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Auditing as the owner's response to the need for reliable manager reporting: A problem of supply and demand of audit services in the presence of hidden auditor actions

Woodlock, Peter David, Ph.D.
The Ohio State University, 1990

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Auditing as the Owner's Response to the Need for Reliable Manager Reporting:

A Problem of Supply and Demand of Audit Services in the Presence of Hidden Auditor Actions

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Peter D. Woodlock, B.S., M.Acc, CPA

* * * * *

The Ohio State University

1990

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To my wife, Karen
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<td>( \bar{x} ), ( x ), ( X )</td>
<td>( x ) is an element of the set of outcomes ( X ). ( \bar{x} ) is the largest element of ( X ).</td>
</tr>
<tr>
<td>( cu ), ( CU )</td>
<td>( cu ) is an element of the set of over-reporting amounts ( (CU) ) available to the manager.</td>
</tr>
<tr>
<td>( ur ), ( UR )</td>
<td>( ur ) is an element of the set of under-reporting amounts ( (UR) ) available to the manager.</td>
</tr>
<tr>
<td>( u^* )</td>
<td>utility function for a given player with the subscript ( A ) used for the auditor and no subscript used for the manager.</td>
</tr>
<tr>
<td>( v^* )</td>
<td>disutility function for a given effort level provided by a player with the subscript ( A ) used for the auditor and no subscript used for the manager.</td>
</tr>
<tr>
<td>( a ), ( A )</td>
<td>( a ) is an element of the set of actions ( A ) available to the manager.</td>
</tr>
<tr>
<td>( e ), ( ne )</td>
<td>( e ) denotes an effective audit and ( ne ) denotes an ineffective audit.</td>
</tr>
<tr>
<td>( af(*) )</td>
<td>compensation function offered to the auditor by the owner.</td>
</tr>
<tr>
<td>( s(*) )</td>
<td>compensation function offered to the manager by the owner.</td>
</tr>
<tr>
<td>( \mathcal{F} )</td>
<td>firm's actual outcome during the period. ( \mathcal{F} \in X ).</td>
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<td>( p(x</td>
<td>c) )</td>
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<td>( m^r ), ( mr ), ( MR )</td>
<td>( mr ) is the set of manager's reports available to the manager for a particular outcome ( x \in X ). ( m^r ) represents a truthful report of firm's outcome.</td>
</tr>
<tr>
<td>( car ), ( CAR )</td>
<td>( car ) is an element in the set of audit reports consistent with a manager's report ( mr ).</td>
</tr>
<tr>
<td>( p[ar \notin car(m^r)] )</td>
<td>probability that the auditor's report will not be contained in the set of reports consistent with the firm's outcome.</td>
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CHAPTER I

INTRODUCTION

1.1 Introduction and Motivation

Analytical research in auditing has provided insights into the determinants of the supply and demand for audit services. For the demand for audit services, Ng and Stoeckinius [1979] show that a demand for audit services results from the cost advantage the auditor possesses over costly owner-manager contracting for inducing truthful disclosure of firm outcome. For the supply of audit services, Antle [1982] shows that absent some exogenous signal of audit effort, the owner cannot contractually induce the auditor to provide effort which will assure reliable management disclosure.

One purpose of this dissertation is to provide a more complete characterization of when the demand for audit services exists. For instance, it would be nice to be able to show that there exist conditions under which costly contracting with the manager cannot substitute for auditing. A circumstance in which this might occur may be when the owner's optimal contract with the manager would not be truth-inducing. Another possibility to consider is the circumstance in which contracting between the owner and manager can never induce reliable management reports. It is the purpose of this dissertation to identify when these circumstances can exist.

The second part of this dissertation reconsiders an audit setting in which no exogenous signal of audit effort is available. The purpose of this analysis is to identify
what information the auditor must be able to relay in order for the owner to be able to contractually induce an effective audit. This analysis could provide support for the expansion of the audit report beyond just a report of firm outcome and provide justification for the need of auditors to gather evidence in support of an audit opinion.

1.2 The Agency Setting

A description is given of the principle-multiple agent setting studied within this dissertation and the unique features of this setting are discussed in this section. The primary antecedent of this agency setting is Antle [1982], although a variant of the agency setting described is consistent with Baiman, Evans and Noel [1987].

The setting considered in this dissertation, along with a variant of this agency setting, can be described by the timeline of Figure 1.1. The owner’s role in the audit setting is to provide an incentive scheme which induces the manager and auditor to choose strategies consistent with the owner’s preferred equilibrium. All agency contracts require that the owner utilize publicly available information for design of the incentive scheme. The observables in our audit setting are the manager’s and auditor’s reports of firm outcome; thus, the owner’s incentive scheme for both the manager and auditor are functions of these reports.

After acceptance of the contract, the manager takes a productive action without any knowledge of the firm’s productive state. The productive state of the firm along with the manager’s action determines a probability distribution over the set of feasible outcomes, which is common knowledge to the auditor, manager, and owner. However, since the manager knows what effort has been taken, the manager knows which conditional distribution will be present. This asymmetry induce the manager to reduce his effort
level unless given an incentive otherwise. This potential use of private effort information by the manager for his benefit will be called moral hazard.

After the product is produced, the manager provides a report of the level of production to the owner. Since the owner cannot view the outcome, the manager has an incentive to under- or over-report the level of firm outcome to the owner. It will be assumed that the internal control of the firm limits the manager to a uni-directional reporting strategy. Thus, full under-reporting would imply that the manager could claim the lowest feasible outcome occurred and consume nearly all firm outcome. Baiman, Evans and Noel [1987] consider a variant of full under-reporting for which the manager is limited to consuming the difference between the outcome reported and the firm outcome by a double transfer system. On the other hand, full over-reporting would imply that the manager could claim that the highest feasible outcome occurred irrespective of firm outcome. Dye [1988], Ng and Stoeckinius [1979], and Antle [1982] consider models in which the manager is limited to full over-reporting of firm outcome. Finally, partial under/over-reporting limits the range of feasible management reports in an obvious way.

To reduce the incentive of the manager to misreport the firm outcome, the owner will hire a utility-maximizing auditor. The auditor may perform the audit either during the accounting period or after the close of the accounting period. Auditing during the accounting period will be known as concurrent auditing. The timeline for concurrent auditing is contained in Figure 1.1. Auditing after the close of the accounting period will be known as ex post auditing. The timeline for ex post auditing is contained in Figure 1.2. Since the auditor's efforts are not observable, the auditor can choose a level of effort

---

1 A double transfer system requires that the manager liquidate the agency and remit the proceeds to the owner who then transfers back the manager's salary.
inconsistent with the owner's preference for audit effort. Thus, potential hidden action exists with the auditor as well as the manager.\(^2\)

---

**Figure 1.1 Concurrent Auditing**

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**Figure 1.2 Ex post Auditing**

The agency setting of either Figure 1.1 or 1.2 contains unique features not present in most previous agency settings of auditing. These features are (1) the unobservability of the firm outcome; (2) the non-limitation of the manager to a single report option; and (3) the non-liquidation of the agency prior to payments to the manager and auditor.

\(^2\)Antle [1984] provides a definition of strong independence which implies that the owner has the ability to contractually alleviate audit moral hazard. Sufficient conditions to insure the owner can contractually induce an effective audit were not provided by his research. An evidentiary requirement rule may be this sufficient condition.
Each of these modelling features is incorporated within this dissertation in order to capture more fully the separation of ownership and management inherent in the modern corporation.³

The inability of the owner to view the firm outcome and the manager’s efforts may make a reliable report of firm outcome either too costly for the owner or not optimal absent auditing. A celebrated finding in agency research known as the Revelation Principle (see Myerson [1979], and Harris and Townsend [1981]) insures that in agency settings with hidden information, the owner’s contract design can be limited to truth-inducing contracts. Antle [1982] hints that an application of the Revelation Principle, to an agency setting absent auditing, precludes the owner from utilizing the report of the manager for motivational purposes. Additionally, Green and Lafont [1986] show that in our agency setting absent manager hidden action, the Revelation Principle does not apply when the report set of manager is restricted to partial under- or over-reporting of firm outcome. Thus, it may be the case that auditing is the only way the owner can signal that the manager’s report is reliable or auditing may be a more cost effective way of inducing a reliable manager report.

Finally, the non-liquidation of the agency (implied by a double transfer system used in Bairman, Evans and Noel [1987] and Penno [1985]) is consistent with the existence of a going concern notion and would allow for a variant of balance sheet audits in a multiple period version of our agency setting. All agency models of auditing distribute the firm outcome at the end of the period. However, by making this restriction in the

³Berle and Means [1932] is recognized as the seminal work for this area. Recent research such as Jensen and Meckling [1976] and Fama and Jensen [1983] consider owner responses to this separation of ownership and management.
agency model, the set of feasible manager reporting strategies is needlessly reduced.\(^4\) Thus, to allow for the broadest set of manager report sets and to capture the notion of continued existence of the firm, this model provides for non-liquidation of the agency.

1.3 Motivation for Evidentiary Requirement Rule

Auditing is concerned with the gathering of information necessary to render an opinion on the fairness of the financial statements prepared by firm management. The evidence accumulated during the course of an audit is contained within the working papers of the audit and can be used to (1) support an opinion, (2) provide a defense for the auditor against negligence suits; and (3) provide evidence necessary in the course of a peer review.\(^5\)

This dissertation considers the importance of the availability of audit evidence for support of an audit opinion within a generalized version of an agency setting similar to Antle [1982] and Baiman, Evans and Noel [1987].\(^6\) An agency setting is a stylized version of the firm in which the firm is viewed as a nexus of contracts between the principal (owner) and his agents (the manager and the auditor). The owner's purpose in the typical agency setting is to design an incentive scheme and an information system in order to align the agent's incentives with those of the owner. In the agency setting

\(^4\)See Baiman [1979] on this point.

\(^5\)Within this dissertation, differences between the manager's report and the agency's outcome are caused by irregularities in the financial statements, since the firm outcome is assumed to be known to the manager prior to the issuance of his outcome report. GAAS requires that the auditor design the audit to provide reasonable assurance of detecting material errors and irregularities (see SAS Nos. 53 and 54). Thus, an effective audit for the agency setting considered within the dissertation is sufficient to insure that the auditor has conformed with GAAS.

\(^6\)The other uses of audit evidence are felt to be secondary to the use of evidence in support of an audit opinion.
considered within this dissertation, the owner designs only the incentive scheme while the auditor provides the information which allows the owner's incentive scheme to align the interests of the owner with those of the auditor and manager. It is maintained that an evidentiary requirement rule (the requirement that the auditor have evidence to support an opinion when the auditor's report varies from that of the manager) allows for the alignment of incentives.

The first published agency model in which the auditor's actions were considered to be unobservable was Antle [1982]. In his paper, Antle showed that the owner may not be able to contractually induce the desired level of audit effort. The reason for the existence of the difference between the supply and demand of audit effort may be caused by either the auditor's optimal randomization of effort strategies or the inability of the owner's incentive contract to alleviate the incentive of the auditor to shirk. Antle arrived at these results by considering the subgame between the auditor and manager created by the owner's optimal incentive contracts to the auditor and manager. It would be natural to assume that within a noncooperative setting like an agency model of auditing, that the owner would be able to utilize any difference between the agents' reports to motivate the agents to choose strategies consistent with the owner's desired equilibrium. However, as Antle showed, the dependence of the incentive contract on the reports of the agents can actually induce both agents to misreport the firm outcome to their mutual benefit.

Other equilibria could also arise within Antle's model. For instance, if the owner paid the auditor a bonus when the auditor's report varied from the manager's report, then the auditor may choose to always state that the manager had misreported firm outcome. An

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7Noel [1981] also treated the auditor as a utility-maximizing agent but wasn't published until 1987.
evidentiary requirement rule could alleviate any alternative equilibria. For instance, if the auditor were subject to an evidentiary requirement rule, then the owner could pay the auditor for detecting management misreporting which would induce effective auditing and truthful reporting by the manager. Thus, in a model in which the auditor performs an audit prior to the end of the accounting period (known as concurrent auditing), the evidentiary requirement rule may be sufficient to insure that the manager’s report can be relied upon by both present and prospective stakeholders.

Baiman, Evans and Noel [1987] considered a model in which the auditor performs an audit after the end of the accounting period. Baiman, Evans and Noel showed that in the presence of a costless outside signal of audit effort, the owner can design an incentive scheme to induce the desired supply of audit effort when the auditor is hired. However, this result may be of limited use if the auditor and manager can influence the availability of the costless outside signal. For example, if the auditor detects management misreporting, then it is highly unlikely that another exogenous source will be available to confirm this finding. Likewise, if (1) the manager reports truthfully, and (2) the auditor does not provide an effective audit, then it is highly unlikely that any outside signal would be available which would contradict the manager’s report or signal an ineffective audit.

An evidentiary requirement rule set within an ex post audit setting may not allow the owner’s incentive scheme to always induce the auditor to perform an effective audit. However, it may be that the evidentiary requirement rule allows the owner’s incentive scheme to induce effective auditing often enough to eliminate any gains to the manager.

---

8An evidentiary requirement rule need not assume that the owner can costlessly determine the authenticity of the auditor’s evidence. Audit committees, for instance, are often in charge of settling disputes between auditor assertions and manager assertions (see Knapp [1987]).
from misreporting. Thus, even though the auditor may not choose the owner's desired level of audit effort in each period, reliable management reporting may be achieved.\(^9\)

Besides being of value in contract design, the existence of an evidentiary requirement rule may allow the modeler to compare the returns to the owner, manager, and auditor under both concurrent and *ex post* auditing. This would allow the accounting researcher to determine what factors affect the timing of audit procedures. Leading audit textbooks, such as Carmichael and Willingham [1987] and Arens and Loebbecke [1980], suggest that timing of audit tests should be influenced by client-specific audit risk. It is suggested that if client-specific audit risk is low, then substantive testing should be performed before the close of the accounting period. However, if the audit risk is high, then substantive testing should be performed after the close of the accounting period. Previous agency research by Penno [1985] suggests that a demand for auditing after the close of the accounting period exists when the audit technology is imperfect and the manager is risk averse. Penno's results may be enhanced because of the lack of any subgame within his model between a utility-maximizing auditor and a utility-maximizing manager.

While past analytical research has ignored the importance of evidence, the importance of evidence in an audit setting has not been ignored by the Auditing Standards Board nor practitioners. For instance, SAS No. 41 requires the auditor to maintain working papers which detail evidence in support of his opinion. Likewise, SAS No. 31 requires that adequate evidence be gathered by the auditor in support of his

\(^9\)Antle says that an auditor is strongly independent under a particular owner incentive scheme if the auditor always chooses the owner's desired strategy. Further, Antle [1984] states that absent strong independence, the owner may not achieve his desired equilibrium. Strong independence in an *ex post* audit setting may not need to be present when an evidentiary requirement rule is present.
opinion. Finally, the third standard of reporting requires that the auditor justify his opinion whenever other than a clean opinion is issued.

Practitioners also realize the importance of possessing evidence to support an opinion. Obviously, if the practitioner is unsure whether or not the manager has misreported firm outcome, the auditor would qualify or issue a disclaimer on the financial statements of the firm.\(^\text{10}\) However, lacking evidence to back up this assertion, it is reasonable to assume that the firm’s management would protest this audit report. To avoid a possible loss of a client caused by differences between the manager’s and auditor’s reports, the auditor would probably extend his tests in order to gather additional evidence to support his opinion.

If an evidentiary requirement rule has value in an audit setting, we should see institutions in place which can gauge the sufficiency of auditing evidence. At a corporate level, the requirement that all firms whose shares are listed on the New York Stock Exchange maintain an audit committee might be the regulator’s way of strengthening the evidentiary requirement. Likewise, peer reviews, mandated by the American Institute of Certified Public Accountants, might be the profession’s way of strengthening the evidentiary requirement.

As this section has discussed, an auditing evidentiary requirement may be valuable in allowing the owner to achieve his desired equilibria and in determining when audit tests should be performed. Institutions such as audit committees and peer review boards may be the owner’s and profession’s way of acknowledging the importance of evidence in an auditing setting. Thus, one must wonder why such a fundamental precept of

\(^{10}\)A disclaimer in the agency setting considered herein would be equivalent to no report of firm outcome. This opinion type is not available to the auditor within this model.
auditing such as evidence has not been derived from studies of agency models of auditing.

1.4 Dissertation Outline

Chapter II of this dissertation provides a literature review of the monitoring literature. This literature review contains agency settings not altogether similar to the agency setting of this study. This is done for two reasons. First, the set of relevant published papers is limited. Second, the literature review is intended to supply the interested reader with information which would be useful in deciding how the type of information asymmetry, existence and perfection of a monitor, and the degree of observability of the monitor's actions affect the results generated from the particular study. Also, by categorizing the literature review in this way it is hoped that open questions will be discovered.

Chapter III formalizes the agency setting involving the manager and owner described in Section 1.2. Chapter IV studies the model of Chapter III to generalize the findings of Green and Lafont [1986]. Chapter V incorporates the auditor into the model of Chapter III and shows that the owner can design a contract with the auditor which will limit the manager to his truth-telling utility level when an auditor evidentiary requirement rule is incorporated within the optimal contract design.

Chapter VI considers timing of auditing in the presence of an auditor evidentiary requirement rule and shows that a proxy of audit risk determines when ex post auditing will provide a Pareto improvement over concurrent auditing. Chapter VII provides a summary of the findings along with contributions, implications, and limitations of this research.
CHAPTER II
LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is (1) to introduce the types of models of asymmetric information to be reviewed; and (2) to consider each type of asymmetric model separately in order to (a) explain the results of these studies with and without monitoring; (b) identify testable implications of these studies; and (c) identify open questions.

The agency setting of Section 1.2 is a special case of hidden action and hidden information in which the hidden information is the firm's outcome. As noted in the dissertation outline (Section 1.4), the number of research papers published in the agency setting of this dissertation is limited because of the difficulty of this multi-player analysis. Given this limitation and for pedagogical reasons, the literature review considers various types of models of asymmetric information with the exclusion of models of adverse selection. Appendix A is supplied to provide the mathematical assumptions typical within a particular agent model and their importance in insuring the existence and uniqueness of the agency solution. It is suggested that Appendix A be read prior to the literature review.

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11Rasmussen [1989] provides the following description of an adverse selection model: "Nature begins the game by choosing Smith's type, unobserved by Brown. Smith and Brown then agree to a contract. Information is complete" [pp. 133-34].
2.2 Types of Asymmetric Information

We discuss three distinct games of asymmetric information. They are games with (1) hidden action; (2) hidden information; and (3) hidden action and hidden information. Each of these game forms are graphically depicted in the timelines of Figure 2.

Figure 2.1 illustrates the timing of a game of hidden action. The timing of this model can be explained as follows. The agent and principal enter into a contract for the agent to supply a level of some input which causes disutility for the agent. This is typically considered to be effort. Next, the agent chooses effort without knowledge of the productive state of the firm. The uncertainty of the payoff from the productive action taken by the agent introduces risk into the agency model which the principal must absorb or compensate the agent for. After the agent has chosen his effort, the productive state is made available to the agent and the firm outcome becomes public knowledge. At this point the owner compensates the agent based upon firm outcome, terminates the agency, and consumes the remaining outcome. The goal of the owner in a game of hidden action is to maximize the level of his consumption by inducing the agent to provide effort needed to produce a product.

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Agent and owner contract. | Agent takes productive action not observed by the principal. | The productive state of the firm is observed. | The outcome of the firm is made publicly available. | Payments are made to the agent by the principal.

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Figure 2.1 Hidden Action

The second game of asymmetric information is known in this dissertation as a game of hidden information. The timeline for this model is contained in Figure 2.2. The
timing of this model can be explained as follows. The agent and owner enter into a contract for which the agent's information is of value. This information could be knowledge of market conditions, the cost structure of a particular firm, or the profit potential of a firm. The key point is that the agent's information will allow the owner to make a better decision. For a game of pre-decision information, the principal then makes a productive decision and the outcome is observed. Payments are made to the agent and the agency is terminated with the owner consuming the residual outcome.

The agent's hidden information can be acquired at any of three distinct time periods. The earliest point in the model at which the agent can obtain information is prior to contracting. The next point in time at which the agent can obtain information is after the principal and agent have contracted but before the principal has made his decision. Finally, the latest point in the model at which the agent can obtain information is after the principal has made his decision. Acquisition of information after the agent has chosen his input level has no value to the agency unless the agency is not terminated at the end of the contract period. See Fellingham and Young [1990] on this point.

Games in which information is received by the agent prior to contracting will be called games with pre-contractual information. Games in which information is received by the agent after contracting but before a productive decision is made by the principal will be called games with pre-decision information. Finally, games in which information is received by the agent after the productive decision is made will be called games with post-decision information.

Games with pre-decision, post-decision, and pre-contract information can be greatly simplified by the Revelation Principle when applicable. The applicability of the Revelation Principle insures that the owner's optimal contract design can be limited to truth-telling contracts. In particular, any set of utilities available when parties have incentives to lie
also can be obtained by making their compensation dependent on these claims such that they no longer have an incentive to lie. The Revelation Principle is helpful because it narrows the contract design problem by constraining the feasible contracts to those which elicit truth-telling (see Myerson [1979], and Harris and Townsend [1981]).

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**Figure 2.2 Hidden Information**

Finally, the last game of asymmetric information considered within this dissertation will be known as a game with hidden action and hidden information. As can be deduced from its name, games of hidden action and hidden information are a blend of games with hidden information and games with hidden action. Games with hidden information and hidden action can contain either pre-contractual, pre-decision, or post-decision asymmetric information. A diagram of a game of hidden action and pre-decision information is provided in Figure 2.3.

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**Figure 2.3 Hidden Information and Hidden Action**
The problem faced by the owner in a game of hidden action and hidden information is that the owner must contractually induce the agent to disclose truthfully his private information and contractually motivate the agent to provide more than minimal effort. Thus, the agency costs within this model at least weakly exceed that of games with either hidden information or hidden action.

2.3 Games of Hidden Action

2.3.1 Properties of Contracts Without Monitoring

As described in Section 2.2, games of hidden action result when the efforts of the agent are not observed by the principal. This game form was the subject of most of the earlier work in the agency research.

Mirrlees [1976] studied a model of hidden action in which the productive technology of the firm exhibited moving support in the agent’s efforts. Additionally, Mirrlees assumed that the agent was risk averse and could be penalized arbitrarily large amounts if caught shirking. The moving support of the production technology allows the principal to infer, for some outcome levels, the effort taken by the agent. With the availability of large penalties, Mirrlees shows that the owner can achieve a first best outcome by imposing harsh penalties for any outcome not consistent with first best effort.

