On the Optimal Relation between the Properties of Managerial
and Financial Reporting Systems*

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August 2007

Abstract

We develop a theoretical model of the firm that links properties (stewardship vs. valuation
focus) of financial reporting regimes with the informational properties of optimal managerial
accounting systems. We show that, contrary to the standard textbook proposition, properties
of management and financial accounting systems are not independent. Significantly, we pro-
vide an explicit connection between exogenous and observable properties of a firm’s financial
reporting system and the quality of the managerial accounting system on which manager(s)
base real economic decisions. As the quality of those economic decisions can also be inferred
from publicly available data, our theory generates new opportunities for empirical manager-
ial accounting research on large non-proprietary samples. Further, by being able to identify
enhanced performance due to improved managerial accounting information, our theory pro-
vides opportunities to gain a better understanding of the link between particular managerial
accounting practices and the quality of the information produced.

*Comments are certainly welcomed and can be directed to either author. We gratefully acknowledge comments and/or
suggestions by Michael Bromwich, Jon Glover, Evelyn Korn, Christian Lenz, Mark Penno, Mary Stanford, Jerry Zimmerman
and participants at the Yale SOM Accounting Research Conference, Accounting Research Day Antwerp, Lone Star
Conference SMU, Freiburg Accounting Research Conference, 2007 American Accounting Association Annual Meeting and
workshops at Instituto de Empresa Madrid, Rotman School of Management Toronto, University of Houston and WHU Otto
Beisheim School of Management Vallendar.
1 Introduction

We explore the optimal (equilibrium) relation between properties such as noise, bias, (value) relevance, and reliability of regulated financial reporting systems and the quality of unregulated management accounting information systems in an economic model where information is (potentially) useful for both decision-making and control. Our model allows us to identify an explicit theoretical link between the properties of a financial reporting regime, the optimal properties of managerial accounting systems and, in turn, the quality of the economic decision-making that takes place in firms. We show that the ability of a financial accounting system to provide stewardship information versus information useful for valuation purposes is a key determinant of the informational properties of optimal management accounting systems designed to provide managers with private decision facilitating information. Accordingly, our analysis provides insights into the real effects of financial reporting requirements via their effect on the quality of management accounting systems.

A key catalyst for this study is (admittedly our perception of) a current (admittedly in our opinion) unfortunate trend in accounting research. It appears that while in practice the relation between financial reporting requirements and managerial decision making is, if anything, getting stronger and more explicit (e.g. Hopper et al 1992; Drury and Tayles 1997; Joseph et al 1996), the divide between financial and managerial accounting research seems to be widening ever more rapidly. One indication of this latter trend is that the content of generally recognized mainstream accounting research journals has become predominantly oriented towards financial reporting issues while managerial accounting issues appear to have migrated to alternative outlets (Bonner et al, 2006).¹

The trend is unfortunate for at least three reasons (in no particular order). First, this separation could make the standard (unproven) textbook proposition that “managerial and financial accounting are fundamentally different entities as they cater to fundamentally different audiences” a self-fulfilling prophecy. Second, not only has managerial accounting research become increasingly insensitive to financial reporting considerations, it has also become largely irrelevant to those concerned with financial

¹We rush to admit to the obvious fact that we are not in a position to comment on every accounting study ever published be it in mainstream or not-so-mainstream journals. Also, we offer our apologies to anyone who may feel hurt by our sincere desire not to acquire such rare, if not unique, expertise before proceeding.
reporting; regulators and researchers alike. Third, it appears that fewer and fewer with a thorough understanding of economics and/or econometrics choose to get involved in managerial accounting research, but focus on financial accounting instead, thus further reinforcing the trend and limiting our understanding of a significant sub-field of accounting practice with likely real economic consequences.

A plausible cause may be the nature of past economic theory development in managerial accounting. It seems that there is a void in the theoretical accounting literature on (potential) links between managerial and financial accounting systems. Further, while some of the theories that have been applied in managerial accounting actually are very refined from a modeling perspective, many of their predictions stem from the presence or absence of particular off-equilibrium (and thus unobservable) events and opportunities or are mainly determined by quite abstract constructs such as an individual’s aversion towards "risk" or "work". Alternatively, many such pieces have aimed specifically at showing that common managerial accounting practices, such as participative budgeting, cost allocations, or particular approaches to variance investigation, can be justified in an economic model.

To have any hope of reversing the current trend in managerial accounting research, we believe that we need a coherent theoretical framework that is capable of identifying determinants of the properties of a firm’s management accounting system (hereafter MAS). We offer a theory linking characteristics of financial reports with the properties of managerial accounting information systems and real managerial decisions which, in turn, will be reflected in economic performance as a first, but hopefully fruitful, step in that direction. By thus showing how properties of optimal MASs depend on properties of financial accounting systems (hereafter FAS), we aim at killing three squirrels with one nut: increase relevance for an economics based perspective in managerial accounting research, suggest new avenues for empirical managerial accounting research, and attract attention from financial accounting researchers and regulators to managerial accounting.

We center our theory development on a relatively simple one-period principal-agent model we augment with an investment decision to be made by the (newly hired) expert agent based on information he obtains privately from a MAS. After this initial decision has been made, the agent then chooses how much effort to supply. Subsequently, a measure of firm performance for the period, the financial report, is produced
and made public. We consider the firm to be longer lived than the manager so that he can be evaluated based on the financial report (and/or any other contemporaneous performance measures), but not on the vector of all future dividends or other equivalent measures of the true economic value of the firm. We then allow the properties of the firm’s financial accounting system to vary both in terms of its ability to reflect managerial actions and firm value and study the implications for the precision of the optimal MAS and (thus) the equilibrium quality of the decisions made by the agent.

While managerial accounting systems potentially provide information useful for both decision making and control, we focus our theoretical developments on its decision facilitating role. We do this for a number of somewhat unrelated reasons. First, while the control function may actually be quite significant, it is not as clear (to us at least) how differences in the control qualities of a MAS would be reflected in firms’ financial statements or market values. This is exactly because the off-equilibrium nature of control eluded to above. Differences in control systems are about the ability to detect off-equilibrium behavior as opposed to particular empirically observable in-equilibrium actions. In contrast, the quality of information for decision making is related directly to the quality of decisions made in equilibrium and thus has observable real economic effects!

Second, we want to make the strongest possible case for the existence of an optimal link between the properties of a firm’s MAS and its FAS. We therefore bias our model against finding such an optimal relation by focusing on the role of a MAS that is the most different from those of a FAS. While both may serve control and valuation roles, the managerial decision facilitating role is the one use of a MAS that does not appear to be a central concern in design of FAS. This also provides the strongest case for the standard textbook proposition that a MAS should be designed independently and without consideration of financial reporting needs. As we proceed to show, however, even in the case where a MAS is designed exclusively for the purpose of managerial decision support while control is maintained via the FAS, the properties of an optimal MAS depend directly on the properties of the FAS in a predictable way.

To synchronize our theory development with historical trends in financial reporting regulation and

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2 Clearly FAS serves a decision facilitating role for external stakeholders. Our focus, however, is on the information that facilitates real economic decisions made by insiders.

3 Focusing on the decision facilitating role of a MAS is also consistent with earlier theory papers on the value of MAS such as Christensen (1982) and Penno (1984) and thus enhances the comparability of our results.
practices, we first consider the extreme case where the financial reporting regime has an exclusive stewardship focus (SF). We proceed to show that the optimal precision and bias to build in to a company’s MAS are directly linked to the properties of the FAS. More importantly, so is the quality of the investment and operating decisions made by the manager. Then, we allow for an increased valuation focus of our financial reporting system (VF). We show that some degree of orientation of the financial reporting regime towards valuation may actually be desirable but that a full migration from a SF to an exclusive VF is the worst possible outcome as only low effort can be contracted for. More importantly, in doing so we document the implications for the optimal MAS, for the quality of the investment decisions, and for the relation between prices and earnings of a move towards a VF.

