the available reporting discretion. If the features of accrual accounting can be utilized for contracting purpose, the principal may induce the manager to report truthfully when the financial reporting system is sufficiently flexible. However, if the ex ante level financial reporting flexibility is low, the optimal contract induces earnings management.

On the modelling front, our research is related to the extant literature on limited liability constraints. A closely related paper is Robert (1991) who demonstrates in an auction design setting that when the agents face limited liability constraints, the principal may be unable to extract the full surplus despite the presence of ex post verifiable signal. Specifically, if the agents’ types are almost independent, the principal must leave information rent for agents. Lewis and Sappington (2001) analyze a model where the agent is privately informed both of his ability and of his wealth. They show that the wealth level and the agent’s ability are complements in determining the power of the incentive scheme. Che and Gale (2000) consider a procurement setting where a seller sells goods to a buyer who may be budget-constrained. The possibility of a binding budget constraint can make it optimal for the seller to use nonlinear pricing, to commit to a declining price sequence, or to require the buyer to disclose his budget or to other financing. By comparison, we consider a dynamic adverse selection model in which the probability that the limited liability constraint binds is stochastically determined by exogenous accounting signals. The possibility of the binding limited liability constraint distorts the allocation efficiency in both periods and may be detrimental to the social welfare.

As the financial signal in our context provides valuable information to fight against an adverse selection problem, our research is also related to the vast literature on the full surplus extraction. The two seminal papers (Cremer and McLean (1985, 1988)) formally identify necessary and sufficient conditions for full surplus extraction for all instances of agents’ utilities. McAfee
and Reny (1992) extend the discussion to incorporate continuous uni-dimensional type spaces. Mezzetti (2007) considers an interdependent-value setting (i.e., agents’ true valuations depend on other agents’ private information). Due to the interdependence of valuations, the payoffs are correlated. Hence, a two-stage mechanism that requires agents to report their types as well as their payoffs can be adopted to achieve the full surplus extraction. Obara (2008) allows the agents to exert effort that affects the probability distribution over types. He shows that conditions similar to Cremer and McLean (1988) continue to be valid in the environment with moral hazard followed by adverse selection. Johnson et al. (1990) investigate whether it can be achieved among a group of agents whose actions generate externality for others. We introduce the limited liability constraints that significantly alter the influence of information asymmetry. Additionally, our setting includes two-period revenue allocations, whereas in all the aforementioned papers allocations are one-shot decisions.

5 Human resource development

Student Supervision. The primary purpose of this proposal is to fund and mentor students who are involved in this project. We expect to conduct this research jointly with one doctoral student at UC Berkeley. In this research project, we expect to 1) provide students the basic tools of formulating contracting parties’ incentives and subsequently designing appropriate mechanisms to elicit valuable information; 2) train students’ ability of identifying appropriate applications to other contexts. Since joining Berkeley in 2007, the PI has supervised or has been supervising several students: Wenbo Selina Cai (Chair), Song Deng (Co-Chair), Ling-Chieh Kung (Chair), Huaning Cai (Committee), Yong Liang (Committee), Nguyen Truong (Committee), Poomyos Wimonkittiwat (Committee), Ye Xu (Committee), Tingting Cui (committee), and Shan Li (committee). If successful, the proposal can be used to partially fund their doctoral studies.

Curriculum development. The outcomes of this research project will be incorporated in the curriculum of a newly-developed course in supply chain management and service operations, that will be offered in Berkeley at the graduate level. This course is designed to engage the students in applying their engineering expertise to other related domains such as auctions, procurement, service operations, product design, manufacturing/marketing compensation, health care, and market design.

Further, the PI is currently leading the IEOR graduate student seminars on a voluntary basis. This seminar series is intended to exchange research ideas among graduate students and get timely feedbacks for preliminary research work. The progress of this project can be then evaluated in
seminar presentations. Meanwhile, the seminar allows the PI to engage a number of students in this field. On a related note, the PI also serves as the faculty advisor of the INFORMS student chapter at UC Berkeley, which has won INFORMS Student Chapter Annual Award (Cum Laude) for its active contribution to the community. This proposal may assist the operations of this student chapter, which has been holding academic and social events on a regular basis for decades. The PI also serves as the faculty advisor for Berkeley Chinese Students and Scholars Association (BCSSA), which may also benefit from the results of this proposal via academic meetings.

**Dissemination of the results.** The research outcomes will be disseminated primarily through 1) the PhD dissertations of the student supported by this project; 2) refereed journal publications in the operations research field, 3) presentations of this work at national and international conferences; and 4) lectures given in the undergraduate/graduate level courses in Berkeley.

**References**


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