Holmstrom [1979] relaxes Mirrlees’ assumption of moving support by assuming that any agent effort could result in any firm outcome. This assumption, known as stationary support, along with an assumed unique effort response by the agent to any compensation contract offered by the principal, allows Holmstrom to describe the optimal second best contract as:

\[ s(x) = \lambda + \mu \frac{f(a|x|a)}{f(x|a)} \quad \forall x \in X \]
where \( \lambda \) and \( \mu \) are constants and \( f(x|a) \) is the conditional distribution of outcome \( x \) given effort level \( a \).

This notation is to be read as the optimal payment to the agent for outcome \( x \in X \) is equal to a flat salary plus a bonus (or minus a penalty) based upon the likelihood of that outcome occurring when optimal effort \( a \) is taken. As Mirrlees [1976] has shown, the first best contract would not impose risk on the agent and can therefore be described as \( s(x) = \lambda \ \forall \ x \in X \).

In comparing the first and second best contracts, it is seen that when hidden action is present, the principal’s optimal contract requires the risk averse agent to accept risk. This imposition of risk on the agent induces additional effort from the agent but is costly to the owner. Thus, Holmstrom’s work shows that the optimal compensation contract in the presence of hidden action requires the owner to trade-off the incentive effects of risk with the additional cost of imposing that risk.

Shavell [1979] arrives at a similar result to Holmstrom [1979] but uses calculus of variations to arrive at his result. Calculus of variations requires that the optimal effort level of the agent be interior to the constraint set. However, there is no guarantee that the optimal agent effort will be interior to the constraint set. Holmstrom [1979] provides a nice illustration of this.

Grossman and Hart [1983] studies a similar model to Holmstrom [1979] but relaxes the assumption that the agent will take a unique effort in response to the owner’s compensation schedule. They introduce a three-step procedure to derive the conditions sufficient to support Holmstrom’s result. The three-step procedure focuses on contracts that induce an agent to pick a particular action. The first step in this procedure is to find each possible effort level and the set of wage contracts that induce the agent to provide that effort level. The second step is to find the contract which supports that effort at the
least cost to the principal. Finally, the third step is to choose the effort level that maximizes profits given the necessity to support that effort with a costly wage contract.

Grossman and Hart find that in using this procedure a spanning condition or two conditions (known as the monotone likelihood property and the concavity of the distribution function) are required to duplicate Holmstrom's findings.

2.3.2 Properties of Contracts With Monitoring

For games of hidden action, the principal monitors the efforts of the agent to avoid (or lessen) the risk-return trade-off necessitated when monitoring is not present. The monitor of the agent's effort can either be perfect or imperfect.

Harris and Raviv [1979] consider a model of hidden action in which a perfect costless monitor of agent effort is available. Harris and Raviv show that if a perfect costless monitor of agent effort is available, then the contract written by the owner should provide the agent his reservation utility only when the owner's directed effort is taken.

Holmstrom [1979] considers a costless imperfect monitor of agent effort. He shows that the welfare of the agency can be improved by an imperfect monitor when the signal from the monitor is informative about the agent's effort, given the observance of firm outcome. Referring back to the optimal contract in the presence of hidden action, the reason for this finding is obvious. Looking at the likelihood ratio \( \frac{f_{a}(x|a)}{f(x|a)} \), if the imperfect monitor is informative about the agent's effort, then the likelihood ratio—as a function of the imperfect signal from the monitor and the agency's outcome—will be more closely linked to the level of effort provided by the agent.

Baiman and Demski [1980] consider a production process whose level of performance is controlled by a utility-maximizing agent. This is the classical quality control setting in which the machine needs to be reset when it no longer is providing
a quality product. As stated above, Baiman and Demski put a new twist on Holmstrom’s story by endowing the principal with an imperfect costly monitor with a fixed cost for each use, which will determine if the agent is shirking his quality control duties. Additionally, Baiman and Demski restrict the agent’s utility to the HARA class and assume conditional independence between firm outcome and the monitor’s signal.

Baiman and Demski show that in this agency setting the optimal investigation strategy depends on the risk preferences of the agent. The second finding by Baiman and Demski has the following incentive explanation. The imperfect monitor imposes risk upon the risk averse agent who then takes additional effort in an attempt to avoid investigation. A similar explanation holds for the less risk-averse agent.

Young [1986] considers a model of Baiman and Demski [1980], along with a distinct class of utility functions, to show that the optimal investigation strategy is two-tailed. Lambert [1985] also considers cases in which the factors influencing the accuracy of the monitor may also result in optimal investigation strategies which are two-tailed.

Dye [1986] considers a model of hidden action in which the monitor is imperfect and costly in order to generalize the results of Baiman and Demski [1980] to agency models with finite action spaces and general utility functions. The three-step procedure developed by Grossman and Hart [1983], alluded to earlier in this discussion, was utilized to determine the optimal investigation region. Dye’s main finding suggests that the degree of perfection of the monitor affects the optimal monitoring region. Dye shows that, in contrast to Baiman and Demski [1980], if the monitor is perfect and certain regulatory conditions on the outcome distribution are present, the optimal monitoring policy is lower-tailed. Additionally, Dye shows that if the conditions similar to Baiman and Demski [1980] exist, then the optimal investigation region is always lower-tailed.
Dye's findings with regard to the perfect monitor can be explained as follows. As in many models of hidden action, the principal difficulty in designing an expected cost-minimizing incentive structure to motivate the agent to perform a particular action $a^*$ involves insuring that the agent has no interest in selecting actions that entail less effort than $a^*$. When the outcome's distribution function satisfies the monotone likelihood ratio property, it is known that any effort selected below $a^*$ produces expected levels of outcome below that produced with $a^*$. By verifying low outcomes, the owner discourages the agent from shirking. Additionally, since the agent is effort averse and has a unique response to a given compensation function, high outcomes need not be investigated.

Dye's second finding parallels that discussed above. It should be noticed that results from this literature suggest that the monitoring region is affected by the costliness of the monitor, the perfectness of the monitor, and the utility function of the agent. Thus, we see monitoring is very much dependent upon the components of a given agency setting.

2.3.3 What We Have Learned From These Studies

Studies of games of hidden action suggest that (1) first-best can be achieved even if the agent's actions are not observable; (2) when first-best is not achievable, the second-best contract results in the owner imposing risk upon the agent to reduce shirking by the agent; (3) the optimal monitoring region is affected by the degree of perfection of the monitor, the agent's preferences, and the cost of the monitor; and (4) monitoring can reduce shirking.

The first finding illustrates that in some agency settings of hidden action first-best can be achieved. Harris and Raviv [1979] shows that if the agent is risk neutral or the firm's productive state and firm outcome is viewed by the principal, then first-best can
be achieved. Further, Mirrlees [1976] shows that if the productive outcome distribution possesses a particular type of support and the owner can impose arbitrary penalties on the agent, then first-best can be achieved in an agency setting of hidden action. Finally, Holmstrom [1979] implies that the inability to view the agents efforts should not preclude the first-best solution when the outcome is perfectly correlated with the agent's effort.

The third finding illustrates that the cost of the monitor and its degree of imperfection affect the optimal monitoring region. For instance, if the monitor is perfect or imperfect but costless and the signal from the monitor provides incremental information about the effort of the agent over and above that provided by viewing the outcome, then the monitor should be utilized for all outcome reports. However, if the monitor is perfect or imperfect but costly and meets the informativeness criteria of Holmstrom [1979], then the optimal investigation region will not be the entire outcome set. This result is intuitively appealing because the cost of monitoring precludes verification of very favorable outcomes. It was also shown by the results of these studies that imperfection of the monitor imposes additional risk on the agent. Thus, in the case of costly imperfect monitoring, the agent's utility function and any dependence of the monitor on firm outcome will affect the optimal investigation region.

2.3.4 Testable Implications and Open Questions

Testable Implications. One possible testable implication, from the work of Holmstrom [1979], is that when outcome is not a perfect predictor of effort, the compensation structure of the agent should not be flat salary. Information should be readily available from compensation studies of various professions to indicate the level of salary coming from straight salary and that coming from bonus awards. A maintained
hypothesis within a study of this form would be that outcome is not a perfect predictor of effort. A scaling mechanism, based upon the observability of effort of the agent, would be developed with a paired comparison of the compensation type and the observability scale measure considered. The null hypothesis in this section would be that no relationship exists between the scale measure and the compensation structure. Rejection of the null should provide some support for Holmstrom’s findings.

Another testable implication from these studies would consider the relationship between the number of Internal Revenue audits (obviously an imperfect monitor) and the level of tax collections between years. This study would have data comparability problems but data transformations may mitigate these problems. The relationship, if any, would allow for a test of how an imperfect monitor affects the reporting decisions of the agents. The first null hypothesis in this section would be that the number of Internal Revenue Service audits (the frequency of monitoring) has no affect on the level of tax collections. Rejection of the null would provide some support to Kanodia [1985]. The second null hypothesis in this section would be that as the number of audits increase (cost of monitoring increases), the optimal monitoring region would expand. Rejection of this null would support the maintained theory that as the cost of monitoring increases the optimal monitoring region should shrink to reflect the additional cost incurred. Thus, it would be expected that as the number of audits increased, the distribution of those audits would tend to be concentrated on taxpayer types which would provide the largest return for the monitoring buck.

**Open Questions.** In all of the monitoring studies, the owner was limited to either monitoring or not monitoring agent efforts. However, Rasmussen [1989] identified at least six other ways in which the principal can reduce agency costs. Foremost among these methods of interest to accountants is tournaments. Mookherjee [1984] shows
conditions within a hidden action setting which make the use of a monitor unnecessary because of the ability of the principal to design a tournament between agents. However, the value of tournaments is predicated upon the correlation between the productive environments of the agents. If there exists no correlation between the agent’s productive environments, then the principal can do no better than contracting with each agent independently. This leads to two open questions. First, what factors influence whether monitoring or tournaments will be used within an agency setting to alleviate hidden action? Second, is tournament competition a substitute or complement to monitoring and, if it is possible, what factors would lead to an economic environment in which tournaments and monitoring are used by the agency for compensation purposes?

The answer to the first question may provide answers needed for empirical tests of the usefulness of tournaments (see Antle and Smith [1986]). The answer to the second question will provide guidance to the managerial accountant as to when it is best to provide comparison performance measures for measuring an employee’s performance as well as when to forsake comparison of performance. These results would be helpful to accountants for design of optimal accounting systems.

A second identified open question deals with the cost of the monitoring system. In all the monitoring models discussed above, either the cost of the monitor was deterministic or the cost was related to the level of firm outcome. A more acceptable assumption, and one used by Ng and Stoeckinius [1979], relates the cost of monitoring to the level of perfection of the monitor’s signal. Therefore, a very precise signal of agent effort would be more costly to obtain than a less precise signal of agent effort. With this particular type of cost structure, the choice of the level of imperfection becomes a choice variable within the model. This allows the researcher to study how model parameters affect the demand for various levels of monitoring precision. For a particular case of
monitoring in the presence of hidden action, it is hypothesized that monitoring would occur both for high levels of outcome and low levels of outcome when cost of the monitor is driven by its precision level. The reason for this two-tailed investigation strategy may be that the owner may want to convince himself that the high outcome was caused by high agent effort while the low outcome was not caused by low agent effort. For instance, the owner would expend very little resources to gather effort information when the outcome was high. Alternatively, the owner may expend higher resources to obtain agent effort information when the outcome was low. This monitoring policy should further alleviate any incentive of the agent to shirk.

A study of this question, within various games of asymmetric information, may provide clues as to how factors inherent in an agency setting affect the precision level necessary in managerial accounting systems. Although abstract, knowledge of these factors should aid the managerial accountant in allocating resources necessary to mitigate various control problems inherent within a firm.

2.4 Games of Hidden Information
2.4.1 Properties of Contracts Without Monitoring

As described in Section 2.2, games of hidden information result when the agent possesses some insight concerning the productivity of the production technology or the firm's outcome which is not shared by the principal. This type of problem has recently been studied within the regulation literature and a special variant of the auditing literature.

Baron and Myerson [1982] study a model in which the principal is the regulator and the agent is the regulated firm. The agent has pre-contractual information about the marginal cost of the firm not shared by the principal. The firm's reservation profit level is assumed to be common knowledge and independent of the firm's private cost.
information. The regulator's objective is to maximize a weighted average of consumer's and producer's surplus.

Baron and Myerson show that the optimal regulatory policy has the following characteristics:

1. The firm receives no rents when its marginal cost is at its highest possible level.
2. The profits of the firm are higher the smaller is the firm's marginal cost.
3. The regulated price set by the regulator is set in excess of the realized marginal cost for all but the lowest possible marginal cost where price is set equal with marginal cost.
4. Provided a plausible regulatory condition is satisfied, the regulated price is never the same for two distinct cost realizations.

In the Baron and Myerson model, the firm's incentive is to always exaggerate its marginal cost in hopes of soliciting greater compensation from the regulator. To counteract this, the regulator must design a contract which elicits the firm's true marginal cost. The Revelation Principle applied to this setting forces the owner to pay for the information acquired. However, knowledge that the marginal cost is low is more important to the regulator than when marginal cost is high. Thus, to insure that the regulator pays no more for the information than what it is worth and the firm has an incentive to truthfully reveal its cost parameter, the regulator sets the price paid by consumers in excess of the marginal cost communicated by the regulated firm. This dampens the demand for the regulated firm's product below that which profit maximization of monopoly profits dictates. Thus, any incentive to misstate firm marginal cost is reduced. Notice when the firm announces that the marginal cost is the lowest
possible, the regulator knows that the firm has told the truth. For this case, the principal need not use his regulatory policy to induce agent truth-telling.

Lewis and Sappington [1989] introduce counter-vailing incentives into Baron and Myerson’s model by allowing the reservation profit level necessary to maintain the firm within the industry to vary with its costs. In this expanded setting, Lewis and Sappington show that the optimal regulator policy has the following quantitative properties:

1. The firm receives exactly its reservation profit for some realization of costs which may differ from the highest possible marginal cost.
2. The profits of the regulated firm decline with the cost realization for some marginal costs and increases for others.
3. The regulated price is set at higher than marginal cost for both high and low cost realizations.
4. Price and marginal costs are set equally at a particular cutoff point and at the two extreme values of marginal cost.

The intuition for these findings is that, in Lewis and Sappington, incentives exist both for the agent to exaggerate costs to improve its profits and to understate its cost structure to enhance its reservation profit levels. To mitigate false reporting of the agent’s cost structure, the optimal regulatory policy either increases production for low cost realizations by setting price less than the marginal cost realization or decreases production for the high cost realizations by setting price in excess of marginal cost. Thus, any firm which attempts to snare additional profits by either understating or overstating their cost parameter is penalized by being forced to produce at other than optimal production levels.
2.4.2 Properties of Contracts With Monitoring

Two distinct cases of hidden information are considered within this setting. The first type of possible hidden information possessed by the agent is knowledge of the productive state of the firm prior to taking his productive action. In this setting, monitoring can improve the returns to the owner by allowing the owner to expand the set of implementable contracts beyond those available absent monitoring. The second type of hidden information possessed by the agent is knowledge of the firm outcome. In this asymmetric information setting, the monitor is present to insure that the principal receives his fair share of the outcome of the agency.

Baron and Besanko [1984] consider a model of hidden state information posed by Baron and Myerson [1982] to study the effects of monitoring on the optimal contract with the agent and to study the resultant optimal monitoring region. In their model, the monitor is perfect and has a fixed cost. The regulator's objective in this setting is to maximize the consumer's and producer's surplus less the cost to audit.

Baron and Besanko interpret the optimal auditing policy as a three-stage process. First, an audit is authorized if the agent's cost report is high where high is defined by some cutoff point. This cutoff point is present to insure those firms with low cost structures do not over-report their costs. Second, when the audit is conducted and the realization of the firm's cost is observed, that cost is compared to a critical point. In order to determine whether refunds of firm profits will be paid to consumers, the regulator finds that the firm misreported its costs if the realized cost is low compared with the critical point. Third, if the firm is found to have misreported its cost, then a penalty is imposed. Since the firm wishes to overstate its cost parameter, the optimal auditing policy and the cut-off point are intended to dampen that incentive.
Townsend [1979] studies the value of monitoring the agency's endowment, which could be interpreted as the firm's outcome. The strictly risk-averse agent, in Townsend's model, knows the productive outcome while the weakly risk-averse principal does not know the productive outcome. The agent at the termination of the agency must transfer an amount to the principal based upon the agent's report of firm outcome. Since the agent would like to minimize the transfer to the principal by claiming a low outcome, the principal is endowed with a costly perfect monitoring technology. The objective of the principal is to design a contract and an optimal monitoring region so that the payment to the principal is maximized. Townsend finds that the optimal contract in the presence of costly outcome verification pays the principal a constant when no monitoring occurs and a contingent amount when verification does occur. Additionally, Townsend shows that if the cost to monitor the agent's outcome report is constant, the principal is risk neutral, and no bankruptcy condition exists on the level of transfer between the agent and principal, then the monitoring region is lower-tailed.

The intuition behind Townsend's result could be explained as follows. Since the verification costs are paid by the agent, the principal designs a contract so that the agent's residual income net of monitoring costs when he understates firm outcome is always less than or equal to the residual income earned from truth-telling. Given the incentive of the agent is to understate firm outcome and the monitoring cost is independent of firm outcome, the principal desires a lower-tailed monitoring region.

Penno [1985] considers a variant of Townsend's model by introducing costly imperfect monitoring of firm outcome. Penno derives a demand in this setting for communication of the manager's report prior to a formal audit. In Penno's model, monitoring is deterministic, whereas Townsend allows the optimal audit region to be
lower-tailed. The principal’s objective in Penno’s model is to maximize his return net of monitoring costs.

Penno finds when the monitor is imperfect, it injects risk into the agency setting. As a means of reducing this risk, the agent can communicate the firm outcome to the principal prior to submitting his outcome report for audit. This enables the owner to write a contract to lessen the level of risk faced by the agent and thereby improve the welfare of the agency.

Baiman, Evans and Noel [1987] generalize Townsend’s results to an environment with a utility-maximizing monitor. The monitor is operationalized as either an internal or external auditor whose responsibility is to limit the risk the agent faces for low outcome reports (see Penno above). The auditor in their study is assumed to commit no Type I error and is assumed to be able to perform either an effective (perfect) or ineffective (no audit) audit. The principal (in Baiman, Evans and Noel) must provide an incentive to the auditor to perform his duties. This makes this paper unique to this stream of research. The objective function of the principal is to maximize the transfer from the agency net of payments to the utility-maximizing auditor and manager.

Baiman, Evans and Noel find that if there exists a signal of auditor effort which is costlessly available to the principal and the outcome endowment to the agent is distributed uniformly, then the auditor will always effectively audit irrespective of the limited liability which the auditor faces for performing an ineffective audit. Additionally, it is shown that if the auditor will always perform an effective audit when hired, then the optimal audit region is lower-tailed.

The intuition for the first finding is that the lottery placed upon the auditor, along with the owner providing an incentive for the agent to misreport, reduces the auditor’s expected level of compensation when an ineffective audit is performed below that when
an effective audit is performed. The second result is based upon the same intuition as that provided by Townsend [1979]. This parallel illustrates that in order to generalize previous results to environments in which the monitor's actions are not observable, it is required that the modeler recognize the monitor's compatibility requirement.

2.4.3 What We Have Learned From These Studies

Studies of models with hidden information suggest that (1) if the Revelation Principle applies, then the owner, absent monitoring, might need to pay for the information provided by the agent; (2) the amount paid for this information will never exceed its worth to the agency; (3) monitoring can reduce the agent's information rents; and (4) when a monitoring technology is replaced by a utility-maximizing agent, the owner must contractually induce a supply of effort from the agent.

The first result of these studies underlies the ability of the owner to limit the set of feasible contracts to those which elicit truth-telling from the agent. This simplifies contract design of hidden information models by allowing the firm's owner to incorporate within the design of the optimal contract a truth-telling constraint. However, this also illustrates that when the agent has private information, the set of feasible contracts available to the owner is reduced. Thus, the agency can never be strictly better off in this setting.

The second result is illustrated by the models from the regulation literature. In both these models, the regulated firms have pre-contractual information which the regulator pays for by the price set for the regulated commodity. Thus, it is of no surprise that the regulator allows the regulated firm to earn profits when it is a low cost firm and no profits when it is a high cost firm. Further, to limit the information rents available to
the regulated firm, the regulator can set the price either above or below reported marginal cost.

The third result is obvious while the fourth result is important to all the monitoring literature which assumes that the monitor's actions are observable. As Baiman, Evans and Noel illustrate, the results of any monitoring paper in which the monitor is a technology is not without loss of generality to similar models in which the monitor is a utility-maximizing agent. Since it is typical that humans perform monitoring tasks, the generality of all previous work in monitoring to environments in which the monitor's actions are not observed requires sufficient conditions to insure the monitor will be effective in limiting the rents of the agent.

2.4.4 Open Questions

One pressing question which needs to be addressed within models of hidden action and hidden information is what conditions are necessary and sufficient for the Revelation Principle to hold? As discussed above, the Revelation Principle makes contract design for agency settings with hidden information very straight-forward. However, limitations on the report sets of the agents may invalidate the Revelation Principle. Green and Lafont [1986] identify a necessary condition on the report sets of the agents which insures that the use of the Revelation Principle for contract design is not without loss of generality. With the current interest in models of hidden action and hidden information, the need to determine when the Revelation Principle is valid for these contexts must be pursued. Chapter IV of this dissertation identifies how constraints on outcome reports within a hidden action and hidden outcome setting affect the validity of the Revelation Principle.

Another open question is what conditions are sufficient to insure the results of studies in which the owner can view the efforts of the monitor carry over to studies in
which the owner cannot view the efforts of the monitor? Baiman, Evans and Noel [1987], in a very specific environment, show that a costless outside monitor is sufficient to insure that Townsend's optimal monitoring region applies to an agency setting in which the monitor's actions are not observed. This dissertation also shows, in a more generalized setting than Baiman, Evans and Noel, that an evidentiary requirement rule on the utility-maximizing auditor allows the owner to limit the manager to no more than his truth-telling level of utility. This is a unique result in this literature and alleviates the need to consider costless outside signals whose strength may be determined by the players within the model.

2.5 Games of Hidden action and Hidden Information

2.5.1 Properties of Contracts Without Monitoring

In this section, the agent has private information about the effort supplied and either has (1) private productive state information of either a pre-contractual or pre-decision nature, or (2) private knowledge of the firm's outcome. An example of an environment which possesses information asymmetries of the first type listed is a decentralized firm. A natural setting for the second type of information asymmetry listed would be a firm characterized by absentee ownership.

Sappington [1983] models an agency relationship in which the agent possesses private state information prior to contracting and is privy to his effort selection. Sappington assumes the agency's outcome is common knowledge and dependent upon the agent's efforts. The principal's objective in this setting is to maximize firm outcome net of a wage payment to the agent.

Sappington shows in this single agent-principal model with binary state information that the optimal firm contract will have the following qualitative characteristics:
1. The agent who provides low effort in the low productive state will earn his reservation wage.