Because our theory is focused on in-equilibrium decisions, it also yields specific predictions about the nature of firms’ MASs that can be tested on publicly available performance related data such as market prices. For the same reason, our model also offers explanations for existing puzzles in various lines of the empirical accounting literature. For example, it seems reasonable to suggest that a move towards VF also implies a reduction in the degree of conservatism. If so, our model can explain why Holthausen and Watts (2001) find accounting conservatism as measured in Basu (1997) was absent prior to 1970, despite, as they argue, conservatism actually was even more prevalent prior to this date. However a substantial increase in this conservatism metric appears to have occurred, despite that FASB, since its creation, has stressed the VF of financial reports. Interestingly, our model shows that the ability to detect such patterns can increase as the financial reporting regime begins to move towards a VF; thus reconciling these seemingly inconsistent findings.4

The remainder of the paper is organized as follows. In section 2 we introduce our basic model structure. Section 3 contains an analysis of the optimal relation between properties of MAS and FAS with a pure SF. In section 4 we explore the implications for an optimal MAS of moving the FAS away from a SF and closer to a VF. Section 5 illustrates how our theory can explain various existing empirical puzzles in financial accounting and section 6 provides a discussion of further empirical implications of our theory. Section 7 concludes.

4The last two sections of our paper are dedicated to this and various other empirical implications.
2 Basic Model

To make our points as precisely as possible we employ simple binary representations of the various components of our firm. In the spirit of backwards induction, then, the financial report that is produced at the end of the model’s horizon we denote by \( y \in \{ y^H, y^L \} \), where superscript \( H \) (\( L \)) indicates that the (binary) realized earnings are high (low). As earnings are ex-ante uncertain, prior to their realization everyone here shares the same expectation as determined by the probability \( Pr(y = y^H | e, d, \sigma) \), where \( e \) represents the agent’s choice of effort, \( d \) his initial investment decision, and \( \sigma \) the "state of nature" or, alternatively, the actual operating environment faced by the firm.\(^5\) We will return to the specifics of \( Pr(y = y^H | e, d, \sigma) \) below as we introduce some structure on \( e, \sigma \) and \( d \) in particular.

Effort here enters almost in the standard way by having the potential to favorably enhance the economic value of the firm as well as the probability distribution of contemporaneous accounting earnings, \( y \). With minimal (if any) loss of generality the effort choice is also binary so that \( e \in \{ e^h, e^l \} \), where \( e^l \) is a base level of effort the agent can be assured to supply under any circumstances and \( e^h \) is a higher unobservable level of effort that carries the incremental cost of \( v > 0 \) for the agent. The key deviation from the standard set-up here is that, while the distributions of earnings and future net cash-flows implemented by \( e^h \) may strictly dominate the earnings distribution implemented by \( e^l \), whether they actually do depends on the state of nature and the "quality" of the agent’s operating decision.

The specific structure we have in mind here is one where the economic conditions of the environment are either favorable for the implementation of project \( A \) or alternatively project \( B \) so that \( \sigma \in \{ \sigma^A, \sigma^B \} \). Information about the actual economic conditions will potentially be available to the agent via a management accounting system to be introduced below. We assume the two projects are equally costly and for simplicity we normalize the cost to zero. Also for specificity we let \( A \) be the more likely to be favored project so that \( \sigma = \sigma^A \) with probability \( \phi \in (.5, 1) \).\(^6\)

To ensure that the management accounting system can play a significant role, we focus on a setting

\(^5\) Of course, unlike the principal, the agent knows the decision and his effort. However, the principal can perfectly infer the relevant features of choices made from the equilibrium.

\(^6\) Eliminating the (measure zero) possibility that \( A \) and \( B \) are equally likely to be favored purely serves to simplify and streamline the analysis and is without any loss of generality as all results can be re-established in this case.
where making the right investment decision is of central importance. Making the wrong decision \( d \in \{ d^A, d^B \} \) that does not match the economic conditions of the environment (for example choosing \( d^A \) when the unobservable true state is \( \sigma^B \)) has (at least) two real economic consequences here. First, managerial input (effort) is not going to be valuable as when the right decision is made. Second, the unobservable potential (maximum) economic value of the firm, \( \Pi \), suffers.

To capture this basic relation in an as simple and notation-economizing way as possible, we assume that if the agent makes the wrong decision, the (again non-observable) economic value of the firm, \( \Pi \), is simply \( \Pi \) regardless of the level of effort put in. Formally, \( \Pi(\sigma^i, e, d^j) = \Pi \) if \( i \neq j \), where \( i, j \in \{ A, B \} \). In contrast, we assume that if the right production decision is made that matches the economic conditions of the environment, and the high level of effort is chosen, the economic value of the firm is \( \Pi > \Pi \). In any other case, including the case where no agent is hired, \( \Pi = \Pi \) which we, for simplicity and without loss of generality, normalize to zero.\(^7\) The design of financial reporting systems involves (at least) two, usually conflicting, roles of providing information useful for promoting stewardship and information for facilitating valuation (SFAC no. 1). In our model, both the agent’s effort \( e \) and the quality of his decision making \( d \) thus act as complements in terms on their impact on the economic value of the firm, \( \Pi \).

As we view traditional financial statements as being incomplete and noisy (in addition to potentially biased) representations of the true economic conditions of the firm, earnings, \( y \), should be stochastically related to the fundamentals (here \( \Pi \)). Clearly, the financial reporting implications of both the quality of the agent’s decision and the level of his effort depend on the specific orientation of the particular FAS in place. We start by characterizing how the implications of effort and decision making on the fundamentals would thus be reflected in the alternative cases of extreme SF and VF in terms of our model components. We then use these extreme cases to generate a continuum of financial accounting regimes containing elements of both to study the implications of changing from a SF towards a VF in the financial reporting system.

Consider first an accounting system that has an exclusive SF. Two fundamental features need to be

\(^7\)Certainly there are other possible interactions between investment decision and managerial effort that might warrant consideration. We leave such potential extensions as a suggestion for future research.
captured by the representation of the FAS here: 1) Only information about effort is provided by realized earnings and 2) effort can only be allowed to matter for accounting earnings when it does for economic earnings. The first part is obvious just from the notion of stewardship. The second part is perhaps a bit more subtle but follows from our view that a FAS is not a system designed to monitor personal effort per se. Rather, it is a system set up to extract information about the underlying economic activities of the firm. Effort is costly to the agent rather than to the firm. Thus - if personal effort doesn’t have any impact on the underlying economics (here \( H \)), then no information about effort should be discernible from accounting income either. With our (complements-based) production function, this implies that information about effort only can be extracted from \( y \) when \( d^i = \sigma^i \). This implies that for an accounting system with a pure SF,

\[
p^H_m = Pr(y = y^H|e^i, d^i, \sigma^i) < p^H_m = Pr(y = y^H|e^h, d^i, \sigma^i) = Pr(y = y^H|e^h, d^i, \sigma^i) = Pr(y = y^H|e^i, d^i, \sigma^i),
\]

where \( i \neq j, i, j \in \{A, B\} \), and sub-script \( m \) indicates a match between the true state and the actual decision made.