2. The agent who operates in the high productive state earns rents irrespective of whether low effort or high effort is put forth.

3. The agent’s compensation schedule is designed so that the agent’s expected marginal utility for high production in the high productive state is set equal to the agent’s expected marginal disutility for high productivity in the high state.

4. The agent’s expected marginal disutility for low production in the low state is lower than the agent’s expected marginal utility for low production in the low state.

5. The high productive outcome is always greater than the low productive outcome.

In Sappington’s model, the agent’s incentive when the high state occurs is to provide low levels of effort. To counteract this behavior, the contract provides for a production plan which is efficient only when the productive state is high. Here again we see the principal allowing the agent to earn information rents only when his information is of value to the agency. Additionally, to entice additional effort from the agent, the compensation schedule is designed so that the agent in the low state has an incentive to provide additional effort. This is accomplished by Parts 3 and 4 above. Thus, the structure of the wage schedule is such that the agent takes the high effort level and earns rents only in the high productive state.

Demski and Sappington [1984] extend Sappington [1983] to multiple risk-averse agents in which the agent’s productive environments are correlated. The principal’s
objective is to design a compensation structure so that the firm's expected outcome net of the agent's expected compensation is maximized.

Demski and Sappington show that the results of optimal contract design within a single agency setting studied by Sappington [1983] carries over to the multiple agent environment. In particular, Demski and Sappington show that the optimal contract with multiple agents in a correlated environment has the following qualitative characteristics:

1. Each agent is held to his reservation level of utility when he observes the low productive state.
2. Each agent may receive rents when he observes the high productive state.
3. The agent faces a lottery regardless of his private information (this is caused by the imperfect correlation).
4. The contract will be designed, as in the single agent case, to induce the agent to produce more output when he observes the high productive state then when he observes the low productive state.
5. Regardless of whether the agent provides the large or small output, his compensation is always higher if the other agent produces the low outcome (this is the tournament aspect of the compensation scheme).

Again, as in Sappington [1983], we see that the agent can earn rents only when the information most benefits the agency. Additionally, the compensation function is designed always to induce the agent to take higher effort when the low state occurs. The new twists to this compensation scheme occur in Parts 2, 3 and 5 above. In the single agent case, the agent who views the high state always earns rents. However, in the optimal contract above, Part 2 states that the agent may earn rents when the high state
occurs. The reason for this variation between the single-agent case and the multiple-agent case is that the principal has another source of information—namely, the second agent. Thus, the need to pay rents to the agent in a multiple-agent setting when the state is high should only occur when the other agent doesn’t signal the high productive state and the productive state is high. Part 3 varies from the single agent case because of the partial correlation between the productive environments of the two agents. Thus, the first agent will view the high state in some periods when the second agent views the low state. Thus, the agent faces the compensation structure in Part 5 irrespective of truth-telling on his part.

As in Sappington [1983], the agents would like to provide low levels of effort when the high productive state is observed. The optimal contract design of above suggests (see Part 3 and Part 5 above) that the agent who knows that the other agent will truthfully reveal his private information has as a best response to also truthfully reveal his private information. However, this contract design has an alternative equilibrium, namely for both agents to defect and claim the low state in all circumstances. This finding indicates the need of the contract design to consider joint defection strategies.

This leads Demski and Sappington to suggest that if a direct mechanism is to be utilized in game design with multiple risk-averse agents in a correlated production environment, then the contract design must dominate one agent to produce the high outcome in the high state and low outcome in the low state. As Demski and Sappington point out, this domination is costly in an imperfectly correlated environment because the truthful agent is rewarded on occasion when the other agent is also truthful but the prospective states of the two environments are not similar for that period.

In response to Demski and Sappington's suggestion that costly domination will occur, Ma, Moore and Turnbull [1988] suggest an alternative solution. This alternative
requires that one agent be treated as both information provider and productive agent. This is accomplished in their setting by expanding the message space available to the "Pet" so that the Pet's outcome report provides insights into whether or not the other agent is shirking. If the other agent in this setting produces the high outcome, then the principal rewards the other agent for the slur against his character. On the other hand, if the other agent produces the low outcome in this setting and the "Pet" signals that the productive state is high, then the other agent's compensation reduces his utility level below his reservation level. This compensation schedule is able to achieve the second-best outcome with the agents which costly domination isn't able to achieve.

Demski, Sappington and Spiller [1988] consider whether the results of Demski and Sappington [1984] hold in a world in which the principal is limited in the level of penalties which can be imposed upon the agents. It is shown that if the agents are risk neutral, operate in a correlated environment, and have either pre-contractual or pre-decision information concerning the productive state of the firm, then the principal need not be concerned with alternative equilibria in which both agents defect.

The intuition follows from the ability of the principal to compensate the agents independently of the other agent's performance. Demski, Sappington and Spiller indicate that this result will not in general hold in a world with more than two productive states, since the owner would want to use the output of each agent for compensation purposes.

Several researchers including Ng and Stoeckinius [1979], Antle [1982], and Dye [1988] have considered models of hidden outcome information. As was seen in other articles reviewed, we would anticipate that the inability to view the agent's effort and outcome would distort the optimal agent contract so that agent rents were earned and high effort was encouraged only for the most favorable of outcome reports. However, for this distortion to be effective, the agent must report the true outcome. Notice in the
case of Sappington [1983], the outcome was perfectly verifiable by the owner. The Revelation Principle, applied to this setting, does allow the contract to induce the agent to reveal truthfully the outcome but at the price of not being able to use the report for motivational purposes. Thus, any attempt by the owner to distort the contract to capture some of the agent’s rents is not available in this setting. This makes alternatives to contracting—like auditing—of interest to the owner when the agent has both private information of effort and firm outcome.

2.5.2 Properties of Contracts With Monitoring

In this section, the agent has private information about the effort supplied and either has (1) private productive state information acquired either before or prior to contracting, or (2) knowledge of the firm’s outcome. Monitoring, in the first setting, allows the owner to determine whether or not the proper action was taken for a particular productive state. Monitoring, in the second case, insures that the owner can utilize the manager’s report for both motivational and investment purposes.

Kumar [1989] studies an agency model of the firm in which the agent has both private state and effort information. The unique features of Kumar’s model is that the owner can choose whether the agent’s effort or the firm’s productive state is to be monitored. In Kumar’s model, the agent possesses private pre-decision information and the firm’s outcome is public knowledge. Monitoring is assumed perfect and costly. The objective function of the principal is to maximize expected net outcome by the choice or an agent action and compensation function.

Kumar shows that, regardless of whether state or action is monitored, the monitoring region will be lower-tailed with respect to the outcome realization. Additionally, Kumar shows that with respect to the agent’s communication of the
productive state, actions will be monitored when the agent communicates the high productivity state, and the productive state will be monitored when the agent communicates that he is in a low productivity state.

The intuition for Kumar's first result has been discussed by Baiman, Evans and Noel [1987]. The rationale for Kumar's second result is that highly productive agents have an incentive to announce low efficiency and then to take low effort. Monitoring of any announcement of a low productive state mitigates this tendency by the highly productive agent. Conversely, with high announced efficiency, it is important to check that the agent does not use the productive state to substitute for his productive output.

Baiman, May and Mukherji [1990] consider an agency model similar to Sappington [1983] except that (1) the agent communicates the state of nature; and (2) the principal has available an imperfect costless monitoring system of the productive state which commits no Type I errors and commits Type II errors with probability $z$ with $z < 1$. The study considers how an improvement in the costless monitoring system affects distortions in production and the level of information rents earned by the agent.

The results of Baiman, May and Mukherji [1990] indicate that the principal's expected profit increases as the monitoring systems' probability of Type II error declines. Further, they find that the agents' information rents, arising from the agent's knowledge of the productive state prior to taking his productive act, may actually increase as the monitoring system's probability of a Type II error decreases.

The intuition behind the second result stems from the fact that the additional production by the agent, which payments of rents to the agent in high productive state encourages, may dominate the wealth redistribution effect that the monitor provides to the agency. Thus, by paying the agent more in the higher productive states and being able to better detect the lower productive states through monitoring, the principal can
elicit higher effort levels than from just monitoring the lower productive states. However, this finding also indicates that the owner may be not be better off monitoring all productive states instead of providing rents to the agent in high productive states.

Ng and Stoeckinius [1979], Antle [1982], Antle [1984], and Dye [1988] all consider models in which the outcome of the firm and the agent’s effort levels are not observable by the principal. Additionally, all four papers consider the principal and agent to be symmetrically informed as to the productive state of the firm. The purpose of each of these studies is to consider the importance of outcome information to an agency setting endowed with a set of internal controls which precludes the agent from stealing any firm outcome.

Ng and Stoeckinius [1979] consider a model of monitoring in which the monitor’s ability to detect misreporting of firm outcome is a function of the cost of the monitor. The principal’s objective is to design a contract with the agent with costly monitoring to limit the level of misreporting available to the agent.

Ng and Stoeckinius discover that in a model where an agent can fully over-report the firm outcome, a contract designed to induce truthful reporting will result in the agent providing the lowest possible effort. Additionally, if auditing is utilized to encourage agent honesty, then the principal can use the manager’s report for motivation purposes. The necessary condition for auditing to provide this benefit is that the audit technology be able to detect any misstatement with positive probability. The sufficient condition for auditing to provide this benefit is that the audit technology not commit any Type I errors.

The intuition for the necessary condition is obvious. Absent the ability of the audit technology to detect any misreporting, the use of an audit technology by the principal would not affect the agent’s misreporting strategy. The intuition for the sufficient
condition is that if the auditor did commit any Type I errors, then the principal will infer that the manager’s report is not truthful and base his compensation on an inaccurate report. The possibility of Type I errors places additional risk on the agent without allowing the agent to vary his actions to counteract this risk. The principal must therefore compensate the agent for the risk, reducing the value of the audit to the agency. If the risk of Type I error was severe enough, then no benefits from the audit’s ability to detect Type II errors would be sufficient for an audit to be performed.

Antle [1982] attempts to generalize Ng and Stoeckinius [1979] by incorporating within their model a monitor which is a utility maximizer but assumes the monitor’s actions aren’t observable. Antle’s purpose for his study is to determine if the inability to view the auditor’s actions has any effect on the owner’s ability to achieve the motivational gains from auditing.

Antle discovers that the motivational gains from auditing may not be possible when the monitor’s (or auditor’s) actions aren’t observable. The first difficulty encountered is similar to that discussed by Mookherjee [1984] and Demski and Sappington [1984] and involves the existence of multiple Nash equilibria for this game setting. Antle, in his Example 1, shows that if a contract is designed to induce truth-telling by the auditor as a best response to truth-telling by the manager (or agent), then there exists non-trivial cases in which an auditor, who is not subject to any form of outside verification, will choose not to audit the client. The reason for this result is the optimal contract design makes the auditor’s compensation linked to the manager’s report and the manager’s compensation linked to the auditor’s report. This linking of compensation to the reports of the two agents provides an inducement to the agents to jointly defect as an alternative Nash equilibrium.
Antle [1984] attempts to define auditor independence using the multiple equilibria problem discussed in Antle [1982]. Antle [1984] defines two types of independence: (1) strong independence, and (2) independence. Antle defines strong independence as the case in which the "auditor plays the Nash equilibrium most preferred by the owner in the subgame defined by the principal's incentive contract." It is obvious that if the auditor is strongly independent, then the owner need not be concerned with whether or not the auditor will supply the owner's preferred supply of effort.

What insures the auditor will be strongly independent? Antle suggests that reputation could be one rationale for the auditor to be strongly independent. Others have considered this question and have offered alternative explanations including strict or negligence liability (see Kinney and Wright [1987], Fellingham and Newman [1985], Smith [1989], Melumad and Thoman [1990]), and professional standards (see Bricker and Grant [1990]).

2.5.3 What We Have Learned From These Studies

Studies of asymmetric games with hidden action and hidden information provide us with clues as to whether the results from games of hidden information and games of hidden action carry over into games of hidden action and hidden information. Sappington [1983] illustrates that the agent with pre-decision information earned rents only in the high state and is induced to provide additional effort only in the high state. Thus, in Sappington [1983], the owner pays the agent for this private information only when it is worth something to the agency. This same finding can be found in the hidden information models. Likewise, in Sappington [1983], the agent is induced to provide additional effort only when it benefits the agency. Again, this is precisely what happens in a model of hidden action. Thus, it may be the case that games of hidden
action and hidden information may not provide any additional insights into optimal contract design other than that already gleaned from studies of hidden action or hidden information. However, it may be that this lack of interaction between the gains generated by the agent in the presence of hidden action and hidden information may be either an artifact of contract design or problem formation. Therefore, generalities should be avoided until theory development progresses further.

From contract design absent monitoring, we have gained a number of interesting insights into how the inability to view the agent’s actions or the private production state (or firm outcome) affects the welfare of the agency. Thus, in a single agent setting, we see that if the agent possesses pre-contractual information, then the owner will distort the contract to provide incentives and information rents only for highly productive states. Likewise, we see that in a multiple agent setting of pre-contractual information, the degree of correlation between the agent’s productive environments impacts the degree to which the agents can earn information rents. For instance, if correlation between the agent’s productive environments is perfect, then it can be shown that the owner may be able to achieve first-best irrespective of the agent’s information endowment. The availability of an alternative resource for productive state information in a multiple agent setting illustrates the importance to the owner of designing the agency to provide alternative sources of productive information.

Another insight from study of these models is that the type of hidden information is important to the welfare of the agency. Thus, it may be that asymmetry of firm outcome is more damaging to owner’s welfare than is asymmetry of private information. The primary reason for this finding is that the firm’s productive state is distributed independently of the agent’s action while firm outcome is dependent on agent action.
Therefore, when the outcome cannot be seen by the owner, the owner cannot motivate the agent to take a particular action.

Additionally, we see that although multiple agents with imperfectly correlated environments provide the owner with an alternative source of information, the owner may have to pay for this information. Demski and Sappington [1984] illustrate this when they prove that in a multiple agent world with imperfectly correlated productive environments, the owner can do no better than to dominate one player to always be truthful. Further, because of the imperfect correlation, the owner must compensate the agent to achieve this domination.

The value of monitoring in the presence of hidden action and hidden information is to reduce the information rents available to the agent or to motivate additional effort from the agent. Baiman, May and Mukherji [1990] show that the gains from an imperfect monitor may not result in reductions of both the information rents available to the agent and the ability of the agent to shirk. Thus, the value of increased accuracy of the monitor may be to allow for the use of agent information rents for motivational purposes.

Finally, this literature is unique in that it considers the supply of monitoring from a monitor whose efforts are not observable. The unobservability of the monitor's efforts requires the owner to design a contract which will elicit the desired supply of monitoring from the monitor. Antle [1982] shows that in a setting in which the owner cannot observe firm outcome, the agent's effort, and the auditor's effort, the owner may not be able to design a contract to generate the desired supply of auditing. This provides an incentive to researchers to consider constraints on the monitor's effort choice. If no such constraints can be found which are feasible within the agency setting studied, then
monitoring in the presence of a utility-maximizing monitor may have no value to the agency.

2.5.4 Testable Implications and Open Questions

One open question would be to study the effects of counter-vailing agent incentives with a model of hidden action and hidden information. Models such as Sappington [1983] and Demski and Sappington [1984] provide an incentive to the agent to always claim that the firm's productive state is low. For this case, these authors have shown that the optimal contract provides incentives for the agent to reveal when the highly productive state occurs. However, the agent's incentive may not always be to understate the firm's productive state. For instance, assume that the owner must make costly firm specific investments to enhance the productivity of the agent. Further, assume that these firm specific investments act as complements to the agent's effort when the productive state is high or act as substitutes for agent effort when the productive state is low. In this setting, the agent may want to overstate the firm's productivity in order to enhance his production possibilities; or the agent may want to understate the firm's productivity in order to limit the level of effort requested by the owner. The effect of the insertion of capital investment into this setting creates a counter-vailing incentive for the agent in disclosing the firm's productivity.

Lewis and Sappington [1989] consider the effects of counter-vailing incentives in a model of hidden information. They show that the optimal contract will reflect these counter-vailing incentives. A study like the one above would enable us to determine if their findings generalize to a setting of hidden action and hidden information. Further, the results of the study may provide insights into how optimal monitoring regions vary in the presence of counter-vailing incentives. For instance, monitoring in the presence
of no counter-vailing incentives may be limited to assertions of low productivity by the agent while with counter-vailing incentives monitoring may occur for announcements of either high or low productivity assertions.

Other questions which might be considered are the effect bankruptcy constraints on the agent’s consumption levels, costliness of the monitor, and imperfection of the monitor have on the value of monitoring to an agency setting characterized by hidden action and hidden information. Answers to these questions may explain why the firm dismisses the agent when low outcomes occur rather than attempting to determine the cause of the low outcome prior to dismissal. Additionally, the imperfection and cost of monitoring may preclude the owner from monitoring.

Finally, very little research has been performed to determine when the desired supply of monitoring will be provided by a monitor whose efforts aren’t observable. The standard assumption is that negligence, strict liability, or some other form of penalty motivates the agent to provide monitoring services. However, this may not be a satisfactory solution when the monitor’s efforts influence the probability distribution of a signal necessary for the owner to impose a penalty on the monitor. For example, in an auditing setting, both the manager’s and the auditor’s strategies influence the availability of a signal of audit effort. Thus, if a manager reports truthfully and the auditor confirms the manager’s report without performing an effective audit, then it cannot be realistically assumed that some outside agency will provide a signal to the owner about the performance of the auditor (remember, the results of peer reviews are private information). Likewise, if the auditor performs an effective audit and the manager has misreported firm outcome, then it is highly unlikely that an outside signal would be available to confirm the auditor’s findings.
Another problem with the use of penalties to motivate the auditor's performance is that the penalty levels which can be imposed upon the auditor may be limited by bankruptcy constraints or by the legal system. Thus, if a signal of audit performance is available to the owner independent of the manager's and the auditor's efforts, then no assurance can be provided that the auditor will provide the owner's desired level of effort when the auditor faces caps on his legal liability (see Woodlock [1990]).

The above example illustrates the need to consider alternatives to the solution of the monitoring supply problem. If alternatives can be determined, the principal could institute certain contractual provisions or demand the creation of institutions to encourage a supply of monitoring.

2.6 Communication as a Potential Response to Hidden Action and Hidden Information

This section of the literature review considers a special economic environment in which the agent has pre-decision and private effort information. Since the agent has information which could be potentially beneficial to the agency prior to taking any effort, the owner may desire that the agent communicate his private pre-decision information to the owner. However, as Christensen [1981] has shown, the agent may not truthfully reveal his private information through this communication. Thus, the principal may need to limit the set of feasible contracts or incur the costs of monitoring if he cannot be assured that the agent's communication is truthful.

Dye [1983] studies a model in which the agent receives private post-decision information. The information received by the agent is correlated with the realized firm output \( x \). The agent communicates this information to the principal who then utilizes this information in compensating the agent. Since the agent's communication is not
revealed by an exogenous source, the principal must provide incentives to the agent to truthfully reveal his post-decision information truthfully.

Dye [1983] shows that the agency benefits from communication if (1) the joint distribution of outcome signals and agent effort is independent in effort and the \textit{ex post} decision signal for some closed set of outcomes; (2) for a closed range of outcomes, the expected outcome is strictly increasing in the \textit{ex post} signal; (3) the support of the random outcome conditional on the \textit{ex post} signal is independent of the \textit{ex post} signal for a subset of \textit{ex post} signals; (4) the optimal contract and action are respectively increasing in outcome and positive; and (5) the principal is risk neutral and the agent is risk averse.

The idea behind these conditions is that communication allows the owner to provide a variation to the compensation contract. The variation is such that if the value of the \textit{ex post} signal falls below a certain level, then the agent expects to receive utility greater than what would be received if he falsely communicated the \textit{ex post} signal. Likewise, if the \textit{ex post} signal exceeds a certain level, then the owner pays the agent an amount greater than the agent could receive by either not revealing the \textit{ex post} signal or falsely communicating the \textit{ex post} signal to the principal. This separating contract is beneficial to the owner only if such variations in the no-communication contract exist, the communication of the \textit{ex post} signal is informative to the principal and a potential benefit to the agency could arise from such a variation in the contract.

Conditions (1) and (3) assure that the firm's outcome is an imperfect signal of the \textit{ex post} information available to the agent. Thus, any contract which is based strictly on firm outcome will impose unnecessary risk upon the agent. If the agent is risk averse, disclosure of this \textit{ex post} signal would allow a Pareto improvement from a reassignment of this risk to a risk neutral principal [condition (5)]. Conditions (2) and (4) insure that
a variation in the firm contract discussed above is available to the owner. The monotonic relationship between the outcome, contract, agent's actions, and *ex post* signal allow for the separating contracts needed in the proof. Finally, condition (1) also insures that the *ex post* signal has incremental value in determining the level of agent effort.

Penno [1985] uses a similar approach to show that financial statement reporting (a form of *ex post* communication) is of value in an agency setting only if the audit technology is imperfect. This work is a nice application of Dye's [1983] work to an audit setting. However, other than the motivation, nothing is learned here which wasn't already learned in Dye [1983].

Penno [1984] considers a model in which the agent's pre-decision information is a substitute for the effort provided by the agent. Penno [1984] shows that communication has value and need not be verified in an environment in which effort and the productive state are substitutes, the principal is risk neutral, and the principal can design the information system.

The intuition for why communication of the state information of the agent is valuable to the agency arises from the ability of the principal to design an information system which ensures that if the information is unfavorable, the agent need not take any effort. Therefore, the agent will prefer the compensation contract which pays him a constant for not working over one which pays him based upon outcome. If this contract payment is chosen properly, risk sharing between the principal and the agent is improved. Thus, a Pareto improvement results from limited communication of the productive state.
2.6.1 Open Questions

These studies indicate communication can be valuable in some circumstances but perhaps not in others. A more general set of necessary and sufficient conditions for honest communication would be valuable to accountants since it would allow the accountant to determine which communications need to be verified and which would not need to be verified. Mukherji [1990] considers this question.

Two of these studies, Penno [1985] and Dye [1983] assume that the firm outcome or the technology used to verify the private information of the agent is not a perfect predictor of the agent's private information. Obviously, if the technology's signal or the firm's outcome were a perfect predictor of the agent's private information, then no communication would be necessary. However, when a monitor is a utility-maximizing agent whose efforts aren't observable, communication may induce the monitor to randomize his strategies which may be looked upon as a special type of monitoring imperfection. In an auditing setting, this induced imperfection of the monitor may make the owner worse off by allowing the manager to misreport the firm's outcome to the manager's benefit. In the audit setting, the ability of the manager to influence the auditor's effort by his report may be detrimental to the agency. Therefore, the question becomes what circumstances insure that the agency is better off from making the manager's report public information prior to hiring a utility-maximizing auditor subject to hidden action?

2.7 Conclusion

This literature review has concentrated on the role of contracting in reducing problems of hidden action and hidden information and how monitoring of the agent's effort or private information can provide a welfare improvement to the agency. As it was
shown in Section 2.6, sometimes communication can be substituted for monitoring. Where communication may not be truthful and monitoring is not chosen, the Revelation Principle may require that the owner adjust the agent’s compensation schedule to induce truth-telling. This distortion in the optimal compensation scheme typically comes at a loss of optimal risk sharing between the owner and agent or the need for the owner to pay the agent for his valuable information. As an alternative to distortions in the compensation contract, the owner can hire a monitor to gather information about the agent’s information.

The value of a monitor is related to the information available to the owner, the cost of monitoring, and the perfectness of the monitor. For instance, in a game of hidden action, the owner would not hire a monitor to gather outcome information because it is costlessly available to the owner. Likewise, if the monitor has a fixed cost and the agent’s preference is to shirk, then the owner will reduce the monitoring region to lower outcomes because they are more likely to indicate shirking. Finally, the imperfection of the monitor can affect when monitoring occurs. Thus, Dye [1986] shows that imperfection of the monitor interacts with the agent’s risk preference to determine the optimal monitoring region.

However, when the monitor actions are not observable, monitoring is valuable to the agency only if there exists conditions which insure a supply of monitoring effort. Most studies (indeed all except Antle [1982]; Antle [1984]; Baiman, Evans and Noel [1987]) presume that the monitor’s efforts were either controlled by principal or could be costlessly observed by the principal. This type of assumption seems artificial and not typical of monitoring settings familiar to accountants like variance investigations, internal audits, and external audits. Thus, the validity of the results of these studies seems questionable
unless sufficient conditions are present to assure a supply of effort from the utility-maximizing monitor subject to hidden action.

Chapter V of this dissertation offers such a condition on the monitor which would appear to be present in variance investigation, internal auditing, and external auditing. Further, the condition identified does not rely on the use of an exogenous signal and **a priori** doesn't impose any technological assumptions on the monitor typical of previous research. Thus, we study a very general model of agency in which contract restrictions provide assurances of monitoring performance.

Studies of the type reviewed in this literature review and considered within this paper are important to accountants because it is the job of accountants to gather and analyze information necessary to make optimal firm decisions. Thus, insights of how the economic environment in which the accountant is placed affects these information gathering decisions holds promises of more efficient and effective accounting information systems.
CHAPTER III
THE OWNER—MANAGER MODEL

3.1 Introduction

This chapter considers the agency setting of Section 1.2 absent the auditor. The purpose of this chapter is to consider the elements of the owner-manager game and to present the assumptions made within this setting to ensure existence and feasibility of an agency solution. Section 3.2 provides a description of the players and the sequence of their moves. Section 3.3 considers the model assumptions and provides the economic rationale for these assumptions. Section 3.4 describes the strategy sets and payoff functions of the agent and owner. Section 3.5 considers the solution concept to be utilized within this model. Section 3.6 contains the model formulation and an explanation of the constraints placed upon the owner’s contract choice.

3.2 Model Description

We consider a model of hidden action and hidden outcome information. This type of model is chosen because it is felt it is representative of the information asymmetry present in the typical absentee owner/operating manager environment. The manager is hired to provide a productive input, such as effort, and to report on the outcome of his efforts to the owner.

The manager is considered to be concerned with the level of effort and his potential compensation. For our agency setting, the manager’s potential compensation can be
affected by either the effort taken by the manager or the report of firm outcome issued by the manager. For example, it is typical to assume that higher management effort leads to higher firm outcome. Thus, if the owner utilizes the manager's report for performance measurement, then the manager has an incentive to provide additional effort. However, the manager can also use his report within this agency setting to affect his compensation level. For instance, if the owner utilizes the manager's report as a performance measure, then the manager can issue his report claiming a higher outcome than what has actually occurred in order to enhance his performance measurement. Likewise, the manager may consume excessive executive perquisites and use his report of firm outcome to mask his enhanced compensation level. Thus, the unobservability of firm outcome and management effort enhances the manager's ability to either shirk or augment his compensation to the detriment of the owner.

Given the unobservability by the owner of the manager's efforts and firm outcome, the owner would like to design a contract with the manager which maximizes his return net of the manager's compensation and perquisite consumption. For instance, assume that the firm outcome is 10 units of product, the manager consumed 2 units of perquisites, and then the manager reports that 9 units of outcome were produced. The return to the owner could be measured as the firm outcome of 10 units less the perquisite consumption of the manager (2 units) and any salary paid to the manager, for a report of 9 units.

The timeline for this model is provided in Figure 3.1. The sequence of play indicated by this timeline can be described as follows. The owner designs a contract contingent upon the manager's report which is either accepted or rejected by the manager. If the manager accepts the contract, he provides a productive input which will positively affect expected firm outcome. This productive input or effort is not observable by the owner.
After the manager provides his productive input, nature chooses the level of outcome generated by the manager's effort. Knowledge of nature's move is never revealed to the owner nor is the knowledge of nature's move available to the manager until after he has taken his effort. After nature moves, the firm's outcome is known to the manager who then reports this outcome to the owner. The owner never learns the value of firm outcome and must rely upon the manager's report to provide a signal of manager effort and the owner's equity in the firm. The owner authorizes a salary payment to the manager and the agency continues into the next period.

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**Figure 3.1 Financial Reporting Absent Auditing**

The sequence and the set of moves in this model are similar to that studied by Antle [1982] and Baiman, Evans and Noel [1987] but differ along two important dimensions. First, the model studied herein does not terminate the agency at the end of the period. Thus, the owner's knowledge of his end-of-the-period equity in the firm is predicated upon the manager truthfully revealing firm outcome. Proxies of firm outcome, such as liquidation value of the firm (see Baiman, Evans and Noel [1987]) are not considered practical within this setting because of transaction costs incurred in forming andliquidating an agency relationship. Secondly, both Antle [1982] and Baiman, Evans and Noel [1987] restrict the set of feasible management reports. Antle [1982] assumes the existence of firm specific internal control which limits the manager to only over-reporting
firm outcome. Baiman, Evans and Noel [1987], on the other hand, use the manager's report along with liquidation of the firm to limit the manager to only under-reporting firm outcome.

The sequence and the set of moves of this model, therefore, allow the results of our model to generalize to these more restrictive cases in which the agency is liquidated at the end of the period and the manager is limited to either under- or over-reporting firm outcome.

3.3 Model Assumptions

Model assumptions are made to ensure an agency problem exists and that a unique feasible solution to the agency problem can be derived from the model.

3.3.1 The Agency Problem

The agency problem is created by the preference ordering of the owner's and the manager's utility functions, the existence of information asymmetry, the effect of the manager's effort on firm outcome, and the costliness of managerial effort.

The owner is assumed to be risk neutral whose payoff from the agency is denoted $mr(\hat{\xi}) - ur(x) - s[mr(x)]$. For our setting, $mr(\hat{\xi})$ is the true firm outcome, $ur(x)$ is any perquisite consumption by the manager, and $s[mr(x)]$ is the compensation paid to the manager for a report of $mr(x)$. The owner's utility function is assumed continuous in all of its arguments.

From the definition of the owner's utility function provided, it is obvious that the agent's reporting strategies, and less obviously the agent's effort choice, affect the owner's utility level. The agent's reporting strategies directly impact the owner's utility through the level of perquisite consumption available to the agent and the level of salary
enhancement available to the agent. This points out the effect that asymmetric outcome information has on the owner's utility.12 Further, it is assumed within this model that the firm's outcome $x$ is a function which maps the set of agent actions and nature's productivity states into a closed subset of the real line. Formally, \( x: A \times \Theta \rightarrow R \), with the manager's effort inducing a probability distribution over the set of firm outcomes $X$. This allows us to consider $x \in X$ as a random variable of management effort. To insure that the owner desires higher effort levels, it is assumed that $P_a(x|a) < 0$, or that higher management effort provides higher firm outcomes.

The manager's utility function is considered additively separable in income and effort and will be denoted as $U\{s[mr(x)] + ur(x)\} - v(a)$, where the first term captures the manager's income from salary $s(\epsilon)$ and from perquisite consumption $ur(\epsilon)$, while the second term captures the agent's disutility for effort $a$. It is assumed that the manager is strictly risk- and effort-averse and that the manager's utility function is continuous in its arguments.

3.3.2 Existence of a Unique Feasible Solution

As Appendix A points out, the existence of an optimal solution to the agency problem studied can be assured if (1) the manager's and owner's utility functions are continuous, (2) the sets of agent efforts $A$ and the set of firm outcomes are finite, and (3) the set of feasible incentive schemes is not empty.

To assure continuity of the manager's and owner's utility functions, we assume that there exists a continuous pre-ordering over the levels of residual outcome earned by the

---

12In the next chapter, we consider when the owner's search over the set of feasible incentive functions can be limited to those which induce truth-telling. Since this limitation is not without loss of generality for some reporting strategies available to the manager, the insertion of the auditor as a revelation mechanism into the model is considered in Chapter 5.
owner and the net consumption of the manager. This continuous pre-ordering allows
the manager to be able to determine his optimal responses to the owner's compensation
function and the owner to determine the optimal compensation function.

The finiteness of the agent's effort set assures that the agent has an optimal effort
reaction or set of effort reactions to any particular incentive offered by the owner. It can
be defended on the basis that the agent can provide no less than zero effort nor more
than a maximum amount which will assure his effectiveness. The finiteness of firm
outcomes allows the manager to choose his optimal under-reporting and cover-up
strategies. Additionally, the finiteness of the outcome set assures that the owner's
compensation function is continuous over the set of possible firm outcomes. The
dependence of firm outcome on agent action along with the finiteness of the agent's
effort set allows us to consider the compensation function to be continuous in agent
effort. Thus, the finiteness of the set of agent efforts along with the finiteness of the
outcome set insures that a particular agent action or set of actions will be induced by a
particular compensation scheme. The finiteness of the outcome set can be defended on
the basis that negative output is not feasible and that any productive facility has a stated
capacity of output.

Finally, we assume that the owner can design a contract which will satisfy the
manager's alternative market opportunities, denoted \( \bar{u} \), can induce truth-telling (when
applicable), and will induce the agent to provide a particular effort level \( a \in A \).

3.4 Strategy Sets and Payoffs

A strategy of the manager \( \sigma^m(a, mr) \) is a tuple of management effort and the
manager's report. The manager's report is a set valued function which maps the firm's
outcome \( x \), the manager's perquisite consumption \( ur \), and the manager's cover-up \( cu \)
into a closed subset of the real line. Notationally, the manager's report can be represented as $mr: X \otimes CU \otimes UR \rightarrow R$. A truthful manager's report is denoted $m\hat{r} = mr(x, cu = 0, ur = 0)$.

The manager's strategy, $s^m(\bullet, \bullet)$, along with the owner's compensation function $s \in S$ provide the manager with his payoff. As discussed in Section 3.3, this payoff is measured in utility. Given the risk averseness of the manager and the separability of the manager's utility function into compensation and effort, the following representation of the manager's payoff can be provided:

$$\text{Manager's Payoff} = u_m[s(mr(x)) + ur] - v(a)$$

where $u_m$ is the manager's utility function for wealth, $s$ is the compensation received by the manager for report $mr$, and $v$ is the manager's disutility function for effort. The manager's objective is to maximize his expected level of utility. For assurance that a maximum exists, we assume $x \in X$ is finitely divisible.

A strategy for the owner is composed of a compensation function $s(mr)$ where $mr$ is the manager's report of firm outcome with $mr \in X$. The owner's strategy, along with the manager's strategy, determines the payoff to the owner. Given the risk neutrality of the owner and the separability of the owner's utility function into firm outcome and agent compensation, the following representation of the owner's payoff can be provided:

$$\text{Owner's Payoff} = m\hat{r}(x) - s(mr) - ur(x)$$

where $m\hat{r}$ is the level of firm outcome, $s(\bullet)$ is the manager's compensation as a function of the manager's report, and $ur$ is the level of perquisites consumed by the agent for a given firm outcome $x \in X$. 
3.5 Solution Concept

We adopt the subgame perfect Nash equilibrium as the solution concept considered within this dissertation. A strategy combination is a subgame perfect Nash equilibrium if (1) it is a Nash equilibrium for the entire game, and (2) its relevant action rules are a Nash equilibrium for every subgame. A subgame is a game consisting of a node, which is a singleton in every player's information partition, that node's successors, and the payoffs at associated end nodes. Thus, in the simple owner-manager game, the only subgame is the game between the owner and manager. For this case, the set of subgame perfect Nash equilibrium is equivalent to the set of perfect Nash equilibrium. This will not be the case for the owner-manager-auditor model.

3.6 Model Formulation

The contract design for the owner-manager model will be constrained by the owner attempting to contractually induce a particular effort level from the manager while simultaneously obtaining truthful disclosure from the manager. As will be shown in the next chapter, the inclusion of the truth-telling constraint may be with loss of generality.

Given the assumptions of Sections 3.3 and 3.5, along with the payoff functions of the manager and owner, we provide the following characterization of the owner's problem when faced with hidden action and hidden information.

\[
\max_{a \in A, cu \in CU, ur \in UR, s \in S} \sum_{mr \in X} [mf(x) - s(mr(x)) - ur(x)] p(x|a)
\]
S.T.

(IR) \[ \sum_x u(s(m \hat{f}(x))) \quad p(x | a) - v(a^*) \geq u \]

(IC) \[ \sum_x u(s(mr(x)) + ur(x)) \quad p(x | a) - v(a^*) \geq \]
\[ \sum_x u(s(mr(x)) + ur(x)) \quad p(x | a) - v(a) \quad \forall \ a^* > a \]

(TT1) \[ u(s(m \hat{f}(x))) \geq u(s(mr(x)) + ur(x)). \]
\[ \forall ur \in \{x: x \in (o, \xi) \quad \text{and} \quad x \in X\} \]
\[ CR = \{0\} \quad \forall \ a \in A \quad \forall \ mr \in X \]

(TT2) \[ u(s(m \hat{f}(x))) \geq u(s(mr(x)). \]
\[ \forall cu \in \{x: x \in (o, \bar{x} - \xi) \quad \text{and} \quad x \in X\} \]
\[ UR = \{0\} \quad \forall \ a \in A \quad \forall \ mr \in X \]

(TT3) \[ u(s(m \hat{f}(x))) \geq u(s(m \hat{f}(x) + ur(x)). \]
\[ \forall ur \in \{x: x \in (o, \xi) \quad \text{and} \quad \xi + ur + cr \in X\} \]
\[ \forall a \in A \]
\[ \forall cu \in \{x: x \in (o, \bar{x} - \xi) \quad \text{and} \quad \xi + ur + cr \in X\} \]
\[ \forall mr \in X \]

Constraint (IR) insures that the agent receives at least his reservation utility if he provides a particular effort and is truthful. Constraint (IC) insures that the agent's contract provides the agent with an incentive to provide the owner's desired level of effort. Constraints (TT1), (TT2), and (TT3) cover three distinct reporting options available to the manager.

Constraint (TT1) provides the manager an incentive not to under-report firm outcome. Constraint (TT2) provides the manager an incentive not to over-report firm outcome. Constraint (TT3) provides an incentive to the manager to not under-report firm outcome and then cover-up this shortage. Obviously, (TT1) and (TT2) are special
cases of (TT3). An example of a model which possesses only (TT1) is Baiman, Evans and Noel [1987]. An example of a model which possesses only (TT2), and not (TT1) and (TT3), is Antle [1982]. Therefore, both Antle [1982] and Baiman, Evans and Noel [1987] are special cases of the model considered herein.

The inclusion of either (TT1), (TT2), or (TT3) is made for completeness purposes. However, as the next chapter indicates, the inclusion of these constraints within the program may identify a solution which is not optimal. This rationale for why this program may not identify the optimal contract is because the truth-telling constraints require that the agent be made indifferent between truthful disclosing and all other disclosures of firm outcome, irrespective of the manager's action or choice of outcome disclosure. For example, if the manager can partially over-report firm outcome, it may not make sense for the owner to make the agent indifferent over possible reports of firm outcome, irrespective of the action taken by the manager.
CHAPTER IV
A RATIONALE FOR AUDITING

4.1 Introduction

In this section, a characterization theorem for the Pareto optimality of a truth-inducing contract in the presence of hidden outcome information and hidden action is developed. This theorem is of value because it provides insights into how the manager’s message space (report set) affects the owner’s desire to induce reliable reporting from the manager. For instance, the owner may not always desire the manager to provide a reliable report of firm outcome when the manager has limited ability to under- or over-report firm outcome.

Green and Lafont [1986] consider an economic environment in which the manager is endowed with hidden state information and takes no productive act. Green and Lafont show that the existence of a nested range condition on the message space available to the manager is necessary to assure the owner’s optimal contact is truth-inducing. Our work determines that the nested range condition is no longer a necessary condition when the agent takes a private action which affects the message space available to the manager. Additionally, we characterize conditions within this environment which provide assurances that the owner will induce truth-telling from the manager.

A subset of the type of message spaces implied by the nested range condition is considered within this paper. This restriction is made in order to make the discussion relevant to a setting involving financial reporting. The manager’s message space is
limited within our discussion to (1) under-reporting firm outcome; (2) over-reporting firm outcome; or (3) under-reporting firm outcome and then covering-up this perquisite consumption.

The limitation of the manager to under-reporting firm outcome presents the owner with a problem like P1 absent constraints (TT2) or (TT3). The limitation of the manager to over-reporting firm outcome presents the owner with a problem like P1 absent constraints (TT1) or (TT3). Finally, the limitation of the manager to a reporting strategy such as (3) presents the owner with a problem like P1 absent constraints (TT2) or (TT1). Limitations of the report sets available to the manager can be defended by the existence of firm specific internal controls. Thus, proper separation of duties mitigates the ability of a single agent to misreport firm outcome for his own benefit.

The remainder of this chapter is organized as follows. Section 4.2 provides a rehash of the model introduced in Chapter III along with applicable definitions. Section 4.3 shows that Green and Lafont's nested range condition is not a necessary condition for the owner to contractually induce truth-telling from the manager when the manager possesses both hidden action and outcome information. Additionally, Section 4.3 provides an analogue to Green and Lafont's nested response condition for a setting in which the manager's actions and firm outcome are private information of the manager. Finally, Section 4.3 shows that truth-telling from the manager cannot be achieved within our asymmetric information environment when the manager can both under-report firm outcome and then cover-up this perquisite consumption. Section 4.4 considers the implications of this work to the demand for auditing.
4.2 The Model

We utilize the model developed in Chapter III. For ease of exposition, the model without constraints (TT2) and (TT3) will be denoted as \(PU\) (problem with under-reporting); the model without constraints (TT1) and (TT3) as \(PO\) (problem with over-reporting); and, finally, the model without constraints (TT1) and (TT2) as \(PB\) (problem with both under- and over-reporting).

**Definition 4.1:** A mechanism for \(PB\) \((mr, ur, cr, a, s)\) consists of a correspondence \(mr: X \rightarrow X\), a management under-reporting option \(ur: X \rightarrow R\), a management cover-up option \(cu: X \rightarrow X\), a management effort choice \(a \in A\), and a compensation function \(s(mr): X \rightarrow R\). A mechanism for \(PU\) is denoted \((mr, ur, a, s(x_{mr}))\). A mechanism for \(PO\) is denoted \((mr, cu, a, s(x_{mr}))\).

**Condition 4.1:** A compensation function \(s(mr)\) is said to be Pareto optimal in the presence of management under-reporting when no other compensation function exists which will allow both the owner and manager to achieve higher returns from the agency.

The goal of this chapter is to study the class of compensation schemes which is Pareto optimal and induces truth-telling when the firm's internal control is not perfect.

**Condition 4.2:** A compensation function \(s(x_{mr})\) induces truth-telling by the manager for the program:

(a) \(PU\): IFF (TT1) binds and the constraint set for \(PU\) is non-empty;

(b) \(PO\): IFF (TT2) binds and the constraint set for \(PO\) is non-empty;
(c) \( PB \): IFF (TT3) binds and the constraint set for \( PB \) is non-empty.

**Definition 4.2:** A compensation function \( s(x_{mr}) \) is said to be Pareto optimal and elicit truth-telling from the manager IFF Condition 4.1 and Condition 4.2 are satisfied.

In the traditional principal-agent models cast in the audit setting (see Ng and Stoeckinius [1979], Antle [1982]), the report set available to the manager was equivalent to the firm’s outcome set. An important result from the incentives literature, known as the Revelation Principle, states that the level of expected utility to the principal and agent achieved by a contract which induces the agent to lie about his private information can also be achieved by inducing the agent to tell the truth. If the Revelation Principle holds for problems \( PU, PO, \) and \( PB \), the owner should have no incentive to design a contract to induce the agent to misstate firm outcome. However, as will be shown in the next section, when the manager’s report strategies limit the level of under- or over-reporting, the owner may find it beneficial to induce the manager to misstate his report.

### 4.3 Results

Green and Lafont [1986] characterize the condition under which the Pareto optimal contract is truth-inducing for an environment in which the agent’s message space is restricted. They introduce a condition on the report set (message space), known as the nested response condition, which is necessary for the Pareto optimal contract to elicit truth-telling.

**Definition 4.3:** A nested range condition on the manager’s report set is said to be present IFF for any three distinct outcomes \( x_1, x_2, x_3 \) in the
outcome set $X$, if $x_2 \in m(x_1)$ and $x_3 \in m(x_2)$, then $x_3 \in m(x_1)$. Here, $m(\cdot)$ is the report set available to the manager when outcome $x_1$ occurs. It is assumed that the truthful outcome is contained in its message space.

Notice, however, that the nested range condition doesn't imply partial under- or over-reporting. This follows immediately from the need of the report sets to nest into one set. Thus, $m(x_3) \subset m(x_2) \subset m(x_1)$. This nesting cannot occur when partial under- or over-reporting is present because the report set must contain the true outcome and at least one report set doesn't contain the largest firm outcome.

**Definition 4.4:** An agent is said to be able to fully over-report firm outcome $\hat{x}$ IFF $m(\hat{x}) = \{x: x \geq \hat{x}\}$. An agent is said to be able to fully under-report firm outcome IFF $m(\hat{x}) = \{x: \hat{x} \leq x \leq x\}$ where $x$ is strictly less than the largest outcome for at least one firm outcome $\hat{x}$ but not for all $\hat{x} \in X$.

Given Definition 4.4, it can be shown that the nested range condition implies the ability of the manager to fully under- or over-report firm outcome.

**Proposition 4.1:** Full under- or over-reporting $\Rightarrow$ nested range condition.

**Proof:** By definition, the nested range condition holds if $m(x_1) = \{x_1, x_2, x_3\}$, $m(x_2) = \{x_2, x_3\}$, and $m(x_3) = \{x_3\}$. This is equivalent to full over-reporting if we allow for $x_1 < x_2 < x_3$. Likewise, if $x_3 < x_2 < x_1$, then the nested range condition is equivalent to full under-reporting.