The first inequality and the last equality follow from the presumption here that earnings are informative about effort only when effort has an actual impact on the firm’s operations. The first equality follows from the quality of the investment not being reflected in contemporaneous earnings under the equilibrium level of effort. There is a slight caveat here regarding 1). One could argue that the system when set up this way actually is not a pure SFed system as in the case of \( e^h \), the quality of the decision does matter now. Unfortunately - there is no way of avoiding that here. The good news is that with the production function we employ, only \( e^h \) is a meaningful equilibrium so once the stewardship problem is solved, no information about the quality of the decision that can be discerned from the realization of \( y \) here.\(^8\)

In contrast to a FAS with a SF, a VF accounting system is aimed at identifying some potential

\(^8\)In our model the equilibrium that the principal will be implementing is only to hire the agent if he can make him supply \( e^h \) cost-effectively. This follows from the assumption here that the economic value of the firm is the same when the agent supplies \( e^i \) as when no agent is hired.
(hypothetical) value of specific projects in place. Accordingly, VF accounting at its core is about reporting (value) relevant data, based on estimates of potential future cash-flows or even the current disposal value of actual projects. As such, a VF involves making significant assumptions not just about future market conditions but (from our perspective) more significantly so about the management of such assets in place. In other words, VF accounting must reflect expected as opposed to actual managerial effort, and should thus exhibit less sensitivity than an accounting system based on a SF to how well the project actually is managed.

Because VF accounting requires an assumption about the agent’s (unobservable) effort choice, an accounting system with a pure VF must reflect equilibrium behavior. Specifically, earnings must be calculated based on estimated future cash-flows assuming that the agent supplies the equilibrium level of effort. Accordingly, should the agent choose the off-equilibrium level of effort instead, it would not be reflected in pure VF earnings. Under pure VF accounting it is only the implications of the investment for the economic output when managed as assumed that determines accounting earnings. In contrast to a SFed FAS, a VFed should carry information about the decision \( d \) whether or not the decision have real economic consequences. That is, as \( d \) here represents real economic activities undertaken by the firm, information about these activities will impact short run financial reports whether they are positive NPV activities or not.

This implies that a VFed FAS must satisfy the following two criteria: 1) the information produced is not useful (valuable) for resolving any stewardship problems and 2) it must have the potential to provide information about the underlying economic value of the firm. The following information structure

\[
p_m^h = Pr(y = y^H | e^h, d^i, \sigma^i) = p_m^i = Pr(y = y^H | e^i, d^i, \sigma^i) > Pr(y = y^H | e^h, d^j, \sigma^j) = Pr(y = y^H | e^i, d^j, \sigma^j),
\]

where \( i \neq j \), and \( i, j \in \{A, B\} \) satisfies exactly both of these two criteria in our setting. The first and last equalities follow from the presumption here that earnings are uninformative about effort, independent of the quality of the investment decision. The inequality follows from the quality of the investment being
reflected in contemporaneous earnings under a VF regime. Notice that while the VF regime does allow the user to make inference about the decision made by the agent, in its pure form it has no stewardship value whatsoever. This is because an accounting system with these properties cannot be used to induce the agent to select $e^h$. On top, if $e^l$ is selected here there is no control problem with respect to the agent’s decision as $d$ then a matter of complete indifference to the principal.

To facilitate the study of implications of moving between a pure SF and a pure VF financial reporting regime, let $C \in [0,1]$, and define $Pr(y = y^H|e^h, d^i, \sigma^i, C) \equiv p^h_m$, $Pr(y = y^H|e^l, d^i, \sigma^i, C) \equiv p^l_m + (1 - C) (p^h_m - p^l_m)$, $Pr(y = y^H|e, d^i, \sigma^i, C) \equiv p_b - (1 - C) q_b$, where $0 < q_b < p_b$, and $p_b = p^h_m$. With this we have,

$$p^h_m \equiv Pr(y = y^H|e^h, d^i, \sigma^i, 1) = Pr(y = y^H|e, d^i, \sigma^i, 1) > Pr(y = y^H|e^l, d^i, \sigma^i, 1) \equiv p^l_m$$

$$p^h_m \equiv Pr(y = y^H|e, d^i, \sigma^i, 0) > Pr(y = y^H|e^l, d^i, \sigma^i, 0) = p^h_m - q_b > 0,$$

so that the properties of a pure SF (VF) financial reporting regime as defined above are recovered when $C = 1$ ($= 0$). Accordingly, for $C \in (0,1)$, a greater $C$ then implies that the reporting regime is relatively more oriented towards a SF than to a VF.

In addition to the FAS, a managerial accounting information system $\Xi$ can costlessly be made available to the agent to inform his decision-making by providing information about the state $\sigma \in \{\sigma^A, \sigma^B\}$. Our aim is to capture, in the simplest possible way, imprecision and bias in this MAS. Accordingly, we assume that the signal $x$ produced by the MAS is also binary, $x \in \{x^A, x^B\}$. We capture the properties of the MAS by the probability $\lambda^A$ that $\Xi$ reports $x^A$ when $\sigma = \sigma^A$, and the probability $\lambda^B$ that $\Xi$ reports $x^B$ when $\sigma = \sigma^B$. Formally, $\lambda^i = p(x^i|\sigma^i)$. Hence, the MAS provides perfect information only if $\lambda^A = \lambda^B = 1$. The system becomes less precise if $\lambda^A$ and/or $\lambda^B$ become smaller and provides information

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9Our characterisation of SF and VF is thus in line with earlier work in this area such as Bushman et al (2006).

10We take the properties of the FAS to be exogenously specified and do not consider the possibility of earnings management. Note, however, that the agent here always exerts some control over the financial report through his choice of effort and his real decisions.

11As a standard and rather trivial reason given for why in practice firms’ MAS often is not independent of their FAS is that it is too costly to maintain such independence, we focus on systems that can be implemented and improved costlessly, thus biasing against finding any dependence between MAS and FAS. As in our model the agent is assumed to be an expert, the costless assumption only applies to him as he is the only one who can interpret the signal.
biased in favor of $A$ ($B$) when $\lambda^B < (>) \lambda^A$.

To fix ideas, one could think of project $A$ as the production of a low volume, high specialty product; and project $B$ as the production of a high volume, low specialty product. A traditional volume based costing system (as opposed to an Activity Based Costing system), some would argue, would then be biased in favor of project $A$ (i.e. $\lambda^A > \lambda^B$) as it would underallocate costs to this project. Therefore the MAS would report on this low volume project as having a higher likelihood of profitability than really is the case. Under those assumptions an ABC system would be an example of a higher quality MAS.

Figure 1 summarizes the relations between $\sigma, x$ and $\lambda$.

- Insert Figure 1 here -

To complete and conclude our model specification, we assume that the principal here is risk-neutral and cares only about $ER$, his (expected) residual take after compensating the agent. The agent is risk averse and, in addition to his (incremental) dislike for (incremental) effort, $v$, he values his contractual payment, $s(\cdot)$, via the strictly increasing and concave function $U(s(\cdot))$. The agent’s inverse utility function we denote by $G(\cdot)$ so that $G(U(s(\cdot))) = s(\cdot)$. Finally, we assume the payoffs to be such that if $\sigma$ and $d$ could be observed by the principal the optimal solution entails making the appropriate decision given the state and providing the agent with a (second-best) contract that makes him choose $e^h$. The time-line in Figure 2 summarizes the notation and the sequence of events.

- Insert Figure 2 here -

3 Benchmark: Pure Stewardship Focused Financial Reporting Regime

In this section, we analyze the demand for and optimal properties of a MAS in an uncompromising extreme ($C = 1$) SF financial reporting regime. We start by establishing two benchmark results. First for the case where the agent has access to perfect state information before choosing $d$ and $e$, and then for the case where he has no information available at all.
Lemma 1 Suppose the agent privately observes $\sigma$ before choosing $d$ and $e$. Then, under the optimal contract he always chooses $e'$. 