Q.E.D.
Green and Lafont's characterization theorem states that in a hidden information setting, the nested range condition on the manager's report set is necessary for the Pareto optimal contract to be truth-inducing. Since we are concerned with specific types of misstatements of private outcome information, we would like to know if the nested range condition is still necessary for the Pareto optimal contract to be truth-inducing when the manager has private information about his effort choice and firm outcome. As Example 4.1 illustrates, Green and Lafont's characterization theorem doesn't generalize to our more expanded model.

Example 4.1

We consider a very simple agency setting in which the agent can take one of two distinct actions. Each of these actions can produce one of three outcomes with various degrees of probability. The relationship between the outcomes and the agent effort is given in Table 4.1.

<table>
<thead>
<tr>
<th>Effort</th>
<th>OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>$a_1$</td>
<td>.7</td>
</tr>
<tr>
<td>$a_2$</td>
<td>.2</td>
</tr>
</tbody>
</table>

Notice, as managerial effort increases, the probability of generating higher firm outcomes also increases. For instance, if the agent takes effort $a_1$, his probability of generating 30 units of outcome is .2; while if the agent takes effort $a_2$, his probability of generating 30 units of outcome is .7.
The message space of the manager is dependent upon the outcome produced and is provided in Table 4.2.

Table 4.2

<table>
<thead>
<tr>
<th>m (40)</th>
<th>=</th>
<th>{40}</th>
</tr>
</thead>
<tbody>
<tr>
<td>m (30)</td>
<td>=</td>
<td>{30}</td>
</tr>
<tr>
<td>m (15)</td>
<td>=</td>
<td>{15, 30}</td>
</tr>
</tbody>
</table>

Notice, from Table 4.2 the manager can only overstate firm outcome when the outcome is 15 units. From Definition 4.3, we see that this set of feasible management reports does not satisfy the nested response condition. If the nested response condition carries over into the agency setting of this dissertation, then it is expected that the owner in this illustration would be better off having the agent misstate firm outcome. However, as will be shown, the agency will not be better off when a contract is written to induce misreporting.

The owner is considered risk neutral with a payoff function $x - s(x)$ where $x$ is firm outcome and $s(x)$ is management compensation for outcome $x$. The manager is risk averse with a payoff function $\sqrt{s(x)} - v(a)$ where $v(a)$ is the manager’s disutility for effort. It is assumed that the manager incurs no disutility for providing effort $a_1$ and 1 unit of disutility for providing effort $a_2$. Further, it is assumed that the manager’s reservation utility is 1 unit of product.

The incentive compatibility constraint for this problem, assuming the owner desires effort $a_2$, along with the truth-telling constraint, can be written as follows:
Notice, if the owner uses the truth-telling constraint for optimal contract design, then
the owner cannot induce effort $a_2$ from the agent. Thus, truth-telling limits the owner
to the lowest possible effort from the agent. Now, assume that the owner ignores the
truth-telling constraint and designs a contract which optimally lies for the agent. Thus,
an outcome of 15 would be reported by the manager as 30 units. The revised incentive
compatibility constraint, IC', can now be written as follows:

\[
IC' \quad .2\sqrt{s(40)} + .9\sqrt{s(30)} - 1 \geq .1\sqrt{s(40)} + .9\sqrt{s(30)}
\]

This example illustrates why, in our setting, the nested response condition is no
longer necessary for the Revelation Principle to hold. As can be seen from the example,
the interaction of the probability distribution induced by the agent's actions and the
management report sets creates a report distribution which precludes the owner from
utilizing the manager's report for motivation purposes.

Example 4.2

This example uses the information above but changes the manager's report sets in
order to illustrate how the owner may benefit from inducing the manager to misreport
firm outcome. Table 4.3 provides the revised report sets for the manager.

\[
\begin{array}{|c|c|}
\hline
m(40) & \{40\} \\
\hline
m(30) & \{30, 40\} \\
\hline
m(15) & \{15, 30\} \\
\hline
\end{array}
\]
Notice, the manager can claim the high state whether 30 units of outcome are produced or 40 units of outcome are produced. The truth-inducing contract requires that $s(15) = s(30)$ and $s(30) = s(40)$ or $s(15) = s(30) = s(40) = 1$. Under this contract, the manager takes effort $a_1$ and the owner expects a residual outcome of 19.5 units. However, if the owner sets $s(15) = 0$ and optimally lies for the manager, the owner's optimal contract provides that the manager will receive 5.76 units of outcome when 40 units of product are reported and .16 units of product when 30 units of product are reported. The manager provides effort level $a_2$ and the owner expects a residual outcome of 23.36 units.\footnote{A similar example for under-reporting can be constructed.}

Examples 4.1 and 4.2 illustrate cases in which the manager's report sets do not exhibit the nested range condition of Green and Lafont [1986]. The results of Example 4.2 hinge on the ability of the owner to use the manager's report for motivation purposes. As can be verified, the report probability distributions, generated by optimal lying by the manager in Example 4.2, are not the same for management action $a_1$ and $a_2$ as was the case for Example 4.1. This allows the owner to utilize the manager's report as a signal of manager effort. This suggests that a possible necessary condition for the Revelation Principle to hold in a model of hidden information and hidden action is that the report probability distribution for a set of management actions not be informative of the level of effort provided by the manager. This leads to the main finding of this section.

**Definition 4.5:** The probability of a report $\bar{x}$: $f(\bar{x} | a, s) = \sum_x p(x | a) \Pi(mr = \bar{x} | s)$. The term $p(x | a)$ is the probability of a particular firm outcome given effort $a$, and $\Pi(mr = \bar{x} | s)$ is the probability that the
manager will choose a particular manager report given the compensation function provided by the owner.

**Proposition 4.2:** For a problem of hidden outcome and hidden action of type $PO$ or $PU$, if $\forall a \ a' \in A$ and any owner compensation function $s \in S$ it is the case that $f(\bar{x}|a) = f(\bar{x}|a') \ \forall \bar{x} \in X$, then the Pareto optimal contract is truth-inducing.

**Part 1**

**Proof:** The incentive compatibility constraint of problem $PO$ requires:

\[
(\text{IC}) \quad \sum_x u[s(mr(x))] \ p(x|a^*) - v(a^*) \geq \sum_x u[s(mr(x))] \ p(x|a) - v(a) \ \forall a^* > a
\]

Using Definition 4.5, $(\text{IC})$ can be rewritten as:

\[
(\text{IC'}) \quad \sum_x u[s(\bar{x})] \ f(\bar{x}|a^*) - v(a^*) \geq \sum_x u[s(\bar{x})] \ f(\bar{x}|a) - v(a) \ \forall a^* > a
\]

By assumption we know, $f(\bar{x}|a^*) = f(\bar{x}|a), \forall \bar{x} \in X$. But if this is the case, the LHS of $(\text{IC'})$ can never be larger than the RHS of $(\text{IC'})$ except for $a^* = \inf A$. The truth-telling constraints for this problem requires that $s(x) = \text{constant}$ for all $x \in X$. As is known, this contract also elicits $a^* = \inf A$ at the lowest possible cost to the owner while satisfying the manager's reservation utility.

Q.E.D.
Part 2

Proof: The incentive compatibility constraint of problem $PU$ requires:

\[
\sum_x u[s(mr(x)) + ur(x)] p(x | a) - v(a^*) \geq \\
\sum_x u[s(mr(x)) + ur(x)] p(x | a) - v(a) \quad \forall \ a^* > a
\]

Using Definition 4.5, (IC) can be rewritten as:

\[
\sum_x u[\bullet] p(x | a^*) \Pi(mr = \bar{x} | s) - v(a^*) \geq \\
\sum_x u[\bullet] p(x | a^*) \Pi(\bullet) - v(a) \quad \forall \ a^* > a
\]

Notice (IC') for the case of under-reporting does not collapse as nicely as it does when over-reporting is only present because of the perquisite consumption available to the manager. The truth-telling contract requires that $s(x) = s(\bar{x}) + UR$, or the owner pays the agent the level of under-reporting plus compensation based upon the manager's reported outcome. The manager's expected utility given this compensation function is:

\[
\sum_x u[s(\bar{x}) + ur] f(\bar{x} | a) - v(a^*) \\
= \sum_x u[\bullet] \sum_x p(x | a^*) \Pi(mr = \bar{x} | s) - v(a) \\
= \sum_x u[\bullet] p(x | a^*) \Pi(mr = \bar{x} | s) - v(a)
\]

Q.E.D.

Proposition 4.2 implies the only sure case for which the owner will find it in his best interest to induce the manager to reveal truthfully the firm's outcome is when the compensation function is not used for motivating a particular agent action. This finding is crucial to a prospective investor in a firm and implies that, in general, an investor and
owner may be at odds over the importance of the manager’s report. The prospective investor may wish to determine the underlying value or net worth of a company while an owner may want to maximize that net worth. As Proposition 4.2 illustrates, congruence of these two players’ objectives may not be feasible through contractual design.

Examples of reporting strategies which meet the requirements of Proposition 4.2 are full under-reporting, full over-reporting, and, in certain cases, partial under-reporting or partial over-reporting. Antle [1982] was the first to show that the Revelation Principle held in a full over-reporting environment. Baiman, Evans and Noel [1987] hint that the Revelation Principle pertains to a full under-reporting environment. Finally, the second part of the proof to Proposition 4.2 implies that the Revelation Principle is applicable also to partial under-reporting models.

An example of a partial over-reporting strategy which does not meet the conditions of Proposition 4.2 is provided in Example 4.2. It is felt that the circumstances of Example 4.2 may be more representative of the relationship between the firm’s outcome distribution and the manager’s report strategies. Thus, it is expected that the owner, facing a partial over-reporting strategy, may induce the manager to over-report firm outcome. This inducement by the owner is usually reasoned as arising from the possibility of reaping higher returns from the potential investor. However, as shown, the owner may actually be utilizing the contract to induce additional effort from the manager rather than to induce the manager to truthfully reveal firm outcome.

Another possible reporting strategy not discussed by past audit models is the case in which the manager can consume perquisites and then cover-up this consumption. An example of this would be kiting. Kiting occurs when the manager consumes some cash collections and then uses future collections to cover-up this perquisite consumption.
For this type of reporting strategy, Proposition 4.2 provides no guidance as to the applicability of the Revelation Principle to contract design. However, it is obvious that for this reporting strategy, the owner cannot design a contract to induce truth-telling by the manager because the true outcome report is not contained within the report set. This is captured formally within Proposition 4.3.

**Proposition 4.3:** Assume that the manager can cover-up any level of perquisite consumption, then the owner will not be able to design a contract which elicits a reliable management report unless the manager receives all firm outcome.

**Proof:** (TT3) of P1 is written as:

\[ u[s(mf)] \geq u[s(mr(x)) + ur(x)] \]

Consider \( cu = ur \), then \( mr = x - cu + ur \), or \( mr = x \). But \( u[s(mr \, (\ast)) + ur] > u[s(x)] \Rightarrow s(mr) + ur > s(x) \) unless \( u[s(x)] = x \). This latter result follows immediately from the inability of the manager to consume any more than the firm outcome.

Q.E.D.

Proposition 4.3 indicates that the owner must pay dearly to induce an agent to report truthfully when the manager has both under- and over-reporting strategies. Proposition 4.3 also highlights the importance of internal controls to the owner. Internal controls, such as proper separation of duties, could limit the degree to which the manager can avail himself of this strategy. Additionally, good internal controls could also limit the degree of under- or over-reporting available to the manager. However, it is usually assumed that management can over-ride the internal controls. As discussed in this section, the extent to which the manager can over-ride these internal controls
determines to a large degree the owner's purpose in contracting with the manager and the usefulness of the manager's report for both motivation and investment purposes.

4.4 Implications to Auditing

As was illustrated in the analysis of this chapter, the inability of the owner to view the firm's outcome places restrictions on the usefulness of the manager's report. Proposition 4.2 negates the value of the manager's report for influencing the potential investor's offering price for the owner's equity within the firm. Proposition 4.3 hints that the manager's report may have no value for either investment or motivation purposes when the manager can cover-up perquisite consumption.

The Auditing Concepts Committee report defines auditing as

"a systematic process of objectively obtaining and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between these assertions and established criteria and then communicating the results to the user."14

From this definition, it is obvious that the auditor is concerned with the assertions made by the manager and their correspondence with what has occurred during the period. In the model of this dissertation, we provide the auditor with the role of ascertaining the degree of correspondence between the firm's outcome and the manager's report. From the results of this chapter, this information is of value to the absentee owner because it allows the owner to utilize the manager's report for motivation and as a basis for future consumption. Further, for certain management report strategies, auditing allows the owner to credibly relay information to investors which otherwise would be discounted by the market.

Obviously, the benefits of auditing come at a cost. The cost incurred by the owner in hiring an auditor covers the auditor's alternative opportunities and the effort provided by the auditor. Obviously, this cost is well worth the benefits received by the owner when the auditor's fee is not too high and the auditor does not shirk his responsibilities. Chapter V considers what contractual requirements are needed to provide assurances that the auditor will not shirk his responsibilities.
CHAPTER V
THE OWNER–MANAGER–AUDITOR MODEL

5.1 Introduction

As discussed in the previous chapter, the owner may not want to commit to contractually induce the manager to issue a reliable report of firm outcome. This places the owner in a delicate position. The owner could commit to not using the manager's report for motivation purposes at a cost of lower expected owner's equity at year end. This strategy would allow him to use the manager's report to be reliable. Alternatively, the owner could use the manager's report in contractual design for motivation purposes to enhance his end of the period equity, but at the cost of introducing uncertainty into the equity markets.

This chapter considers auditing as an alternative to using the contract to induce truth-telling from the manager. If this alternative is successful in inducing honest management reporting, the owner can concentrate on utilizing the manager's report for strictly motivational purposes. Thus, auditing can allow the optimal manager contract to be used to enhance the expected end of the period owner's equity without sending a signal to the prospective investor that the manager's report may be misstated. This is where the value of auditing lies.

However, as Antle [1982] originally pointed out, the economic auditor has to be properly motivated to provide a needed level of audit services. Absent the owner being able to contractually induce this supply of audit, any motivational aspects of the
manager's contract may be construed by the investor as providing an incentive to the manager to misstate firm outcome. Thus, the question of the economic institutions sufficient to assure that the economic auditor will provide the needed level of audit services is of importance to the audit profession, owners of firms' risky assets, and potential investors. This chapter is devoted to considering this audit supply question.

Numerous studies have considered the economic institutions which are sufficient to answer the supply side question. The solution proposed by research on this question has fallen into two major categories: reputation and negligence liability court damages against the auditor. Examples of research into how auditor reputation can solve the audit supply question include Datar [1987], Sen [1989], and Thoman [1989]. Examples of research into how court damages can solve the audit supply question include DeJong [1983], Nagarajan [1984], Melumad and Thoman [1990], and Moore and Scott [1989].

This paper offers an alternative solution to the audit supply question by reconsidering why the owner's contract isn't sufficient for inducing an effective audit from the economic auditor. We believe this is a better approach to offering a solution to the supply question because the cause of the audit supply problem will provide insights into its solution. Past research has not involved this needed analysis of the agency problem which severely limits the usefulness of these alternative solutions. For instance, court damages arising from lawsuits against the auditor are jointly determined by the auditor, the manager, and nature. If the firm operates in a particularly friendly economic environment, it is conceivable that any management misreporting would go undetected unless the auditor performs an effective audit. However, given the manager's misreporting will not lead to court damages against the auditor, what is the auditor's incentive to provide an effective audit? Similarly, reputation models rely on repeated play of the game. Given the similarity of audit quality from the Big Six, it is not
inconceivable that the owner will switch to another audit firm. Further, the auditor will probably know in advance of his pending loss of the client. The auditor’s knowledge of switching in the last period presents the auditor with a single period model for which reputation is not an appropriate solution.

Section 5.2 concentrates on model assumptions necessary to incorporate a utility-maximizing auditor into Problem P1. Section 5.3 provides a revised program for the solution of the owner-manager-auditor model. Section 5.4 contains the results of this chapter. Section 5.5 provides the implications of the findings.

5.2 Model Assumptions

5.2.1 The Auditor as an Economic Agent

The auditor is assumed to be risk averse with utility function $U^A$ which is a mapping of sets of audit efforts $E$, audit reports $AR$, and manager reports $MR$ into a closed subset of the real line. Notationally, $U^A: E \times AR \times MR \rightarrow R$. This notation captures the key elements of the auditor’s return from the audit engagement. The first element is the auditor’s effort, $e \in E$. To provide an agency problem, it is assumed that the auditor dislikes effort or, equivalently, the auditor’s utility level is reduced by the level of effort taken. The second element affecting the auditor’s return is the relationship between the auditor’s and the manager’s reports and the effect this relationship has on the compensation provided to the auditor. For instance, our model assumes that no outside signal of firm outcome is available to the owner. This forces the owner to rely on the auditor’s report. If it is assumed that the auditor can detect misreporting only if he works, then a contract design which rewards the auditor for detecting misreporting would encourage the auditor to perform an effective audit. The auditor’s compensation is assumed to increase the utility level of the auditor.
The auditor's utility function is assumed additively separable into the auditor's disutility for effort and the compensation paid to the auditor and is denoted $u_a [af (x_{mn}, ar(\otimes))] - v^A(e)$. Within this functional representation, $af$ is the audit fee paid to the auditor as a function of the manager's and auditor's reports of firm outcome, and $v^A(e)$ is the auditor's disutility for effort.\[^{15}\]

The utility function of the auditor is assumed to be continuous in $e$ and $af$. Continuity of the auditor's utility function in effort and compensation assures us that the auditor can determine his maximal report/effort strategy tuple. The utility function of the auditor is also assumed to be differentiable in $e$ and $af$ with $u^A'(\otimes) > 0$, $u^A''(\otimes) < 0$, and $v^A'(\otimes) > 0$, $v^A''(\otimes) > 0$. The derivatives defined on $u^A$ imply that the auditor is risk averse and prefers more compensation. The derivatives defined on $v^A$ imply that the auditor is effort averse.

The auditor is assumed to have outside opportunities available which will provide him his reservation profit $\overline{AF}$. Because of the outside opportunities available to the auditor, the owner must design the contract to provide an inducement for the auditor to accept the owner as a client. These alternative opportunities for the auditor are captured by an individual rationality constraint being imposed upon the feasible set of auditor contracts.

The set of auditor efforts are finite valued. This assumption has two purposes. The first purpose is to insure the optimal auditor effort level exists given any level of auditor compensation. The second purpose is to recognize the scarcity of the auditor's effort resource.

\[^{15}\]A pure strategy involves no mixing between strategies by the auditor. Thus, if $E = \{a, b\}$, a choice of $a \in E$ is a pure strategy, while the convex choice combination $\lambda(a) + 1 - \lambda(b)$ is a mixed strategy.
The auditor’s effort choices for this section of the dissertation will be limited to either effective auditing, denoted \( e \), and noneffective auditing, denoted \( ne \). Thus, we can write \( E = \{e, ne\} \). Effective auditing allows the auditor to perfectly detect any management misreporting. Ineffective auditing provides the auditor with no insights into whether or not the manager’s report is misstated.

The auditor’s reporting strategies can involve Type I and Type II errors. Thus, the effective (ineffective) auditor can claim that the manager’s report is misstated even when the manager’s report isn’t misstated. Likewise, an effective (ineffective) auditor can claim that the manager’s report isn’t misstated even though the manager’s report is misstated. This differentiates this model from some of those in the literature. For instance, Melumad and Thoman [1990] assume that the auditor must accept the report of the manager when the manager reports truthfully.

Finally, the auditor’s report is a function mapping firm outcome and the amount of management misreporting back into itself. Notationally, \( ur: X \otimes UR_A \otimes CU_A \to X \otimes UR_A \otimes CU_A \). Thus, we visualize the auditor providing information about firm outcome and any management misreporting. For analogy purposes, if \( ur_a = 0 \) and \( cu_a = 0 \), we could say the auditor issues a clean opinion. Likewise, if \( ur_a \neq 0 \) and/or \( cu_a \neq 0 \), we could say that the auditor qualifies his report of firm outcome. A truthful audit report will be denoted \( at \), and the set of unqualified audit reports as UAR with \( UAR = \{ar \in AR: cu = 0, ur = 0, x\} \).

Given the auditor’s report is the triple \( (x, ur_a, cu_a) \), while the manager’s report is an element of a closed subset of the real line, the auditor’s report may provide a check on the auditor’s effort level. For instance, assume that the manager reports an outcome of 10 units and the auditor reports the triple \( (5, 4, 6) \). Upon issuance of these reports, the owner can utilize the known relationship between the auditor’s report and the manager’s
report to determine that the auditor hasn’t performed an effective audit. The check of audit effort provided by a comparison of the auditor’s and manager’s reports provides an impetus to the auditor to issue an audit report consistent with the manager’s report.

We denote \( CAR(mr) \) as the set-valued function which maps feasible audit reports into a particular manager’s report. Notationally, \( CAR: AR \rightarrow MR \) with \( CAR = \{ ar \in AR: x - ura + cu_a = mr \} \). Notice, this notation captures consistency between the manager’s and auditor’s reports by requiring that the auditor’s report of firm outcome \( x \), plus the levels of the auditor’s qualification \( (cu_a \text{ and } ur_a) \) equal the manager’s report of firm outcome. For the example above, we see that an audit report of \( (5, 4, 6) \) is not consistent with a manager’s report of 10, whereas the auditor’s report \( (5, 0, 5) \) would be consistent with a manager’s report of 10.

The set of firm outcome reports \( (x) \), the set of under-reporting amounts \( (UR) \), and the set of over-reporting amounts \( (CU) \) are all finite valued. This assures the auditor can choose an optimal effort/audit report tuple. Additionally, this assumption recognizes the inability of the manager to misreport firm outcome by an indefinite amount. The set \( UR_A \) is defined as \( UR_A = \{ x: 0 \leq x \leq \hat{x} \} \), where \( \hat{x} \) is the firm outcome. The set \( CU_A \) is defined as \( CU_A = \{ x: 0 \leq x \leq x^* - \hat{x} \} \), where \( \hat{x} \) is the firm outcome and \( x^* \) is the maximal element of the set \( x \). If the manager can both under-report and consume perquisites, the sets \( UR \) and \( CU \) are limited to those values \( cu \) and \( ur \) such that \( x - ur + cu \in X \).

Finally, we assume that no signal of audit performance is available from an exogenous source. This limits the owner to using only the manager’s and auditor’s reports to induce a supply of audit effort.\(^\text{16}\)

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\(^\text{16}\)Remember, it has been assumed previously that no signal of management effort or firm outcome is available to the owner.
5.2.2 Strategies and Payoffs

An auditor's strategy, $\sigma^A$, is the quadruple $\sigma^A = \{x, ur_A, cr_A, e\}$. The auditor's strategy, the auditor's compensation $af^*$ (which is continuous in the reports), and the manager's strategy map into a payoff for the auditor. This payoff is stated in terms of utility to the auditor as $u_A: AR \otimes MR \otimes E \rightarrow R$, where $u_A$ has been defined previously.