Proof. To see this, recall that here $p_n^h \equiv Pr(y = y^H | e^h, d^i, \sigma^j, 1) = p_v \equiv Pr(y = y^H | e, d^i, \sigma^j, 1), i \neq j$ and $e \in \{e^h, e'\}$. Accordingly, the probability of achieving high accounting earnings $y^H$ is the same whether the agent makes the wrong production decision given the conditions of the economic environment while investing only low effort or makes the right production decision while investing high effort. However, the latter choice carries a personal cost of effort, $v$. The agent who privately observes $\sigma$ before choosing $d$ and $e$ will therefore always mismatch his production decision with the economic environment observed and exert low effort, as he can pretend to be of the high effort / right decision type. The incentive compatibility constraint that must be satisfied for the agent to choose high effort (combined with either production decision) is given as

$$p_v U(s(y^H)) + (1 - p_v) U(s(y^L)) - v \geq p_v U(s(y^H)) + (1 - p_v) U(s(y^L)).$$

As $v$ is positive by definition there does not exist a contract that can incentivize high effort. The principal will therefore only be able to contract for low effort (and does not hire the agent). 

Lemma 1 reveals an interesting feature of a pure SFed FAS in this setting where effort and decisions act as complements. The flip side of realized earnings carrying no information about $d$ when the agent supply $e^h$ is that there are no earnings implications of shirking if the wrong decision is made. More generally, providing the agent with private pre-decision information magnifies the control problem the principal is facing with respect to the agent’s effort. By Lemma 1 it is therefore pointless here for the principal to attempt to motivate the agent to choose $e^h$ if he has perfect private decision facilitating information as he can then always "disable" the stewardship properties of earnings by deliberately making the wrong decision.

Note that Lemma 1 thus also establishes that a MAS that provides perfect information about the state privately to the agent (i.e. one that has $\lambda^A = \lambda^B = 1$), would be undesirable to the principal. Thus,
even in a decision facilitating context were pre-decision information is inherently useful for making good investment decisions, providing such high quality information to the agent is not necessarily desirable.\footnote{For a given contract, however, the agent would always prefer a higher quality MAS. This is because his improved decision making ability lessens the risk he faces in his compensation as determined by the performance measure produced by the FAS.} Lemma 2 establishes the implications of instead providing the agent with no such information at all.

**Lemma 2** Suppose the agent receives no information prior to choosing $d$ and $e$. Then, under the optimal contract he chooses

\[
e = \begin{cases} 
  e^h & \text{if } \phi \Pi - p_b G(U(s(y^H))) - (1 - p_b) G(U(s(y^L))) + s > 0 \\
  e^l & \text{otherwise}
\end{cases}
\]

where,

\[
U(s) = U_s,
\]

\[
U(s(y^H)) = U + v + \frac{(1-p_b)v}{(1-\phi)(p_b-p_m)},
\]

and

\[
U(s(y^L)) = U + v - \frac{p_b v}{(1-\phi)(p_b-p_m)}.
\]

**Proof.** See Appendix. \[\Box\]

**Corollary 1** The agent is hired if and only if \(\phi \Pi - p_b G(U(s(y^H))) - (1 - p_b) G(U(s(y^L))) + s > 0\).

The Corollary follows directly from the Lemma and the fact that the principal here can recover the same level of economic profit if he does not hire the agent as when the agent was to supply $e^l$ for sure. The point here is that there are actually conditions that favor hiring the agent even if he must make the investment decision without any specific information other than his priors. We constrain our analysis to such conditions and thus by the inequality provided in the Lemma and its Corollary. It is also worth noting that when this condition is met, arguably the value of a MAS is at its lowest. If we can demonstrate the existence of an optimal relation between the properties of managerial and financial accounting information systems in this case, such a relation is at the very core of accounting system design.
Before we can start exploring the connection between good managerial accounting systems and properties of a financial reporting regime we first need to establish that providing some MAS to the agent actually can be valuable in this model. Unless the agent’s investment decision depends on the signal \( x \), a system that provides \( x \) to the agent cannot be of value. In order for the MAS to have such decision influencing ability, different signals must signal a higher likelihood of different states. The following Lemma provides the technical condition for this to be the case.

**Lemma 3** A necessary condition for a managerial accounting system to be of value is that either

\[
\frac{1 - \lambda^A}{\lambda^B} \leq \frac{1 - \phi}{\phi} \leq \frac{\lambda^A}{1 - \lambda^B}
\]

or

\[
\frac{1 - \lambda^A}{\lambda^B} \geq \frac{1 - \phi}{\phi} \geq \frac{\lambda^A}{1 - \lambda^B}.
\]

**Proof.** \( \Xi \) can only be of value if it is the case that different signals signal a higher likelihood of different states. Accordingly, \( \text{pr}(\sigma^j|x^i) \geq .5, j = A, B \) or \( \text{pr}(\sigma^j|x^i) \leq .5, j = A, B \). The necessary and sufficient condition for this to be the case is the one provided in the Lemma. ■

In what follows we focus on managerial accounting systems that have such decision influencing ability and refer to such systems as being "relevant". Technically, the agent’s investment decision could depend on the realization of the signal in two ways: he could either choose to match \( d^j \) to \( x^j \) (when presented with a MAS for which the first condition of Lemma 3 holds) or to mismatch \( d^j \) to \( x^i, i \neq j \), \( i, j = A, B \) (when presented with a MAS for which the second condition of Lemma 3 holds). The latter case is subsumed by the former, however, as one can always re-label \( x^A \) as \( x^B \) and vice versa such that the agent always ends up matching \( d^j \) to \( x^j \) when the system is useful to the agent. Accordingly we concentrate on systems for which the first condition in Lemma 3 is satisfied. The following Lemma then provides the details of the optimal contract when the agent is provided with a relevant MAS.

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Lemma 4. The optimal contract when the management accounting system provides signal $x^i$ privately to the agent, and the principal contracts with the agent to match $x^i$ in decision making $d^i$ and to provide $e^h$ is given by

$$U(s(y^H)) = U + v + (M + 1) \times \frac{(1 - p_b) v}{(p_b - p'_{m})},$$

$$U(s(y^L)) = U - v - (M + 1) \times \frac{p_b v}{(p_b - p'_{m})},$$

where $M = \max \left[ \frac{\phi \lambda^A}{(1 - \phi)(1 - \lambda^B)}, \frac{(1 - \phi) \lambda^B}{\phi(1 - \lambda^A)} \right]$.

Proof. The optimal contract when the MAS provides signal $x^i$ privately to the agent, and the principal contracts with the agent to match $x^i$ in decision making $d^i$ and to provide $e^h$ is the solution to the following program:

$$\min_{s(y)} p_b s(y^H) + (1 - p_b) s(y^L)$$

s.t.

$$p_b U(s(y^H)) + (1 - p_b) U(s(y^L)) - v \geq U \quad (IR)$$

$$p_b U(s(y^H)) + (1 - p_b) U(s(y^L)) - v \geq p_b U(s(y^H)) + (1 - p_b) U(s(y^L)) - v \quad (IC1)$$

$$(p_b - p'_{m}) \left[U(s(y^H)) - U(s(y^L))\right] \geq v + \frac{\phi \lambda^A v}{(1 - \phi)(1 - \lambda^B)} \quad (IC2)$$

$$(p_b - p'_{m}) \left[U(s(y^H)) - U(s(y^L))\right] \geq v + \frac{(1 - \phi) (1 - \lambda^B) v}{\phi(1 - \lambda^A)} \quad (IC3)$$

$$(p_b - p'_{m}) \left[U(s(y^H)) - U(s(y^L))\right] \geq v + \frac{(1 - \phi) \lambda^B v}{\phi(1 - \lambda^A)} \quad (IC4)$$

$$(p_b - p'_{m}) \left[U(s(y^H)) - U(s(y^L))\right] \geq v + \frac{\phi (1 - \lambda^A) v}{(1 - \phi) \lambda^B} \quad (IC5)$$

IC1 ensures that, when $e^h$ is exerted, the agent will match $x^i$ in decision making $d^i$. IC2 ensures that, when the agent observes $x^A$, his utility from implementing the appropriate decision $d^A$ and providing high effort exceeds that of (inappropriately) implementing $d^B$ and providing low effort. IC3 ensures that, when the agent observes $x^A$, his utility from implementing $d^A$ and providing high effort is at least as high as that of implementing $d^A$ but only providing low effort. IC4 and IC5 impose similar conditions on the contract as IC2 and IC3 for the case where the agent observes $x^B$.

Benevolence guarantees the satisfaction of IC1. Also, given the relevance condition provided by Lemma 3, it is straightforward to verify that IC3 is slack compared to IC2 and that IC5 is slack.
compared to IC4. Solving the program with IR and either IC2 or IC4 binding yields the contract detailed in the Lemma.

Note that $M = \frac{(1-\phi)\lambda^B}{\sigma(1-\lambda^A)}$ and thus IC4 binding requires that the MAS is biased with $\lambda^A > \lambda^B$ and this bias is sufficiently strong so that $\frac{\lambda^A(1-\lambda^A)}{\lambda^B(1-\lambda^B)} \leq \frac{(1-\phi)^2}{\sigma^2}$. If the MAS is not biased ($\lambda^A = \lambda^B$) or if it is biased with $\lambda^A < \lambda^B$, $M = \frac{\phi\lambda^A}{(1-\phi)(1-\lambda^A)}$. Also note that it is only possible to contract for $e$ when the MAS signals $x^i$ privately to the agent (as in the contract in Lemma 4) when $\lambda^i < 1$, $i = A, B$. Finally, note that Lemma 4 characterizes the optimal contract provided a relevant MAS is in place.

We now turn our attention to the relation between the properties of the optimally designed MAS ($\lambda^A$ and $\lambda^B$ as chosen optimally by the principal ex-ante) and the properties of the SF financial reporting regime. However, while Lemma 4 lays the foundation for much of our analysis it still does not establish whether it can ever be optimal to have any information made privately available to the agent in this setting. That this is always the case here, along with the central properties of an optimal MAS is established (in reverse order) by the next two results which also represent a key separation result of this paper.

**Lemma 5** If it is optimal to introduce a relevant MAS, then the optimal MAS satisfies $\frac{\lambda^A(1-\lambda^A)}{\lambda^B(1-\lambda^B)} = \frac{(1-\phi)^2}{\sigma^2}$.

**Proof.** From here onwards all proofs are relegated to the Appendix.

**Proposition 1** It is always optimal to introduce a relevant MAS here.

A key implication of Lemma 5 is that an optimal MAS, in addition to being noisy, is also biased in favor of the more likely economic conditions. For example, when in a particular market a high specialty, low volume product is expected to be most profitable, the optimal MAS could be a traditional full cost accounting system that arguably underallocates costs to such products and therefore shows these high specialty, low volume products to be more profitable than they are. Further, the properties of the optimal
MAS do not depend on the properties of the FAS in the following sense. The decision is made without any consideration of financial reporting issues and the realization of the financial accounting measure is independent of the quality of the decision made by the agent. Moreover, the fact that, as the proof of Lemma 5 in the Appendix shows, both IC2 and IC4 bind, adds to this general equilibrium independence of the MAS and the FAS in this model, since the "strength" of the incentives as perceived by the agent is also independent of his private information.

In other words, the model set-up here (with \( C = 1 \)) appears to support the view that financial and managerial accounting systems can be developed independently as they serve different needs and the use of one has no implications for the use of the other. However, even for this model with all this apparent separability, concluding that the properties of the optimal MAS can be chosen independently of the properties of the firm's FAS is incorrect. Proposition 2 provides formal insight into the fallacy of relying on this appearance to draw conclusions about the (lack of) dependence between MAS and FAS.

**Proposition 2** When the management accounting system is chosen optimally, \( \frac{d\lambda_i}{dp_m^h} > 0 \), \( \frac{d\lambda_i}{dp_m^l} < 0 \), \( i = A, B \), \( \frac{d(\lambda^A/\lambda^B)}{dp_m^h} < 0 \), and \( \frac{d(\lambda^A/\lambda^B)}{dp_m^l} > 0 \).

Proposition 2 provides a direct mapping from certain characteristics of the financial reporting regime onto optimal properties of an optimal MAS. What is of particular interest is the relation between the stewardship value of the FAS and the bias in the MAS. As shown in Lemma 5, the latter is always biased independent of the specific properties of the FAS. However, increasing \( p_m^h \) while keeping \( p_m^l \) constant or decreasing \( p_m^l \) while keeping \( p_m^h \) constant, will decrease the bias in the MAS \((\lambda^A/\lambda^B)\) which in turn alters the nature of the bad decisions made in equilibrium.\(^{13}\) Proposition 3 details the economic effects of this.

**Proposition 3** Define \( E^*\Pi \equiv \bar{\Pi}[\phi\lambda^A + (1 - \phi)\lambda^B] \) as the expected in-equilibrium economic profit of the firm before compensation to the agent. When the management accounting system is chosen optimally, \( \frac{dE^*\Pi}{dp_m^h} > 0 \), and \( \frac{dE^*\Pi}{dp_m^l} < 0 \).

\(^{13}\)For example, Wagner and Dittmar (2006) document how the increased stewardship value of FAS brought on by the Sarbanes-Oxley act resulted in companies developing better information systems to support their operations and avoid making bad decisions. Another example of changes in a company's MAS following a required change in the focus of its FAS can be found in Ball (2004).
While Proposition 2 establishes the "quality" of the MAS in terms of precision and bias, Proposition 3 establishes that, despite decisions being made independent of the financial report, improvements in the financial reporting regime do have real effects here beyond the resulting improvements in the optimal contract. This follows because as the purely SF financial reporting regime is improved, so is the optimal MAS. Accordingly, the quality of the decision making improves which eventually will generate higher economic profits for the firm even without considering the benefits brought by improved risk sharing. Thus, while our model is consistent with the prevailing view that management accounting systems and financial reporting systems are entirely separate systems used for different purposes it does not support the maintained hypothesis that the properties of MAS and FAS can freely be determined separately - to the contrary.

4 Implications of moving from SF towards VF

We now turn our attention to the analysis of the relation between the properties of managerial and financial reporting systems when the financial reporting regime deviates from the accounting regime with an exclusive SF analyzed in the previous section by containing elements of a VF. Technically, then, in what follows we investigate the effects on an optimal MAS of reducing the value of parameter $C$ from 1, which was the value assumed in section 3, towards 0. The latter here represents an extreme case of accounting with an exclusive VF. Lemma 6 provides the foundation.

Lemma 6 Suppose it is optimal to introduce a private MAS when $C \in (0,1)$. Then, the optimal contract that under the optimal MAS induces the agent to match $x^i$ in decision making $d^i$ and to provide $e^h$ is given by

\[
U(s(y^H)) = U + v + \frac{(1 - p_{hm}^h + \Delta)v}{D},
\]
\[
U(s(y^L)) = U + v - \frac{(p_{hm}^h - \Delta)v}{D},
\]
where \( \Delta \equiv (1 - C)q_B[(1 - \lambda^A)\phi + (1 - \lambda^B)(1 - \phi)] \) and for \( C > \frac{q_B}{p_m^h - p_m^l + q_B} \),

\[
D = \Pr(\sigma^i|x^j)C(p_m^h - p_m^l) + (\Pr(\sigma^j|x^i) - \Pr(\sigma^j|x^i))(1 - C)q_B, \quad i, j = A, B,
\]

and \( D = C(p_m^h - p_m^l) \), otherwise.