5.2.3 Solution Criteria

We limit the feasible set of subgame perfect Nash equilibria to those which make effective auditing the dominate strategy for the auditor irrespective of the manager's strategy. We do this for two reasons. First, we are concerned with a sufficient condition which assures the auditor will provide an effective audit in each period. Second, there may exist alternative auditor preferred equilibria when the owner's contract doesn't make effective auditing the dominant strategy.

Formally, we define $\sigma^A^*$ as the audit strategy which provides for both truthful disclosure and effective auditing. Notationally, $\sigma^A^* = \{x = \hat{x}, cu = c\hat{u}, ur = u\hat{f}, e\}$, where $\hat{x}, c\hat{u}, u\hat{f}$, and $e$ are the firm's outcome, the manager's chosen level of cover-up, the manager's chosen level of perquisite consumption, and the auditor's choice of an effective audit.

Definition 5.1: $\sigma^A^*$ is the auditor's contractually dominant strategy if there exists an auditor compensation function $af^* \in AF$ such that:

$$U^A(\sigma^A^*, af^*, \sigma) \geq U^A(\sigma^A, af^*, \sigma) \quad \forall \sigma \in \sum, \forall \sigma^A \in \sum^A \setminus \sigma^A^*$$
This definition implies that no matter what the auditor's or manager's strategies, the auditor compensation function $af^*$ will induce the auditor to truthfully disclose his audit report following an effective audit.\textsuperscript{17}

5.2.4 Audit Timing

As Figures 1.1 and 1.2 indicate, the auditor can perform the audit during the period under audit or immediately after the close of the period under audit. When the auditor performs the audit during the period to be audited, we assume that the auditor has no knowledge of the manager's report prior to release of his audit report. We call auditing performed during the period under audit concurrent auditing.

Auditing performed after the close of the period under audit is referred to as ex post auditing. When ex post auditing is present, we assume that the auditor views the manager's report prior to performing the audit.

5.2.5 Model Formulation

The owner-manager-auditor model for the concurrent auditing setting can be formulated as follows:

\[ PA1 \]

\[ (0) = \max \sum_{x} [m\ell(x) - s(mr(x), ar) - af(mr(x), ar) - ur(x)] \cdot p(x|a) \]

\textsuperscript{17}Truthful disclosure and effective auditing in the presence of collusion or auditor access to firm outcome are not considered.
S.T.

\(\sum_x [u(s(m\mathcal{M}(x), ar))] \quad p(x | a) - v(a^*) \geq \bar{u}\)

(Tr) \(\sum_x [u(s(m\mathcal{R}(x), ar)) + ur(x)] \quad p(x | a) - v(a^*) \geq\)

\(\sum_x [u(s(m\mathcal{R}(x), ar)) + ur(x)] \quad p(x | a) - v(a) \quad \forall a^* > a\)

(TT1) \(u[s(m\mathcal{R}(x), ar)] \geq u[s(\bullet, ar) + ur(x)].\)

\(\forall ur \in \{x: x \in [\mathbf{0}, \mathbf{\hat{x}}]\}
\quad \text{and} \quad x \in X\)

\(\forall a \in A \quad \forall mr \in X\)

(TT2) \(u[s(m\mathcal{R}(x), ar)] \geq u[s(\bullet\bullet, ar)].\)

\(\forall cu \in \{x: x \in [\mathbf{0}, \mathbf{\bar{x}} - \mathbf{\hat{x}}]\}
\quad \text{and} \quad x \in X\)

\(\forall a \in A \quad \forall mr \in X\)

(TT3) \(u[s(m\mathcal{R}(x), ar)] \geq u[s(\bullet\bullet\bullet, ar)].\)

\(\forall ur \in \{x: x \in [\mathbf{0}, \mathbf{\hat{x}}]\}
\quad \text{and} \quad \mathbf{\hat{x}} + ur + cr \in X\)

\(\forall cu \in \{x: x \in [\mathbf{0}, \mathbf{\bar{x}} - \mathbf{\hat{x}}]\}
\quad \text{and} \quad \mathbf{\hat{x}} + ur + cr \in X\)

\(\forall a \in A \quad \forall mr \in X\)

(IRA) \(u^A[af(\bullet, a\mathcal{R})]] \quad - v^A(e) \geq \bar{A}^A\)

(ICAT) \(u^A[af(m\mathcal{R}, a\mathcal{R} \in \text{car}(m\mathcal{R})])
\quad - v^A(e) \geq u^A[af(m\mathcal{R}, ar \in \text{car}(m\mathcal{R})]
\quad p[ar \in \text{car}(m\mathcal{R})]
\quad + u^A[af(m\mathcal{R}, ar \notin \text{car}(m\mathcal{R})]
\quad p[ar \notin \text{car}(m\mathcal{R})]
\quad - v^A(ne)\)

(ICAF) \(u^A[af(mr \neq m\mathcal{R}, a\mathcal{R} \in \text{car}(mr)]
\quad - v^A(e) \geq u^A[af(mr \neq m\mathcal{R}, ar \in \text{car}(mr)]
\quad p[ar \in \text{car}(mr)]
\quad + u^A[af(mr \neq m\mathcal{R}, ar \notin \text{car}(mr)]
\quad p[ar \notin \text{car}(mr)]
\quad - v^A(ne)\)

(TTA) \(u^A[af(mr, a\mathcal{R})] \quad - v^A(e) \geq u^A[af(mr, ar \in \text{car}(mr), ar \neq mr)]
\quad - v^A(e)
\quad \forall ar \in \text{car}(mr); ar \neq a\mathcal{R}\)
\( \sigma \) is the objective function of the owner. The owner wishes to maximize his residual outcome where residual outcome is defined as firm outcome less management perquisite consumption, management compensation, and the audit fee. Notice, neither the manager's compensation nor the auditor's compensation is a function of firm outcome unless the auditor and manager report truthfully. The constraints (IC), (IR), (TT1), (TT2), and (TT3) are the same for P1 and for PA1 except that for PA1 the manager's compensation is tied to the auditor's report. Obviously, if the manager's compensation were not tied to the auditor's report, then the manager would have no incentive to report truthfully and the owner would be strictly better off without the auditor because of the auditor's reservation wage \( \bar{A}F \). Constraint (IRA) captures the auditor's outside opportunities while constraints (ICAT) and (ICAF) ensure that it is in the best interest of the auditor to provide an effective audit irrespective of the reporting strategy taken by the manager. That is, (ICAT) and (ICAF) provide the constraints necessary to reduce the set of feasible contracts to those which make effective auditing the auditor's dominate effort choice. Finally, (TTA) limits the feasible set of contracts to those which insure the auditor will truthfully reveal his audit findings.

5.3 Results
5.3.1 Concurrent Audit Setting

Proposition 5.1: If the manager can only partially under-report or partially over-report firm outcome; then for Problem PA1, (TTA) and (IRA) bind while (ICAF) and (ICAT) do not bind. Equivalently, the owner can contractually dominate \( \sigma^A \).

Proof: All we need to show is that for some \( mr \in MR, p[ar \notin car (mr)] > 0 \) for either honest management reporting or dishonest
management reporting. If this can be shown, then the owner can impose penalties upon the auditor for failing to provide an audit report consistent with the manager's report and (ICAT) and (ICAF) will not bind. Further, if (ICAT) and (ICAF) do not bind, or equivalently there does not exist a hidden action concern with the auditor, then a constant fee will make the auditor indifferent between truthfully revealing firm outcome and not truthfully revealing firm outcome. The constant fee will need to make the auditor indifferent between accepting the position and performing an effective audit or accepting his next best alternative $\overline{AF}$. Thus, (TTA) and (IRA) will bind.

**Step 1:** $p[ar \notin car(mr)] > 0$ for honest management reporting.

**Proof:** Since the manager reports truthfully, it is known that $car(mr) = car(mt) = car(X)$ so that $p[ar \notin car(mr)] = p[ar \notin car(x)]$. But by definition an audit report is not consistent with the manager's report when $x + ur(x) - cu(x) \neq mr$. Given the truthfulness of the manager, this implies $p[ar \notin car(x)] = p(x \neq x)$. As we know from the assumed support of firm outcome, $p(x | a) > 0$, $\forall x \in X$. Thus,

$$p(x \neq x) = \sum_{x \neq x} p(x | a) > 0$$

**Step 2:** $p[ar \notin car(mr)] > 0$ for fraudulent management reporting.

**Proof:** Since the manager can only partially under- or over-report, firm outcome and all outcomes have positive probability, there are at
least two manager reports which will occur. Denote these reports \( m\hat{r} \) and \( m\hat{f} \) with the \( p(m\hat{r}) > 0 \) and \( p(m\hat{f}) > 0 \). Thus, \( p[ar \notin \text{car}(m\hat{r})] = p(x - ur(x) + cu(x) \neq m\hat{r}) = p(x - ur(x) - cu(x) = m\hat{f}) > 0. \)

Q.E.D.

Proposition 5.1 illustrates that an expansion of the auditor's report to include both firm outcome and the level of management misreporting will allow the owner to design a contract with the auditor which makes \( o^A*(ar, e) \) the auditor's dominant strategy. The expansion of the auditor's report allows the owner to contractually dominate the auditor's strategy choice because (1) the manager's optimal report is not a singleton for all firm outcomes \( x \in X \); and (2) the auditor in a concurrent audit setting does not view the manager's report. The nonexistence of a single optimal management report and the inability of the auditor to view the manager's report forces the auditor to guess the manager's report. Since there is a probability that the auditor will guess incorrectly, the owner can impose penalties on the auditor in these cases to make it the best response of the auditor to always provide an effective audit.

Proposition 5.1 is of interest with regard to the findings of Antle [1982]. In Antle [1982], it is suggested that multiple equilibria can result from the optimal contract design for the manager and auditor. However, any internal control limitation on the report options available to the manager along with the expansion of the auditor's report totally eliminate the multiple equilibrium concern.

Proposition 5.1 is based on the manager's optimal fraudulent report being dependent on firm outcome. What happens if the manager has a unique optimal fraudulent report irrespective of firm outcome?
Proposition 5.2: If the fraudulent manager has a unique optimal report $mr^*$ irrespective of firm outcome, then there doesn’t exist an auditor’s contract $af(\bullet, \bullet)$ which satisfies (TTA) and (ICAF) or (TTA) and (ICAT). Equivalently, the owner’s contract cannot contractually dominate $\sigma^A$. 

Proof: For (ICAF), the best response of the auditor for a constant audit fee is to issue the unqualified report $ar(mr^*, 0, 0)$ in response to the manager’s report $mr^*$. The manager’s best response to the unqualified report $ar(mr^*, 0, 0)$ is $mr^*$. Thus, $[\sigma^A(ar(mr^*, 0, 0), ne), \sigma^M(mr^*, a^*)]$ results in a subgame perfect Nash equilibrium. However, the owner can upset this equilibrium by paying the auditor for any qualification of the manager’s report and penalizing the manager for this qualification. This payment arrangement provides an inducement to the manager to choose $mr \neq mr^*$, creating uncertainty for the auditor similar to Proposition 5.1. In response to this uncertainty, the auditor always performs an effective audit and, consistent with standard assumptions, honestly reports any manager misreporting. This induces the manager to report truthfully. However, since the auditor receives a bonus for qualifying the manager’s report, the auditor also always qualifies the manager’s truthful report. 

Q.E.D.

Proposition 5.2 makes abundantly clear the owner’s problem when the manager can misreport firm outcome and the owner can no longer use the inconsistency of the
auditor's report as a gauge of auditor performance. The cause of this problem is the inability of the owner to distinguish a valid audit qualification of the manager's report from an invalid audit qualification. Therefore, if the owner could distinguish a valid audit qualification from an audit qualification without merit, the owner should be able to design a contract for which effective auditing and truthful disclosure is the auditor's dominant strategy.

Definition 5.2  **Corroborating evidence** is the supporting documentation for a particular firm outcome.

Auditors gather evidence in support of their audit report. This evidence allows them to determine the firm outcome for a particular period. Sources of corroborative evidence include (1) authoritative documents such as truck titles, etc.; (2) internal control; (3) calculations such as retabulation of an account balance; (4) physical existence obtained by observation and counts of inventory; (5) authoritative statements by third parties; (6) interrelationships of the accounts such as a relationship between patient days and hospital in-patient room revenue; and (7) subsequent events.

Evidence Assumption (EA):

There exists sources of corroborative evidence (or equivalently there exists an audit trail). Further, if the auditor provides an effective audit, then he obtains corroborative evidence necessary to support an audit report of the firm's outcome and the manager's actual level of misreporting. If the auditor provides an ineffective audit, then he obtains no corroborative evidence to support his audit report.
Assumption (EA) implies that competent and sufficient evidential matter is possessed by the auditor only when an effective audit is performed. Further, (EA) implies that the auditor's corroborative evidence supports the auditor's report of firm outcome and management misreporting only if the auditor's report is truthful. Assumption (EA) allows us to impose a requirement upon the auditor to disclose the corroborative evidence when he issues other than an unqualified audit report.

**Corroborative Evidence Requirement Condition (CERC):**

When the auditor issues a qualified audit report, then he must provide the corroborative evidence to the owner in support of this opinion.

(CERC) is similar to the third standard of reporting which requires the auditor to disclose the rationale for any qualification. However, the third standard of reporting does not require that the corroborative audit evidence be transmitted to the owner. One possible reason that the third standard of reporting is not equivalent to (CERC) is that any unwarranted audit qualification would be protested by the manager. The owner would then need to ask for the auditor's corroborative evidence in support of the audit report to settle the dispute between the manager and auditor. Thus, the third standard of reporting may tacitly assume (CERC) exists.

(CERC) and Assumption (EA) now allow us to reconsider the results of Proposition 5.2.

**Proposition 5.3:** Given (CERC), Assumption (EA), and Problem PA1, (ICAT) and (TTA) do not bind while (ICAF) and (IRA) bind for the optimal audit contract \( a_f^* (\bullet, \circ) \). Equivalently, the owner can contractually dominate \( \sigma^A \).
Step 1: (TTA) does not bind.

Proof: (CERC) and (EA) insure that any erroneous qualification by the auditor will be detected by the owner.

Step 2: (ICAT) does not bind.

Proof: See Proposition 5.1.

Step 3: (ICAF) binds.

Proof: Given the manager has a unique optimal reporting strategy irrespective of firm outcome, the RHS of (ICAF) will always be greater than the LHS of (ICAF) unless the auditor receives a bonus for the detection of management misreporting, which makes the LHS of (ICAF) equal to the RHS of (ICAF).

Step 4: (IRA) binds.

Proof: Assume not. This would imply that the auditor expects to receive more than his reservation utility when he provides an effective audit. From Step 3, Step 2 and Step 1, we know that the only way the auditor will receive greater than his reservation wage is for the manager to misreport firm outcome. However, this is not an optimal management response to effective auditing.

Q.E.D.

Proposition 5.3 indicates that the auditor will be made indifferent between choosing a report consistent with the manager's optimal report strategy ($mr^*$) and providing an effective audit. Since $v(e) < v(ne)$, the optimal auditor contract will provide the auditor
an incentive to issue a qualified report irrespective of whether or not the manager has misreported firm outcome as in Proposition 5.2. However, given (CERC), the auditor can only issue a qualified report when the manager has misreported firm outcome. Therefore, (CERC) and Assumption (EA) eliminate the false audit reports arising from auditor compensation schemes which reward report qualification.

The audit fee under the optimal audit contract \( a^* (e, \circ) \) is \( h[\bar{AF} + v(e)] \) where \( h: R \to R \) transforms utility levels into audit fees. Thus, (CERC), along with Assumption (EA), allows the owner to contractually dominate the auditor to provide an effective audit and report truthfully while limiting the auditor's expected compensation to no more than his reservation utility.

The results of Proposition 5.3 contrast with those present within Antle [1982]. From Proposition 5.3 we see that the owner can contractually dominate the auditor to choose \( \sigma^A(a^*, e) \). Further, this domination is not costly because the owner can use the auditor's qualification as a sure sign that the auditor has worked when (CERC) and Assumption (EA) hold. Antle [1982] implies that multiple equilibria could exist within the auditor-manager subgame. His finding is based upon the same setting as that discussed here, but he failed to consider any constraints upon the auditor's set of feasible reports. When the set of feasible reports is constrained by (CERC) and Assumption (EA) within our setting, the existence of multiple equilibria in the subgame induced by the owner's contract with the manager and auditor cannot occur.

5.3.2 Ex post Audit Setting

Within an \textit{ex post} audit setting, the auditor views the manager's report prior to performing the audit. For an \textit{ex post} audit, the incentive for the auditor would be either (1) to issue a qualified report when the owner provides a contract which rewarded report...
qualification, or (2) to accept the manager's report of firm outcome without performing an audit when the owner provides a constant audit fee to the auditor. The former case is not favorable to the manager while the latter case is not favorable to the owner. The cause of the unfavorable former result is the owner's inability to differentiate between a valid audit report qualification and an invalid audit report qualification. The reason for the owner's predicament in the latter case is the owner's reward structure does not provide the auditor with any incentive to put forth any effort. This same circumstance was present for the variation of concurrent auditing considered in Proposition 5.2 and suggests that perhaps (CERC) and Assumption (EA) will again allow for the owner to costlessly dominate the auditor to choose $\sigma^A(a^A, e)$ for each period. However, this isn't the case.

**Proposition 5.4:** Assume (CERC) and Assumption (EA) hold and the auditor plays after receipt of the manager's report, then there does not exist an optimal compensation contract $a^f(\bullet, \bullet)$ which satisfies the constraints (TTA), (ICAT), and (ICAF).

**Proof:** See Proposition 5.2.

Q.E.D.

Proposition 5.4 indicates that the owner cannot contractually induce the auditor to chose $\sigma^A$ $\ast$ $(\sigma^A, e)$ for each period. The reason for this finding stems from the auditor's realization that the auditor's enhanced audit fee for audit report qualification is viewed as a threat by the dishonest manager. The threat to the manager is sufficiently great to dissuade the dishonest manager from always misreporting firm outcome. The auditor's best response to this management strategy is obviously to provide an effective audit in certain periods, while for other periods to issue an unqualified opinion consistent with
the manager's report. Given these strategies by the auditor and manager, the auditor is always better off. But, given these strategies, is the manager better off with the ex post auditing in the presence of (CERC) and Assumption (EA)?

**Proposition 5.5:** Assume (CERC) and Assumption (EA) hold and the auditor plays after receipt of the manager’s report, then the manager's expected utility—when the manager optimally randomizes between honest and dishonest reporting in response to the auditor's optimal randomization between effort and not effort audit—never exceeds that generated from consistent honest reporting.

**Proof:** Assume not. If the manager were to receive more than that achieved by consistent honest reporting, then the auditor's best response to this strategy would be to increase his level of effective auditing to reap the benefits generated from the detection of management misreporting. But, then in response the manager would vary his level of randomization contradicting the optimality of the manager's randomization strategy.

Q.E.D.

Proposition 5.5 illustrates that (CERC) and Assumption (EA) limit the manager to expected returns no greater than that received by the manager when he truthfully reports firm outcome. The results of Proposition 5.3 and 5.5 imply the conclusion of 5.5 applies irrespective of the timing of the audit. This conclusion depends crucially on (CERC) and illustrates the importance of evidence in an audit setting.

The results of Proposition 5.5 and 5.3 suggest an alternative definition for auditor independence.
**Definition 5.3:** An auditor is said to be independent IFF $A(e, o)$ limits the manager's utility level to no greater than that received by an honest manager.

This definition is stated in terms of the auditor's impact on the final utility level of manager and insures that no side payments would ever be made between an independent auditor and a manager. Further, we don't make distinctions between strong independence and independence since these concepts from Proposition 5.4 imply that the audit is performed without viewing the manager's report. Finally, the owner is concerned with his expected payoff and is considered to be risk neutral. Therefore, if the auditor can limit the misreporting manager to no more than the compensation received when the manager truthfully reports firm outcome, the distinction between independent and strongly independent becomes moot.

**5.4 Conclusion**

This chapter has considered the importance of the auditor gathering corroborative evidence in support of his opinion and disclosing this evidence when a qualified audit report is issued. As was shown, if such a corroborative evidence requirement condition is present, then the owner can design a compensation schedule which can induce the auditor to be independent within our setting.

This finding has two important implications. The first implication is that there needs to be an institutional mechanism to insure that (CERC) holds. One possible institutional mechanism would be an audit committee which could pass judgments on disagreements between the auditor and manager. Another possible institutional mechanism would be

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18This is immediate since the side payments to the independent auditor would need to be equal to all gains from misreporting, thus alleviating the incentive for the manager to misreport.
peer reviews which would provide insights into the sufficiency of the auditor’s evidence in support of his opinion. Each of these two regulatory responses should enhance (CERC) and should receive increasing attention from regulatory bodies.

The second implication of this work is that the owner’s contract with the auditor affects the independence of the auditor. This points to audit failures being caused by the owner’s failure to provide adequate incentives to the auditor to do his job. This lack of incentive could be rectified by possibly rewarding the auditor for any discoveries made of management misreporting.
CHAPTER VI
TIMING OF THE AUDIT

6.1 Introduction

Timing of the audit is of importance in an auditing context. For instance, if audit risk is high, then the auditor will delay his substantive tests until the manager has reported firm outcome. Alternatively, if audit risk is low, the auditor will perform his substantive tests during the accounting period. In this chapter, the \textit{ex post} and concurrent audit models are reduced to their normal form to develop the conditions for which \textit{ex post} auditing is Pareto preferred to concurrent reporting.\textsuperscript{19}

It will be shown in this chapter that in the presence of (CERC), \textit{ex post} auditing is Pareto preferred to concurrent auditing only when the probability of the receipt of a signal of audit failure is high. High, in this context, is defined as that level of detection which reduces the ineffective auditor's reservation utility to below his reservation wage.

Timing of auditing has been studied elsewhere by Penno [1985]. Penno [1985] shows for an imperfect audit technology there exists a weak Pareto improvement to the agency by having the audit technology utilized after the manager reports. The reason for the Pareto improvement in Penno's setting is the improved risk sharing that results by having the audit technology applied after the manager reports firm outcome.

\textsuperscript{19}For this chapter only, \textit{ex post} auditing is said to occur if substantive tests are performed after the receipt of the manager's report. Concurrent auditing is said to occur if substantive tests are performed before the receipt of the manager's report.
The difference in results between the work here and that done by Penno [1985] is caused by the replacement of Penno’s imperfect audit technology by a utility-maximizing auditor who determines the level of imperfection. This difference in modeling between Penno [1985] and the model considered within this chapter provides an alternative explanation for the financial reporting process and the timing of audits in particular.