The issue now becomes what the implications are of introducing some degree of a VF into the financial reporting regime. The case of \( C = 1 \) we introduced in section 3 serves as a benchmark, but certainly should be thought of only as such. Clearly, most if not all financial reporting regimes contain some degree of a VF as here defined. Indeed, one could argue that the whole idea of accrual accounting is to combine historical transactions with valuations based on estimates. The interesting question then becomes one of how much of a SF vs. a VF is the best mix. In the context of our model, to gain insights into that question we need to understand the implications of varying \( C \). Proposition 4 is helpful in teasing out the various effects.

**Proposition 4** There exists a \( \hat{C} \in (\frac{2q_B}{p_m^h - p_m^l + 2q_B}, 1) \) such that the optimal MAS is perfect if and only if \( C < \hat{C} \).

Proposition 4 shows that if the financial reporting regime becomes sufficiently slanted towards a VF (low values of \( C \), below a cut-off strictly lower than 1), managerial decision making should improve as the optimal MAS becomes the perfect one (or at least the best MAS that can be implemented). This follows from the fact that the feature of a purely SFed FAS that private decision facilitating information magnifies the control problem becomes less pronounced as the FAS migrates towards a VF. For the same reason, the optimal MAS will be imperfect above that cut-off. Combined with Lemma 6 it is also clear, however, that decreasing \( C \) too much may not be such a good thing overall. Indeed in the extreme we have,
Lemma 7  Under the extreme VF financial accounting regime \((C = 0)\), only \(e^l\) can be implemented in equilibrium.

Clearly, what our results up to this point highlight is that our model captures a well known and documented trade-off between decision making and control. But more significantly and not previously recognized, that this trade-off must lead to an equilibrium relation between the properties of the financial reporting regime and the optimal MAS. However, to get to the point where we will be able to provide directly testable empirical predictions about the quality of the MAS and the economic performance of firms as a function of the properties of the financial reporting regime we need to be able to map out the relation between \(C\) and the economic consequences for the firm.

By Proposition 4 the optimal MAS can (and will) only be perfect if the financial reporting regime exhibits a certain degree of VF. Proposition 5 traces out how changes in the financial reporting regime affect the principal’s expected residual in such regimes for which a perfect MAS is optimal.

Proposition 5  Define the principal’s expected residual under the optimal contract as

\[
ER \equiv \Pi[\phi \lambda^A + (1 - \phi)\lambda^H] - G(U(s(y^L))) - [G(U(s(y^H))) - G(U(s(y^L)))] (p_m^h - \Delta).
\]

For \(C < \tilde{C}\), \(\frac{dER}{dC} > 0\) if \(C \leq \frac{q_b}{p_m^h - p_m^l + q_b}\) and \(\frac{dER}{dC} < 0\) if \(C \geq \frac{q_b}{p_m^h - p_m^l + q_b}\).

Following Proposition 5, for those financial reporting regimes for which a perfect MAS is optimal, there is an optimal \(\bar{C} = \frac{q_b}{p_m^h - p_m^l + q_b}\) at which the expected residual to the principal is maximized. From a regulatory viewpoint this identifies how financial reporting standards and systems will have real effects on decision making profits via their effect on the properties of optimal management accounting systems. Contrary to the conjectures made by Johnson and Kaplan (1987), we show that this link between FAS and MAS is not necessarily counter-productive. Indeed, in a financial reporting regime with sufficient orientation towards a VF such profits will be maximized via the endogenous choice of a perfect MAS.
Now, however, we turn to settings where $C > \hat{C}$ and therefore the optimal MAS will be imperfect. The specific properties of an optimal MAS when $C > \hat{C}$ are provided by Lemma 8.

**Lemma 8** If $C > \hat{C}$, the optimal MAS satisfies

$$\frac{\phi \lambda^A + (1-\phi)(1-\lambda^B)}{\phi \lambda^A (1-C) q_b + (1-\phi)(1-\lambda^B)[C(p^u_m - p^l_m) - (1-C) q_b]} = \frac{(1-\phi)\lambda^B + \phi (1-\lambda^A)}{(1-\phi)\lambda^B (1-C) q_b + \phi (1-\lambda^A)[C(p^u_m - p^l_m) - (1-C) q_b]} \Rightarrow \frac{\lambda^A (1-\lambda^A)}{\lambda^B (1-\lambda^B)} = \frac{(1-\phi)^2}{\phi^2}.$$

**Proof.** The proof follows directly from Proposition 4 and Lemma 6.

Lemma 8 reinforces that for $C$ sufficiently large, the optimal MAS is imperfect. Moreover, it shows that the optimal MAS satisfies the same condition (and thus contains the same bias) as that in Lemma 5 obtained in the case of extreme SF ($C = 1$). As documented by Proposition 6, however, how this condition is satisfied for $C \in (\hat{C}, 1)$ depends on the financial reporting properties of the individual firms.

**Proposition 6** Suppose $C > \hat{C}$. Then, for any $q_b > 0$, if $p^h_m - p^l_m$ is sufficiently small, $\Pi(C = \hat{C}) > \Pi(C = 1)$ and $E \Pi(C = \hat{C}) > E \Pi(C = 1)$. Moreover, for any $p^h_m - p^l_m > 0$, if $q_b$ is sufficiently small, $\frac{d\Pi}{dC} > 0$ and $\frac{dE \Pi}{dC} > 0$.

The message of Proposition 6 can be summarized as follows. If there is any underlying potential of the FAS to reveal bad decision making and its potential to reveal shirking by the agent is sufficiently small, moving towards VF accounting will allow the firm to benefit from this in terms of increased profitability and expected residual. On the other hand, if the FAS has some ability to reveal shirking and its ability to detect the quality of the decision is sufficiently small, the firm benefits more from a regime which has more of a SF. In sum, whether or not a firm benefits from VF or SF accounting depends on the relative potential of detecting shirking and bad decision making for that firm. If shirking is relatively difficult to detect, too strong a SF is not desirable. On the other hand, if it is hard to measure the quality of the investment decision, any increase in the SF yields profit as well as Pareto improvements.

Figure 3 summarizes the results of this section.
5 Puzzles on the relation between earnings announcements and market returns

We now proceed to investigate the relation between earnings announcements and market returns when the MAS is chosen optimally. Specifically, we map out the impact of earnings announcements on returns over the range of financial reporting regimes as modeled by $C$ and show how our findings can explain some of the existing puzzles in the empirical financial accounting literature. Define the returns $r^i$ at an announcement of earnings $y^i$ as $r^i = \frac{\Pr(H|y^i)-\Pr(H)}{\Pr(H)}$, where $i = H, L$. Then the following result obtains:

**Proposition 7** For $C \notin (\hat{C}, 1)$, $r^i = 0$. For $C \in (\hat{C}, 1)$, $\frac{dr^H}{dC} > (>)0$ and $\frac{dr^L}{dC} < (>)0$ if $C < (>) 1$

Proposition 7 implies that there will be no price reaction to a (high or low) earnings announcement when the financial reporting regime is sufficiently slanted towards a VF ($C \leq \hat{C}$) or when the financial reporting regime is one with a pure SF. Only if the financial reporting regime contains a sufficiently large SF accounting component, but does not have an exclusive SF ($C \in (\hat{C}, 1)$), will there be a price reaction to earnings announcements. More significantly, however, by doing so, Proposition 7 suggests that value relevance is not monotone in the degree of the VF contained in the financial reporting regime. While seemingly counter intuitive that a move to a VF may lead to lower value relevance of financial reports, the reason for this is that improvements in the decision facilitating information that follow in equilibrium make the quality of the firm’s investment decisions easier to predict by outsiders. This, in turn, reduces the role of the financial report in informing outsiders about the underlying economic value of the firm, eventually making the financial report irrelevant.