Section 6.2 will discuss the derivation of the normal forms of both the concurrent and ex post audit games. Section 6.3 provides the results of our analysis while Section 6.4 provides the conclusion to this chapter along with implications.

6.2 Normal Forms
6.2.1 Concurrent Audit Normal Form

In Chapter V, the model of concurrent auditing was solved for the optimal auditor contract. As the analysis shows, the auditor receives \( h(\bullet) > h[AF + v(e)] \) when the auditor discovers any management misreporting, \( h[AF + v(e)] \) when the auditor’s and manager’s reports agree, and a payment sufficiently small when the auditor’s report is inconsistent with the manager’s report to reduce the ineffective auditor’s net utility below his reservation utility \( AF \). On the other hand, the manager’s optimal contract in the presence of (CERC) provides the manager with (1) a payment based upon his report of firm outcome when the auditor’s report is consistent with the manager’s report and unqualified; (2) a payment based upon the managers’ report of firm outcome when the auditor’s report is inconsistent with that of the manager or the auditor’s qualification doesn’t satisfy (CERC); and (3) a payment which reduces the return to the manager to zero when the auditor’s qualification satisfies (CERC).

\[ 20 h[AF + v(e)] = \text{the audit fee need to provide agent utility } AF + v(e). \]
The normal form of the subgame induced by this contract is provided in Table 6.1.

### Table 6.1

<table>
<thead>
<tr>
<th>Auditor</th>
<th>Manager</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF</td>
<td>AF⁺</td>
<td>̅u</td>
<td>0</td>
</tr>
<tr>
<td>AF⁻</td>
<td>AF⁻SEP</td>
<td>̅u</td>
<td>̅u</td>
</tr>
</tbody>
</table>

\[ ̅u > ̅u \]
\[ AF⁺ ≥ AF⁻; \quad AF⁻SEP > AF⁻; \quad AF⁻ > AF⁻SEP \]

- E = Effective Audit
- NE = Ineffective Audit
- T = True Manager's Report
- F = False Manager's Report

Notice the payoffs have been converted from audit fees (or, equivalently, management salary) back to utility terms for the auditor (manager). For purposes of this table, the relative payoffs to each player are captured although the differences in the relative payoffs are considered to be equal with the absolute differences in payoffs for each of the cells of the true payoff matrix. For instance, the difference between \( AF⁻ \) and \( AF⁺ \) is the same as the difference between \( u[h(\bar{F} + v(e)) - v(e)] = \bar{AF} \) and \( u[h(af(mr, at)) - v(e)] = AF⁺ \). The unique equilibria for this game results in payoffs of \( ̅u \) to the manager and \( \bar{AF} \) to the auditor.

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21 As long as the relative payoffs maintain the same absolute difference in payoffs as the actual payoffs, the set of perfect Nash equilibria will not be affected (see Basar [1982], p. 84).
6.2.2 Ex post Audit Normal Form

An ex post audit model in the presence of (CERC) would vary from Table 6.1 only for the cell \{NE, T\}. For this cell, the auditor’s ability to view the manager’s report allows the auditor to avoid being penalized by an inconsistent audit report. With this in mind, the payoff matrix for the ex post audit setting is contained in Table 6.2.

Table 6.2

<table>
<thead>
<tr>
<th></th>
<th>MANAGER T</th>
<th>MANAGER F</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUDITOR E</td>
<td>(\hat{u})</td>
<td>(\hat{u})</td>
</tr>
<tr>
<td>AUDITOR NE</td>
<td>(\overline{AF})</td>
<td>(AF^+)</td>
</tr>
</tbody>
</table>

This table uses relative payoffs and also maintains the absolute differences in relative payoffs equal to the actual differences in agent’s payoff for each possible strategy.

Notice for Table 6.2, as opposed to Table 6.1, the auditor’s effective audit strategy does not dominate his ineffective audit strategy. This stems from the ability of the auditor to view firm outcome prior to performing the audit.

The subgame perfect Nash equilibrium of the concurrent audit setting is readily determined from Table 6.1. As this table indicates, the auditor’s dominant strategy is to provide an effective audit while as a best response the manager will truthfully report firm outcome. The payoffs to the auditor and manager within this concurrent audit setting are \(\overline{AF}\) and \(\hat{u}\) respectively.

The subgame perfect Nash equilibrium for the ex post audit setting is in mixed strategies. A mixed strategy provides for a probability distribution over pure strategies.
For the \textit{ex post} audit setting, the optimal mixing strategy for the auditor is readily determined as:

\[ p(\text{effective audit will occur}) = \frac{\bar{u} - \hat{u}}{u} \]

\[ p(\text{ineffective audit will occur}) = \frac{\hat{u}}{u} \]

The optimal mixing strategy for the manager is:

\[ p(\text{manager truthfully reports}) = \frac{AF^+ - AF}{AF^+ - AF} \]

\[ p(\text{manager falsely reports}) = \frac{AF^+ - AF}{AF^+ - AF} \]

These mixed strategies determine the expected payoffs to the manager and auditor for this bimatrix game. The auditor's and manager's expected payoffs using their optimal mixing strategies are:

\textbf{Auditor's Expected Payoff:}

\[ \frac{\bar{u} - \hat{u}}{u} \left[ \left( \frac{AF^+ - AF}{AF^+ - AF} \right) \bar{F} + \left( \frac{AF^+ - AF}{AF^+ - AF} \right) AF^+ \right] + \frac{\hat{u}}{u} [AF] \]

\textbf{Manager's Expected Payoff:}

\[ \frac{AF^+ - AF}{AF^+ - AF} [\hat{u}] + \frac{AF^+ - AF}{AF^+ - AF} \left[ \bar{u} \left( \frac{\hat{u}}{u} \right) \right] = \hat{u} \]

As is apparent from these expected payoffs for the auditor and manager, the manager is no better off in an \textit{ex post} audit setting than in a concurrent audit setting. Obviously, if it were the case that the manager were better off in the \textit{ex post} audit game, then the auditor would improve his utility level by increasing the proportion of effective audits in order to capture the higher net utility $AF^+$. The auditor's expected payoff is higher in
the ex post audit setting because the auditor is allowed to capture the higher utility level $A_F^+$ when he detects misreporting and the higher utility level $A_F^e$ when he does not audit effectively. Finally, because of the need to motivate the auditor to provide an effective audit, the owner's return in the ex post audit game is always less than that in the concurrent audit game. These comparisons of the player's payoffs imply that no Pareto comparison can be made between the ex post and concurrent audit games.

However, if the owner did not need to provide contractual inducements for the auditor to choose the proportion of effective audits necessary to limit the manager's expected return, then the owner could pay the auditor a constant amount, the manager's expected return would be limited to no more than received when reporting truthfully, and the owner would be weakly better off.

6.3 Results

Proposition 6.1: Assume (EA). If there exists a perfect public signal $y$ of management misreporting with $y$ independent of the level of misstatement, $p(y) > 0$ for positive levels of management misreporting, and $u^A[af(\cdot, \cdot)] p(y) + u^A[af(\cdot, \cdot)] 1 - p(y) - v(ne) \leq A_F^+ + v(ne)$, then ex post auditing is Pareto preferred to concurrent auditing.

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22The auditor would never increase the proportion of effective audits beyond the proportion of effective audits which provides the manager with expected return $\bar{u}$. Any increase in the proportion of effective audits above this point induces the manager to use his threat strategy of truthful reporting. Since the auditor is rewarded for the detection of management misreporting, the auditor is better off providing some incentive for the manager to misreport.
Proof: From Proposition 5.5 and Proposition 5.3, it is known that the manager never expects to benefit from misreporting. Thus, the manager is indifferent as to timing of the audit.

From Proposition 5.3, it is known that the auditor expects to receive net utility equal to his reservation utility when he performs the audit prior to the receipt of the manager's report.

For the \textit{ex post} audit setting, it was shown that the auditor can expect to receive:

\[
\frac{\bar{u} - \hat{u}}{u} \left[ \frac{AF^+ - AF}{AF^+ - AF} \right] \bar{A}F + \left[ \frac{AF - \bar{A}F}{AF^+ - A\bar{F}} \right] A\bar{F}^+ \right) + \frac{\hat{u}}{u} [AF]
\]

Since this expected payoff always exceeds $\bar{A}F$, the auditor always prefers \textit{ex post} auditing.

In order to insure the owner finds \textit{ex post} auditing weakly preferable to concurrent auditing, the owner's payments to either the manager or the auditor in the \textit{ex post} audit case cannot exceed the payments in the concurrent audit case. From Table 6.1 and Table 6.2 it is obvious that the manager's compensation level will not vary irrespective of the timing of the audit. Thus, if the owner pays the auditor a constant $h[\bar{A}F + v(e)]$ irrespective of the timing of the audit, then the owner would be no worse off with \textit{ex post} auditing. From the auditor's expected payoff, we see that if there exists a $y$ with positive measure so that the owner could design a contract such that $u^A[af(\bullet, \bullet)] p(y) + u^A[af(\bullet, \bullet)] [1 - p(y)] - v(ne) \leq \bar{A}F + v(ne)$, then $AF \leq \bar{A}F$ so that $Af^+ \text{ could}$
be set equal to $\overline{AF}$. Thus, irrespective of the timing of the audit test, the owner would expect to pay the auditor $h[\overline{AF} + v(e)]$. 

Q.E.D.

The result of Proposition 6.1 illustrates the importance of detection of audit failure on the timing of an audit. If the audit failure can be detected with sufficient regularity, the owner doesn't care when the audit is performed. Baiman, Evans and Noel [1987] consider the measure of an exogenous signal $y$ in designing a contract for an ex post audit game which insures that (1) the auditor receives his reservation wage when performing an effective audit, and (2) the auditor is indifferent between performing an effective audit and performing an ineffective audit. The optimal contract design of Baiman, Evans and Noel [1987] suggests that the condition of Proposition 6.1 holds and therefore the owner is indifferent to audit timing. However, it cannot be assumed that the condition of Proposition 6.1 holds in all cases and suggests that timing of audit procedures may be an important contractual variable.

As discussed in the introduction to this chapter, Penno [1985] studies timing of audit procedures in the context of the financial reporting process. Penno's [1985] results and the results contained in Proposition 6.1 are affected by the existence of a utility-maximizing auditor within our setting. In Penno [1985], the imperfect audit technology imposes risk upon the manager. This imposition of risk creates the demand for the manager's report. In our setting, when the owner hires an auditor to perform the audit after the manager has reported firm outcome, additional audit costs caused by the inability of the owner to use the auditor's report as a gauge of effort may be incurred. Thus, a utility-maximizing auditor should perform an audit after receipt of the manager's report only when knowledge of the manager's report does not provide the auditor any
benefit. An example of when no benefit accrues to the auditor from viewing the manager’s report is when the possible detection of an audit failure is high.

6.4 Conclusion

This chapter considers the importance of audit timing on the welfare of the agency. It was shown that a Pareto improvement exists when \textit{ex post} auditing is performed rather than concurrent auditing only when the probability of detecting an audit failure is high. This seems consistent with established audit practice and suggests that any delay in auditing may provide a signal to the financial markets concerning the eventual audit report. Empirical work by Keller [1986] and Whittred [1980] provide support to this latter assertion.
7.1 Summary

A model of hidden action and hidden outcome information was considered. As it was shown, the effect of the owner's optimal contract on the manager in this asymmetric information setting is affected by the reporting constraints placed upon the manager. For instance, it was shown that for full under- or over-reporting, the owner's optimal contract design induces the manager to disclose the firm's outcome. However, the owner pays dearly for the knowledge of firm outcome. It was shown that for full over-reporting, the owner pays the manager a constant which induces only minimal effort from the manager. Alternatively, for full under-reporting, the owner must transfer the full outcome to the manager.

As Chapter II illustrates, it is common for the owner to pay for the information endowment of the agent only when that information is of value to the agency. For example, Demski and Sappington [1984] illustrate that the owner provides information rents to the manager only in the high productive state. This dissertation illustrates that the owner pays for the manager's outcome information—irrespective of its value—for certain report options available to the manager, while for other report options the owner cannot purchase the manager's outcome information or is better off not buying the manager's outcome information. This illustrates the importance of the manager's report.
options for determining when firm outcome will be reliable when the owner contracts with the manager with no auditor present.

In response to the unavailability or costliness of a reliable manager’s report, the owner can hire a utility-maximizing auditor to serve the role of a revelation mechanism of firm outcome. The auditor’s services are costly and the owner must provide adequate motivation for the auditor to provide an effective audit. In general, the owner cannot design a contract with the auditor which both induces truth-telling and an effective audit when the audit report is limited to the firm’s outcome. The reason for this result is that the auditor’s motivation to provide an effective audit rests with the rents earned when the audit report varies from the manager’s report. However, this compensation schedule also provides the auditor with the incentive to qualify the audit report.

One feasible response by the owner to the inability of the audit contract to provide both auditor motivation and truth-telling is to expand the report of the auditor to include both a report of firm outcome and the level of management misreporting. As is shown in Chapter V, this expansion of the audit report allows for the audit contract to contractually induce effective auditing and truthful reporting when (1) the manager’s maximal report is not a singleton, and (2) the auditor does not view the manager’s report prior to performing the audit. These requirements force the shirking auditor to guess a firm outcome and a level of management misreporting which may not be consistent with the manager’s report. The possibility of incongruence in reports allows the owner to use the manager’s and auditor’s reports in contract design to alleviate auditor shirking.

Another feasible response to the inability of the auditor’s contract to motivate the auditor and to induce auditor truthful disclosure when the optimal management report is a singleton requiring the auditor to provide corroborative evidence of his audit report when the auditor qualifies the manager’s report. This expansion of the auditor’s report
space (known as CERC) allows the owner to write a contract with the auditor which assures the manager (subject to a bankruptcy constraint) receives no more than his truth-telling level of utility irrespective of whether or not the auditor has viewed the manager’s report prior to performing the audit.

This result suggests that expansion of the auditor’s report space does allow the owner to use the auditor as a revelation mechanism. It also suggests that the value of an audit to the owner rests on the evidence gathered by the auditor.

Finally, the timing of the audit, given the owner-imposed expansion of the auditor’s report space, can also affect the welfare of the agency. It is shown that the agency will always be better off when the auditor performs the audit prior to the receipt of the manager’s report unless the probability of detection of audit failure is high.23

7.2 Contributions

The fundamental contributions lie in (1) extending the work of Green and Lafont [1986] to models of hidden action and hidden outcome information; (2) identifying changes in the auditor’s report space which insures the owner’s contract will induce sufficient effort from the auditor and limit the manager to no more than his truth-telling payoff; and (3) identifying when ex post auditing provides a Pareto improvement over concurrent auditing.

Green and Lafont [1986] consider a model of hidden information in which the agent’s private information is valuable in making a business decision. We extend this work by allowing the agent’s hidden efforts to determine the underlying probability distributions of the agent’s outcome information. This change in the information

23When the probability of detection of audit failure is high, the manager’s report holds little value to the auditor for determining audit effort. Thus, the agency should be indifferent to timing of the audit.
endowment of the agent invalidates Green and Lafont's nested range condition as a necessary condition for the applicability of the Revelation Principle. We discover that the reporting options available to the manager determine the applicability of the Revelation Principle to optimal contract design. Thus, it is shown that if the manager can fully under- or over-report, the Revelation Principle is always applicable. However, if the manager can partially over-report or under-report and then cover-up firm outcome, then the Revelation Principle may or may not be applicable.

A second contribution of this work is showing that an expansion of the auditor's report space can eliminate the existence of multiple equilibria within an owner-manager-auditor model. Antle [1982] suggests that when the audit report is composed strictly of a statement of firm outcome, the set of owner preferred perfect Nash equilibria may not coincide with the set of subgame perfect Nash equilibria induced by the owner's contract. Our work utilizes the model setting of Antle [1982] to show that multiple equilibria may be eliminated in a concurrent audit setting when the auditor's report states the cause of the audit qualification. Additionally, it is shown that if the audit report space is further expanded so that the condition known as (CERC) applies, multiple equilibria never exist in the subgame induced by the owner's optimal contract irrespective of the timing of the audit.

Other solutions offered for the alleviation of multiple equilibria within an owner-manager model concentrate on the existence of an outside signal of audit performance. However, the signal's strength may not be sufficiently great because of either exogenous or endogenous factors. For example, the strength of this signal may be affected by the actions of the manager and auditor. Alternatively, the strength of the outside signal may be regulated by market factors not controlled by the owner. Thus, models which incorporate audit reputation or audit liability such as Baiman, Evans and Noel [1987],
Datar [1987], Thoman [1989], etc., alleviate audit hidden action by an exogenous signal of auditor quality. We suggest that a signal of auditor quality will not be necessary if the optimal owner contract with the auditor requires the auditor's report to meet the condition known as (CERC).

Finally, we identify conditions under which the auditor should delay his audit until after the receipt of the manager's report. Penno [1985] considers when ex post auditing is of value to the agency and shows that when the audit technology is imperfect, the manager is risk-averse, and the principal risk neutral, then auditing after issuance of the manager's report is Pareto preferred to auditing prior to the issuance of the manager's report. Our work indicates that this rationale for ex post auditing doesn't hold in a setting in which the auditor controls the perfection of the audit. We show that, if (CERC) holds, the issue of timing of the audit revolves around the probability of detection of any audit failure. For instance, if the probability of detection of audit failure is high, then the owner doesn't care whether the audit is performed before or after the issuance of the manager's report. This finding supports to some degree the rationale provided within the audit literature about when the audit should be performed. Additionally, this finding illustrates that the results obtained when the auditor is a technology may not pertain when the auditor is a utility-maximizing agent whose efforts are not observable.

7.3 Theoretical Considerations of the Research

Recent theoretical work in accounting and economics has been concerned with situations in which the Revelation Principle isn't applicable. The Revelation Principle states that the owner's optimal contract design can be limited to contracts which induce truth-telling by the agent. We have shown for a model of hidden action and hidden
outcome information that the manager's report options affect the applicability of the Revelation Principle. This implies that models of hidden action and hidden outcome information which utilize the Revelation Principle for optimal contract design may identify as optimal a contract which can be improved upon by the agency. This suggests that for models of asymmetric state or outcome information, the assumed structure of the message space (or report options) of the agent is an important component of model formulation.

Additionally, it was assumed that the dimension of the message space affects the implementability of a particular perfect Nash equilibrium (see, for instance, Ma [1988], Ma, Moore and Turnbull [1988], and Moore and Repullo [1988]). These researchers show that if the agent's message is expanded, the cardinality of the set of implementable perfect Nash equilibria can increase. For our study, we show that the dimensionality of the message spaces of each player may be optimally controlled by the owner for his benefit. Thus, not only should the researchers consider dimensionality of the message space as a critical feature for implementability, but should also consider what dimensions each agent's message space should possess.

Finally, as Chapter II indicates, the monitoring literature has almost exclusively assumed that the monitor is a technology. As indicated from the results of Chapter VI, this assumption may dramatically affect the results generated from the analysis. Thus, the optimal monitoring region, the value of monitoring, and what to monitor may all be affected by the existence or non-existence of a utility-maximizing monitor. This suggests that additional work be performed to better understand how the agency is affected when the optimal contract trades-off the costs and benefits of a utility-maximizing monitor whose actions are not observable. It is suggested that a condition such as (CERC) may allow for such an analysis.
7.4 Practical Implications of the Research

The results of this study indicate that the existence of audit failures rests not only with the auditor but also with the firm's owners. As Chapter V illustrates, the owner can expand the dimensionality of the auditor's report and write a contract which makes it individually rational for the auditor to provide an effective audit. Further, from the motivation in Chapter V, this expansion of the auditor's report is already present within an auditing context. Therefore, one must question why audit failures exist.

Several possible answers exist to this question. First, the auditor may receive side payments from the manager for a particular auditor report. However, these side payments could be anticipated by the owner and incorporated within the auditor's incentive scheme. Another answer, which isn't appealing, is that the auditor isn't individual rational. However, if the auditor weren't individual rational, then it is conjectured that the owner would not hire the auditor. Finally, the answer to this question may lie in the unwillingness of the owner to pay the auditor in accordance with the optimal contract design specified within Chapter V. This unwillingness may stem in part from the ability of the owner to sell the agency to an investor and avoid the repercussions of the externality created by ineffective auditing. If this latter case is present, the auditor may be providing assurance through his wealth that the audit report is representative of the firm's outcome and management reporting activities.

If the cause of the existence of audit failures arises from the unwillingness of the owners to pay for the audit services, then regulation should be put into place either to regulate audit fees or, similarly, force the owner to be a price taker in the audit market.
In fact, this may be the role of audit standards and the effect of recommendations of national commissions concerned with audit failures.\textsuperscript{24}

The results of this study also indicate that the auditor's corroborating evidence is important in ensuring the effectiveness of the audit. This suggests that the working papers of the auditor should contain evidence to support the audit report and that any disagreements between the manager and auditor concerning the auditor's report be settled by the owner. This former suggestion is captured by SAS No. 31 which requires that auditor's working papers be maintained, while SAS No. 41 requires that adequate evidence be gathered in support of an audit opinion.

7.5 Limitations of the Research

The primary limitation of any analytical research is the inability of its results to generalize to changes in the characteristics of its parameters. For instance, a primary assumption of this dissertation is that the auditor can either be effective or ineffective. This assumption is obviously a gross simplification but this simplification does allow us to generate results which appear to be intuitively appealing. Nevertheless, an alternative assumption would allow the auditor's effectiveness to be a function of the effort provided. However, the notion of effective auditing is meant only to convey that the auditor is providing effort which is interior to his action set.

A second simplification was taken in Chapter VI where the report types were labels true or false. Obviously, the auditor may not be able to detect all management misreporting. This suggests that the report types should be relabeled materially misstated or not materially misstated. But, as was previously mentioned, the labels

chosen were taken for simplification purposes and were chosen to impress upon the reader that proper audit incentives will limit the manager's ability to misstate firm outcome.

Additionally, it was assumed that the auditor had "deep pockets." This assumption seems needlessly strict given the ability of the auditor to limit any liability or penalties imposed upon him by compliance with accepted audit standards. Woodlock [1990] considers such a limitation to derive a demand for audit standards.

Finally, the limitations imposed by the use of an agency model are present within this analysis (see Baiman [1982] for a discussion of these assumptions). For instance, it was assumed that the owner is a price-taker in the factor markets. However, this assumption does not seem to be too disagreeable given the existence of minimum wage standards. Additionally, it is assumed that if the manager or auditor is indifferent between a given strategy and the owner's preferred strategy that the manager or auditor will choose the strategy desired by the owner. Within a single period model, this assumption does not appear to be restrictive. However, in a multi-period world, this assumption may not be without loss of generality since the principal may learn something about the agent's private information which will lead to reduced agent returns in future periods.