The returns reaction to earnings announcements in this region is the largest at $C = 1 - \frac{1-\phi\lambda^A-(1-\phi)\lambda^B}{1-\phi\lambda^A-(1-\phi)\lambda^B}$. 

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14 The returns reaction to earnings announcements in this region is the largest at $C = 1 - \frac{1-\phi\lambda^A-(1-\phi)\lambda^B}{1-\phi\lambda^A-(1-\phi)\lambda^B}$. 

22
Indeed, the empirical literature on the relation between accounting data and market prices over time has documented a puzzling decline in such value relevance of accounting data during a period where regulation seems to have become more oriented towards VF accounting (e.g. Collins et al 1997; Lev and Zarowin 1999; Francis and Shipper 1999; Ely and Waymire 1999, Dontoh et al 2004). We suggest the period during which this decline has occurred corresponds with the period in which also significant innovations in MAS have been undertaken. Our theory predicts that it is in the industries in which this decline in value relevance has been most substantial, that most MAS innovations will have occurred.

A second empirical puzzle our model can explain relates to the differential returns reaction to good versus bad news. Proposition 8 formalizes our theoretical prediction.

**Proposition 8** The returns reaction \( r^H > (<)|r^L| \) if \( p^h_m < (>) (1 - C) q_b \left( 1 - \phi \lambda^A + (1 - \phi) \lambda^B \right) + \frac{1}{2} \) and the differential returns reaction to high and low earnings announcements \( r^H - |r^L| \) is decreasing in \( p^h_m \).

**Proof.** The proof follows from the proof of Proposition 7.

One definition of conservatism would be that the FAS produces a favorable impression of firm performance with a lower probability than the probability that the firm actually is performing well. Here this is the case when \( p^h_m < \phi \lambda^A + (1 - \phi) \lambda^B \). As a lower \( p^h_m \) thus is consistent with a more conservative accounting regime, Proposition 8 is consistent with the interpretation of the particular asymmetry documented by Basu (1997) in the sense that when \( p^h_m \) is sufficiently small, it predicts the same "kinked" earnings/returns relation as the one he documented: an asymmetrical association of returns with earnings in that earnings are more positively associated with returns when they reflect good news than when they reflect bad news.

What is of particular interest here, however, is the RHS of the condition in Proposition 8. Note that while the LHS has a natural interpretation in terms of accounting conservatism, the RHS reflects the implications of a SF vs. a VF in the FAS; both through \( C \) and the \( (\phi \lambda^A + (1 - \phi) \lambda^B) \)-term. The RHS thus brings up an interesting implication for the relation between VF accounting and the Basu
conservatism measure. To be specific, differentiate the RHS of the condition in Proposition 8 w.r.t. $C$ to get

$$
\frac{dRHS}{dC} \bigg|_{C=1} = -q_b \left( 1 - (\phi \lambda_A + (1 - \phi) \lambda_B) \right) < 0,
$$

$$
\frac{dRHS}{dC} \bigg|_{C=\bar{C}} = -(1 - \bar{C}) q_b \left( \frac{d (\phi \lambda_A + (1 - \phi) \lambda_B)}{dC} \right) > 0.
$$

Accordingly, by the first of these inequalities, initially as a financial reporting regime starts to move away from being SF (arguably more conservative) and towards a VF, the Basu pattern will become stronger and more easy to detect. This can help explain the following puzzle in this line of inquiry: a failure to be able to document such kinked patterns prior to 1970, given that conservatism existed and arguably would have been more prevalent prior to this date (Holthausen and Watts 2001). Furthermore, since the creation of FASB a substantial increase in this particular conservatism metric has occurred (see e.g. Givoly and Hayn 2000, Ryan and Zarowin 2003, Watts 2003), despite FASB arguably seemed to have an increasing VF. However, once the financial reporting regime becomes sufficiently slanted towards VF, the second inequality implies this pattern could weaken and even likely reverse although at ever lower levels as the value relevance simultaneously declines following Proposition 7.

### 6 Further empirical implications

As pointed out by Zimmerman (2001), the decline in economics based managerial accounting research has taken place under the cover of limited data availability. Because, it is frequently argued, managerial accounting data are not as readily available as financial or market data, the standard large sample econometric techniques are of less use here and other approaches to documenting patterns are therefore needed. Such data constraints obviously do present challenges. However, as our model is focused on the implications of changes in FAS for real in-equilibrium economic decisions informed by an optimal MAS, it produces several empirical implications (time-series as well as cross-sectional) that are testable using publicly available measures of firm characteristics such as reflected in financial statements and market prices. Indeed, if discrete exogenous changes are made to the FAS (by imposing new and significantly
different reporting standards), the expected changes in the MAS and thus in the quality of the decision making lead to expected changes in future firm performance that should be impounded in stock prices at the time the changes to FAS occur.

We first outline some of the time-series predictions generated by exogenous changes in financial reporting requirements that our theory provides. Consider as an example SFAS 107 that came into effect in 1993 and imposes fair value requirements on financial instruments. Arguably imposing such requirements in terms of our model implies a move towards more VF. Proposition 6 predicts that, following this standard’s implementation, companies that rely heavily on the use of such financial instruments such as those in the banking or oil and gas sector (Rajgopal 1999) will have upgraded their MAS, and/or spent more on IT. Our model predicts that real economic effects of this change in the financial reporting regime should be accompanied with a favorable market reaction for those firms most heavily affected by this change.

Second, w.r.t. cross-sectional implications of exogenous changes in financial reporting requirements. Consider companies for which the impact of a fair value requirement such as SFAS 107 is relatively high. This might be the case for firms that, other things equal, have longer operating cycles causing more need to rely on estimates in current financial reporting, rely more on financial instruments that are subject to fair value reporting under SFAS 107, and deal with volatile operating conditions. Such companies also seem to be characterized by financial reports that would be slower at revealing the consequences of bad decision making. Examples of sectors that feature some or all of these aspects, and therefore may be substantially impacted by fair value requirements, could be banking, insurance, real estate, construction, agriculture, oil and gas, and mining. Proposition 6 predicts that such firms typically have better quality MAS in place. Thus, these firms should be able to achieve higher valuations as the result of superior quality of the decision making process. Counter-examples of sectors that are likely less impacted by fair value requirements are wholesale and retail. Here our model predicts that lower quality management accounting systems will be in place, and that lower valuations are achieved.\footnote{While our theory potentially also speaks to the voluntary financial reporting choices by firms, empirically it becomes harder to disentangle the economic conditions that motivate different choices from the economic effects of changing MAS.}
Because we have deliberately focused our attention on the aggregate property of a MAS, namely information quality, our theory also allows for gaining better understanding about what specific managerial accounting procedures lead to such superior information quality from proprietary data of management accounting practices. Managerial accounting textbooks typically take for granted which particular MAS components are better. However, there is little evidence available for evaluating such assertions. By making predictions as to which firms would have better MAS, our theory provides ample opportunity for identifying where such evidence can be looked for and how to generate samples of proprietary data. For example, if ABC systems that use a high level of disaggregation with many cost pools and define cost drivers at each of those cost pools to reflect cause and effect relationships, actually produce better quality information for decision making purposes, we should observe relatively more ABC systems in firms that are more exposed to VF reporting requirements. Accordingly, if one was to generate a proprietary sample to assess whether or not ABC actually does produce superior decision facilitating information, our theory suggest that in order to make such inferences it is necessary that the data contains variations along the financial reporting dimension.