7.6 Extensions

Antle's [1984] definition of strong independence implies that the auditor will choose the strategy desired by the owner. Only one other analytical model of auditing has demonstrated conditions which lead to the existence of strong independence within an audit model. Baiman, Evans and Noel [1987] show that if the owner can view the firm's outcome a set fraction of the time, then the owner can design a contract with the
auditor to elicit strong independence. This study suggests that the existence of (CERC) also allows the owner to write a contract with the auditor which allows the owner to assume that the auditor is strongly independent. Both the results of this study and that of Baiman, Evans and Noel [1987] require that the owner receive a signal of audit effort. In the case of Baiman, Evans and Noel [1987], this signal comes from a source exogenous to the model. In the case of this study, the signal of audit effort comes from the auditor's report which is endogenous to the model. Future work in this area should continue to strive to isolate factors endogenous to auditing which are sufficient or necessary for the auditor to be independent.

7.7 Conclusion

This study has maintained the importance of reliable management outcome information to show that auditing may be preferred to contracting as a means of inducing reliable management reporting. However, the introduction of a utility-maximizing auditor whose efforts are not observable creates additional incentive problems for the owner.

This study shows that a condition familiar to accountants, known as (CERC) insures that the owner's contract with the auditor will alleviate any gains to the manager from misreporting. These gains to the manager from misreporting stem from the ability of the manager to shirk or consume excessive perquisites.

Future research should determine if (CERC) is valuable in providing theoretical support for the existence of audit standards and how (CERC) may be useful in elucidating problems of independence and notions of due care. Evidence is the cornerstone of auditing and any theory development within an audit environment should obviously incorporate evidence.
APPENDIX
APPENDIX A

REVIEW OF THE MATHEMATICS OF AGENCY

A.1 Introduction

The purpose of this section is to consider a sufficient set of conditions to assure existence, feasibility, and uniqueness of the solution of an agency problem and to consider factors which influence the shape of the optimal agent contract and the level of potential agency costs. This information is summarized in Figures A.6, A.7, and A.8 and hopefully will provide some insight into why certain assumptions are made within the context of an agency model.

Section A.2 of this Appendix discusses the existence of an agency solution. As is known, the optimal solution to an agency problem of hidden action is composed of the optimal compensation function and the optimal agent effort. For most model formulations, there is no certainty that either the optimal compensation function or optimal agent action is either feasible or unique. Section A.2 considers the feasibility question while Section A.3 considers the uniqueness question. Section A.4 considers the assumptions made to insure the optimal compensation function is monotonic in firm outcome while Section A.5 considers how certain assumptions within the agency model can limit the level of agency costs caused by the agent’s private information. Section A.6 provides a brief conclusion.
A.2 Existence and Feasibility of an Agency Solution
A.2.1 Existence of a Solution

The existence or nonexistence of an optimal solution to an agency problem can be affected by (1) the level of interdependence between the components of the optimal solution to an agency problem and their affects on the utility levels of the principal and agent; (2) the properties ascribed to the outcome set, the agent’s action set, and the set of feasible incentive schemes; and (3) the continuity of the agent’s and owner’s utility function along with the continuity of the incentive function utilized to illicit a desired action from the agent.

The lack of interdependence between the components of the optimal solution to an agency problem and their affects on the utility levels of the principal and agent may either eliminate the formation of the agency or the need to be concerned with optimal contract design. For instance, if it is assumed that the owner’s utility level is unaffected by the agent’s efforts, then the owner would be better off not hiring the agent. Likewise, if the agent’s utility level is not affected by his effort selection, then the agent’s knowledge of his effort has no effect on the owner’s ability to achieve a first-best outcome. These examples illustrate that existence of an optimal solution to an agency problem is trivial when there does not exist the requisite interdependence between the principal and agent.

Agency models capture the interdependence between the principal and agent by specifying the impact of effort and compensation on the welfare of these players. Thus, it is typical to assume that the agent’s effort reduces his utility level while the compensation required from the principal increases the agent’s utility level. On the other hand, it is typical to assume that the agent’s efforts determine firm outcome, which has a positive effect on the owner’s utility, while the compensation paid to the agent reduces
the owner's utility. The built-in friction, caused by making the owner and manager interdependent in this manner, allows the agency model to capture the effects of separation of ownership and management and insures that the existence or non-existence of the optimal solution is not a trivial question.

The choice variable of the agent within an agency model is his effort while the choice variable of the owner is the incentive function. In order to be able to determine which effort the agent will take in response to a particular owner incentive, the agent must be able to order his utility level to determine which effort level provides the highest return to the agent. Likewise, in order to be able to determine which incentive will be offered by the owner in response to a particular agent effort, the owner must be able to order his utility level to determine which incentive function will provide the highest return to the owner. Continuity of a utility function implies that the player possesses a continuous pre-ordering over the choice variables.

Agency models assume that the owner's and agent's utility functions are continuous. The pre-ordering imposed upon these utility functions is discussed above and determines the objective of each player. Thus, the objective of the owner is to maximize the outcome produced by the agent's effort net of any compensation paid to the agent. Alternatively, the objective of the agent is to maximize his compensation net of the cost of his effort.

Given the presence of interdependence of the players and the continuity of each players' utility function, discussion now focuses on characterizing the supply of effort from the agent for a particular owner incentive. Obviously, the agent may not be able to determine the optimal effort to provide in response to the owner's incentive function unless the set of agent actions contains that optimal effort and there exist limits to the set of agent actions. Compactness of the agent's action set in $\mathbb{R}^n$ provides closure and
boundedness to the agent's action set. Closure insures that all limit points of the action set are contained within the action set. Boundedness insures that the agent's action set cannot exceed nor fall below a certain effort level. Illustrations of sets in $\mathbb{R}^2$, which are respectively bounded, closed, and closed and bounded are provided in Figures A.1 (a), (b), and (c). Figure A.1 (a) illustrates how the lack of boundedness can affect the existence of an optimal effort response. Notice, although the set of actions contains the closure AB, the set of actions has no lower bound. In this setting, it is conceivable that the agent would like to take the smallest level of effort possible in response to an incentive such as $I$. However, such a smallest effort cannot be determined because of the lack of any limit on the smallest possible agent effort. Figure A.1 (b) illustrates how the lack of closedness of the agent's action set can affect the existence of an optimal effort response by the agent. Notice, although the set of agent actions is bounded above and below by the line segment AB and the x axis, the set of agent actions does not include either the line segment AB or the x axis. Thus, if the agent's optimal effort response was either on the line segment AB or on the x axis, no optimal effort response would exist. Figure A.1 (c) illustrates how the closedness and boundedness of the agent's action set allows the agent to choose his optimal effort choice.

The compactness of the agent's action set and the continuity of the agent's utility function insures that the agent can choose between incentive schemes offered by the owner. However, the set of incentive schemes which can induce a particular agent effort may not be closed nor bounded. If the set of incentive schemes is not closed and bounded, then the owner may not be able to choose the optimal incentive scheme to induce a particular agent effort.

Grossman and Hart [1983] consider conditions sufficient for the set of incentive schemes to be closed and bounded. Grossman and Hart [1983] point out that the
constraints on the owner's set of agent contracts, within an agency setting or hidden action, are weak inequalities and thus provide closure to the set of optimal agent contracts. Likewise, Grossman and Hart [1983] show that either risk neutrality of the agent or risk averseness of the agent in the presence of stationary support of the firm's outcome distribution provides sufficiency for boundedness of the set of incentive contracts.

Once it is known that the principal and agent can determine their optimal responses, attention can be shifted to whether or not an optimal solution exists to the principal-agent model. The existence of an optimal solution to the principal-agent model can be assured if it can be shown that the agent's optimal reaction to the owner's incentive varies upper semi-continuously in the incentive provided by the owner.

Berge [1963] develops the maximum theory. This theory can be stated as follows. Let $u(z, x)$ be a real-valued (and single-valued) continuous function in $Z \otimes X$, and $\varnothing(z)$ be a multi-valued function from $z$ into $x$ such that $\varnothing(z) \neq \varnothing$ for all $z \in Z$ and $\varnothing(z)$ is continuous in $z$. Then, $v(z)$ is continuous and $t(z)$ is (USC) in $z$ [Takayama 1987, p. 254].

For application to our setting, let $u'(i, a)$ be the agent's utility function which from condition (2) is both single-valued and continuous in $I \times A$. Given $i \in I$, the effort response by the agent is restricted to a subset of $A$ by a set-valued function $\varnothing: I \rightarrow A$. As it was shown above, the owner can always contractually induce a particular agent effort when the constraint set isn't empty. Therefore, it is known that $\varnothing(i)$ is non-empty for all feasible owner incentives. We now assume that the set of firm outcomes is finite valued and that the incentive function is defined over the set of firm outcomes. This assumption implies that $\varnothing(i)$ is continuous. This last result allows us to apply the results of the maximum theory and conclude that the supply of agent effort is upper-
semicontinuous in $I$. Further, the optimal supply of agent effort $s(i)$ is closed in $I$ by its upper-semicontinuity and bounded by the compactness of the set of agent actions $A$.

From above, we know that the owner's utility function is continuous. From above, it is also known that the optimal supply of agent effort $s(i)$ defines a closed and bounded or compact set. Clearly then, the owner's utility level is defined over this compact set $s(t)$ and an application of the Weierstrass Theorem insures the existence of the optimal solution.

A.2.2 Feasibility of the Optimal Solution

Grossman and Hart [1983] discuss the possibility that the owner's optimal solution may not be feasible when $s(i)$ is multi-valued. This can be seen in Figure A.2 which is an adapted version of a figure contained in their work. The y axis represents the effort level provided by the manager. Notice, the compensation levels become smaller as one moves from left to right along the x axis. Consistent with assumptions above, it is assumed that the owner's utility increases in the north-easterly direction, implying that the owner would like more effort for less money. We denote the owner's utility level as $RI$ to signify that it is typical for the owner to receive the residual income of the firm and the agent's supply of effort for a particular owner incentive as $s(i)$.

As can be seen from Figure A.2, the agent's supply function is multi-valued. If it is assumed as above that the agent desires less effort to more, then the feasible supply of agent effort is composed of the line segments AB and DE. However, as can be seen, this precludes the owner from achieving the desired optimal solution C. Thus, even though the optimal solution exists, the solution is not feasible because the agent would never choose the point C in response to the incentive $I$. 
To alleviate the need to distinguish when an optimal solution is feasible, various authors have made simplifications which alleviate the need to make this distinction. For instance, the first order condition (FOC) approach utilized by Holmstrom [1979] and discussed by Rogerson [1985] is a means of alleviating the need to make the distinction between optimal and feasible solutions. The first order condition assumes that the agent takes a unique action in response to the owner's contract. Thus, the problem of multiple agent effort responses does not exist in this setting and the optimal solution is also feasible. Mirrlees [1979] discusses an assumption which also insures that the optimal solution is feasible. However, Mirrlees allows for multiple agent effort responses to an incentive scheme but assumes that there exists a one best action using first order stochastic dominance. Mirrlees denotes this condition (CDFC), or concavity of the distribution function condition.

A.2.3 Summary

The existence of an agency solution can be assumed if (1) interdependence of the owner and agent is present; (2) the agent and owner's utility functions are continuous; (3) the agent's actions set is compact and the set of feasible solutions is finite; and (4) the set of owner's compensation constraints isn't empty.

Condition (1) assures us that a potential agency problem exists and that the agency will be formed. Condition (4) assures us that the owner can motivate the agent contractually to provide a particular effort level. Conditions (2) and (3) are present to assure us that the owner's residual income is defined over a compact set and therefore a minimal and maximal value of residual income exists.

The feasibility of the optimal solution identified is affected by the preference for the agent for alternative actions. One way to alleviate the need to distinguish between
optimal and feasible solutions is to assume that the agent chooses a single action in response to a given owner incentive. This implies the existence of a first order condition on the agent's optimal effort selection. An alternative to the first order condition is to assume that the agent prefers one of several actions possible because that action is less risky than the other actions. This assumption is consistent with Mirrlees' [1979] concavity of distribution function condition.

A.3 Uniqueness of the Optimal Solution

The feasibility of the optimal solution does not provide assurances that the optimal solution to the agency problem is unique. Possible reasons why an optimal feasible solution may not be unique are provided in Figures A.3 and A.4. Figure A.3 illustrates the case in which $s(i)$ is singular valued for any incentive function offered to the agent. Notice, the optimal contract to be offered by the owner is not unique in this setting since two $RI$ curves cross. This crossing indicates that the owner would receive the same utility irrespective of which incentive was offered to the agent. The reason for the multiplicity of solutions is the non-convexity of $s(i)$ in the level of incentives provided by the owner.

Figure A.4 illustrates the case in which $s(i)$ is singular valued for any incentive function offered to the agent, $s(i)$ is convex in the incentive offered, and $RI$ is not concave in incentives and agent actions. As can be seen, the lack of concavity of $RI$ allows for the existence of multiple solutions of the agency problem.

Figures A.3 and A.4 illustrate that uniqueness of the optimal solution to an agency problem hinges on the shape of the agent's reaction curve $s(i)$ and the owner's utility function. The requirement that $s(i)$ be convex in the incentive provided by the owner may seem unrealistic. Basically, what this means is that increases in the wages offered
to the agent produce increasing efforts but at a decreasing rate. This type of a response by the agent may be valid when the agent’s efforts and/or private information is observed, but may not be realistic when the agent possesses private information. The requirement that $RI$ be concave in $i$ and $a$ does not seem as disagreeable since it indicates that increases in income eventually result in little increase in agent effort. Nevertheless, these two conditions, concavity of $RI$ in $i$ and $a$ and convexity of $s(i)$ in $i$ are sufficient, in the presence of either (FOC) or (CDFC), to provide for the existence of a unique optimal solution.

### A.4 The Shape of the Optimal Compensation Function

Discussion within this section focuses on conditions which are sufficient in order for the owner to provide an incentive scheme which is increasing in firm outcome.

From Holmstrom [1979] it is known that the optimal second-best contract in the presence of hidden action has the following form:

$$s(x) = \lambda + \mu \frac{fa(x, a)}{f(x, a)}$$

where $s(x)$ is the incentive provided by the owner for providing outcome $x$; $\lambda$ and $\mu$ are Lagrangian multipliers with $\lambda > 0$ and $\mu \geq 0$, and for some $x \mu > 0$; and $\frac{fa(x, a)}{f(x, a)}$ is a likelihood ratio.

The likelihood ratio measures the likelihood that a particular firm outcome would be associated with a particular agent effort. Oftentimes, it will be assumed that the likelihood ratio will display the monotone likelihood ratio condition. This condition basically assumes that higher levels of agent effort will produce higher levels of firm outcome. The likelihood ratio is useful in contract design when hidden action is present.
because it allows the owner to design a contract which causes the agent’s incentive compatibility constraint to bind.

However, the usefulness of the likelihood ratio in generating a particular agent effort hinges on the agent being indifferent between an optimal effort level and another less taxing effort level. Thus, as Grossman and Hart [1983] have shown, the likelihood ratio may be of no value in contract design when the agent is indifferent between more than two effort levels. In this case, the weighted average of these actions and their underlying probability distribution may cause the likelihood ratio between the weighted average of the non-preferred actions and the preferred owner action to not be useful in contractually inducing the preferred action.

This again points to the need for either the (FOC) or (CDFC) to insure the agent’s optimal supply of effort is unique for a given compensation function. Absent either of these conditions, the owner may not be able to use the likelihood ratio to induce a particular effort. Additionally, the optimal contract may not be monotone increasing even if the likelihood ratio exhibits the monotone likelihood ratio condition. Thus, both (CDFC) and (FOC) and the monotone likelihood ratio condition are sufficient for a monotone compensation function. However, absent either (CDFC) or (FOC), the monotonicity of the likelihood ratio is not sufficient for the optimal incentive contract to be monotone in firm outcome.

A.5 Determinants of First- and Second-Best

The first-best agency solution exists when no information asymmetry exists. A second-best agency solution arises when the information asymmetry between the principal and agent limits the set of contracts available to the owner to motivate a particular agent effort. For instance, in a model of hidden action, the second-best
contract imposes risk upon the agent in order to provide the agent an incentive to provide a particular effort. If the owner could observe the agent's efforts, the optimal contract would provide the agent a constant return when the optimal effort was provided, irrespective of the firm outcome.

This section of the Appendix discusses which factors affect whether or not information asymmetry limits the contract design of the owner. All of the factors discussed herein have been documented elsewhere in the literature. Figure A.8 is meant to summarize these factors and provide references to previous research which has considered these factors in detail.

The first factor which can limit the effect of information asymmetry on owner contract design is the assumed outcome distribution support present within an agency model. Two types of support have received recognition within the literature. These are stationary support and shifting support. When the outcome distribution possesses stationary support, the set of possible outcomes does not vary with the effort taken by the agent. When the outcome distribution possesses shifting support, the set of possible outcomes varies with the effort taken by the agent.

Given the owner's underlying knowledge of the probability distribution for each agent effort, an outcome distribution which possesses shifting support will provide the owner a signal of agent effort in certain periods. The ability to perfectly infer the agent's effort without viewing the agent's efforts allows the owner to design a contract which reduces the information advantage available to the agent. It is for this reason that agency models assume that the outcome has stationary support.

A second factor which can limit the information advantage of the agent is the risk characteristics of the agents. Harris and Raviv [1979] show that if an agent is risk neutral or the firm's productive state is viewable by the owner, then no agency problem
exists. The rationale for the first finding is that the agent's risk neutrality makes him indifferent between working for the firm or paying the owner first-best residual outcome and renting the firm from the owner. This indifference does not exist when the agent faces a bankruptcy constraint and the firm may lose money in certain periods. The rationale for the second finding is that when the owner can view the firm outcome and productive state, he can infer the effort level taken by the agent. This finding indicates that alternative information may be useful in limiting the information advantage of the agent.

A third factor which may limit the information advantage possessed by the agent is the informativeness of the outcome signal about the agent's effort. Grossman and Hart [1983] show that as the informativeness of the outcome signal about the agent's effort improves, the information advantage to the agent diminishes. In the extreme, outcome would provide perfect information about the agent's effort. Obviously, for this case no agency problem would exist and the owner could achieve first-best within a model of hidden action.

Finally, as Chapter II has illustrated, the type of information asymmetry present within the model influences the degree of restriction placed upon the principal's contract design. Thus, a model of hidden action and pre-contractual information would be weakly inferior to an owner to a model of hidden action, *ceteris paribus*.

### A.6 Conclusion

The assumptions made within the agency model influence not only the existence, feasibility, and uniqueness of an optimal contract, but also influence the shape of the optimal contract and the seriousness of the agent's information advantage. With this in mind, the researcher should consider the effect of a particular assumption prior to
including it or failing to include it within his model. Only by paying attention to these details will the model allow for meaningful analysis necessary to provide intuition for the reader.
Figure A.1 (a) Non-existence of Lower Bound on Effort

Figure A.1 (b) Lack of Closure on the Agent's Optimal Response to the Owner's Compensation Level

Figure A.1 (c) Compactness
Figure A.2 Multi-valued $s(i)$
Figure A.3 Non-convex $s(i)$
Figure A.4 Non-concave $R_I$
<table>
<thead>
<tr>
<th>Assumptions Made</th>
<th>Technical Assumption</th>
<th>Economic Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The agent's utility level is defined over the incentive function and agent efforts.</td>
<td>$u_1: l \times A \rightarrow R$ $u_1 = \text{Agent's utility function}$ $l \in I \equiv \text{Incentive provided by the owner.}$ $a \in A \equiv \text{Effort level provided by the agent.}$</td>
<td>If the agent's effort does not affect his return, no agency problem.</td>
</tr>
<tr>
<td>2. The principal's utility level or residual income is affected by the agent's efforts and the agent's incentives.</td>
<td>$u_0: l \times A \rightarrow R$ $u_0 = \text{Owner's utility.}$</td>
<td>If the owner's incentive to the agent does not affect the owner's return, then the owner wouldn't care about salary paid to agent.</td>
</tr>
<tr>
<td>3. Agency is formed.</td>
<td>The set of actions generated by the owner's incentive is not empty.</td>
<td>Absent agency formation, no agency problem exists.</td>
</tr>
<tr>
<td>4. The set of agent responses to all incentives provided by owner is closed and bounded.</td>
<td>$A$, or the set of agent actions is compact.</td>
<td>Agent can provide no more than 168 hours of work per week and no less than 0.</td>
</tr>
<tr>
<td>5. (a) Owner's utility function is continuous.</td>
<td>The owner possesses a continuous pre-reordering over $u_0(\cdot, \cdot)$ with more $a$ preferred to less and less $l$ preferred to more $l$.</td>
<td>Obvious.</td>
</tr>
<tr>
<td>5. (b) The agent's function is continuous.</td>
<td>See above for owner; the agent prefers more $l$ to less $l$ and more $a$ to less $a$.</td>
<td></td>
</tr>
</tbody>
</table>

Figure A.5 Sufficient Conditions to Assure Existence of a Solution to an Agency Problem
<table>
<thead>
<tr>
<th>Assumptions Made</th>
<th>Technical Assumption</th>
<th>Economic Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The agent's chooses a unique action for each incentive.</td>
<td>((\text{CDFC}) \equiv \text{Concavity of the distribution function condition.})</td>
<td>The owner can illicit a unique agent effort with a particular incentive system.</td>
</tr>
<tr>
<td></td>
<td>((\text{FOC}) \equiv \text{First order condition. See Rogerson (1985).})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(s_j(a</td>
<td>\text{compensation function})) is convex.</td>
</tr>
<tr>
<td>2. The set of agency responses to all incentives provided by the owner is convex.</td>
<td>(c(a)) is convex.</td>
<td></td>
</tr>
<tr>
<td>3. The owner's utility function is concave in (a) and (i).</td>
<td>(u_1(i, a)) is concave in (i) and (a).</td>
<td>Law of diminishing returns. For further increases in compensation, the increase in agent effort decreases.</td>
</tr>
</tbody>
</table>

**Figure A.6** Sufficient Conditions to Assure Existence of a Unique Solution to an Agency Problem
<table>
<thead>
<tr>
<th>Contract Type</th>
<th>Sufficient Conditions</th>
<th>Intuition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing in outcome</td>
<td>1. (CDFC) or (FOC).</td>
<td>(CDFC) or (FOC) insures unique agent response to incentive.</td>
</tr>
<tr>
<td></td>
<td>2. (MLRC).</td>
<td>(MLRC) insures that any unique agent response can be induced using the probability distribution of the optimal response and another agent response.</td>
</tr>
</tbody>
</table>

**Figure A.7 Shape of the Agent’s Compensation Function**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. The risk preference of the agent.</td>
<td>Harris and Raviv [1979]</td>
</tr>
<tr>
<td>4. Availability of a costless perfect monitor.</td>
<td>Harris and Raviv [1979]</td>
</tr>
<tr>
<td>6. Information possessed by each agent.</td>
<td>See Chapter II.</td>
</tr>
</tbody>
</table>

**Figure A.8 Factors Which Influence the Severity of the Agency Problem**
REFERENCES


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