Finally, our theory provides new opportunities for interpreting existing survey evidence. For example, a recent survey by Al-Omiri and Drury (forthcoming) suggest that the financial sector is more likely to adopt ABC, and that their costing systems exhibit more cost pools and more different types of cost drivers. Since our model predicts that superior MAS are used in the financial sector, this survey evidence provides support for the maintained hypothesis that ABC leads to better quality information. For surveys focused on a single sector such as manufacturing (for example, Libby and Waterhouse 1996 and Krumwiede 1998) our theory provides a way to assess the quality of specific MAS refinements to the extent their adoption follows specific changes in the financial reporting regime.

7 Conclusion

We study a model of the firm in which a manager has to make investment decisions in addition to supplying productive effort. Two information systems are present. Shareholders are provided information generated
by a financial reporting system to aid them in valuing the firm and evaluating managerial performance. The manager in addition may be allowed access to a managerial accounting system as a basis for informing his operating or investment decisions. Our focus is on the optimal informational properties of such a system as they relate to the informational properties of the financial reporting system in place as well as the co-determination of these two types of accounting systems.

We are motivated to pursue this study by a number of related reasons. First, we are unsatisfied with the standard explanations for why most firms have substantial overlaps between the financial and managerial reporting systems despite most managerial accounting textbooks suggesting otherwise. Second, we are concerned about the increasing split between managerial and financial accounting research. While financial accounting research is dominated by empirical work largely informed by economic theory, such work is becoming increasingly (relatively) rare in managerial accounting research. Accordingly, managerial accounting research has migrated to outlets other than the established top tier accounting research journals with quality and impact being the likely casualties.

Much of this divergence has been attributed to data limitations, the idea being that the very nature of (proprietary) managerial accounting information makes it inherently more difficult to get good reliable data sets. We take a somewhat different perspective. We suggest that performance measures such as market prices contain a wealth of information about managerial decision making which presumably would be informed by a managerial accounting system. Accordingly, if one had a theory linking measurable properties of a firm to the properties of the managerial accounting system they employ, there would be ample room for using standard empirical techniques to develop a large body of knowledge about managerial accounting systems. Our theory linking the properties of optimal managerial and financial accounting systems is an attempt to address these issues jointly.
8 References


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9 Figures

Figure 1: Probabilistic relation between state signals and managerial accounting system reports.

\[ \sigma \]

\[
\begin{align*}
\Phi & \quad \sigma^A \\
\sigma & \quad \sigma^B \\
1-\Phi & \quad 1-\lambda^A \\
\lambda^B & \quad x^A \\
\lambda^A & \quad x^B
\end{align*}
\]

\( \sigma \) denotes state signal, \( \sigma \in \{ \sigma^A, \sigma^B \} \)

\( \phi \) denotes probability of state \( \sigma^A \)

\( x \) denotes report of the management accounting information system, \( x \in \{ x^A, x^B \} \)

\( \lambda^A \) denotes probability that management accounting system reports \( x^A \) following \( \sigma^A \)

\( \lambda^B \) denotes probability that management accounting system reports \( x^B \) following \( \sigma^B \)
Figure 2: Time-line and notation.

\[
\begin{aligned}
&\text{A accepts or rejects contract } s(y) \\
&\text{economic condition } \sigma \in \{ \sigma^A, \sigma^B \} \\
&\text{MAS system reports } x \in \{ x^A, x^B \} \\
&\text{A chooses } d \in \{ d^A, d^B \} \\
&\text{y} \in \{ y^L, y^H \} \\
&\text{publicly observed } s(y) \text{ paid to A}
\end{aligned}
\]
### Figure 3: Summary of results.

<table>
<thead>
<tr>
<th>FAS property C</th>
<th>Valuation focus C=0</th>
<th>[ \bar{C} = \frac{q_b}{p_m^h - p_m^l + q_b} ]</th>
<th>[ \hat{C} = \frac{2q_b}{p_m^h - p_m^l + 2q_b} ]</th>
<th>Stewardship focus C=1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAS property ( \lambda^j )</td>
<td>MAS perfect: ( \lambda^j = 1, j = A, B )</td>
<td>MAS imperfect: ( \lambda^j &lt; 1, j = A, B )</td>
<td>MAS biased with ( \hat{\lambda}^j = \frac{1 - \lambda^j}{\Phi^2} )</td>
<td></td>
</tr>
</tbody>
</table>

#### Decision making

- at maximum: \( \hat{E}\Pi = \bar{\Pi} \)
- \( E\Pi = \bar{\Pi}(\Phi \lambda^A + (1 - \Phi) \lambda^B) < \bar{\Pi} \)

#### Expected compensation

- \( ES = p_m^h G(U + v + \frac{(1 - p_m^h + \Delta)v}{D}) + (1 - p_m^h)G(U + v - \frac{(p_m^h - \Delta)v}{D}) \)
- \( D = C(p_m^h - p_m^l) \)
- \( \frac{\delta ES}{\delta C} < 0 \)
- \( \frac{\delta ES}{\delta C} > 0 \)

- \( ES \to \infty \): only contract for \( \epsilon_1 \) is possible

#### Expected residual to P

- \( \frac{\delta ER}{\delta C} > 0 \)
- \( \frac{\delta ER}{\delta C} < 0 \)
- \( \frac{\delta ER}{\delta C} > 0 \)

for any \( q_b > 0 \), if \( p_m^h - p_m^l \) is sufficiently small,
\( ER(C = \hat{C}) > ER(C = 1) \)
for any \( p_m^h - p_m^l > 0 \), if \( q_b \) is sufficiently small,
10 Appendix: Proofs

Proof of Lemma 2

Given the agent has no information (beyond knowledge of \( \phi \)) about the actual state of nature, the agent’s strategy space can be represented by the pair \( e, \alpha \in \{ e^j, \alpha^j \}, j = h, l \), where \( \alpha^j \) denotes the probability that the agent chooses \( d = d^j \) when he exerts effort level \( j \). As a consequence, given effort level \( j \) his operating decision will match the economic environment with probability \( \rho^j \equiv 1 - \phi - \alpha^j + 2\phi \alpha^j \), and will not match with probability \( \phi + \alpha^j - 2\phi \alpha^j \equiv 1 - \rho^j \). Now, consider a contract, \( \{s(y^H), s(y^L)\} \), with \( s(y^H) > s(y^L) \) satisfying

\[
\rho^h [p^h_m U(s(y^H)) + (1 - p^h_m)U(s(y^L))] + (1 - \rho^h) [p^h U(s(y^H)) + (1 - p^h)U(s(y^L))] - v
\]

or, equivalently

\[
p^h U(s(y^H)) + (1 - p^h)U(s(y^L)) - v = \rho^l [p^l_m U(s(y^H)) + (1 - p^l_m)U(s(y^L))] + (1 - \rho^l) [p^l U(s(y^H)) + (1 - p^l)U(s(y^L))] \quad (IC_\alpha)
\]

for some \( \tilde{\alpha}^h \) and some \( \tilde{\alpha}^l \). Since the RHS is decreasing in \( \alpha^l \), the agent’s expected utility under the contract is maximized by choosing \( e^l \) together with \( \alpha^l = 0 \). Thus, the agent can be made indifferent between \( e^l \) and \( e^h \) only if \( \{s(y^H), s(y^L)\} \) satisfies \((IC_\alpha)\) for \( \tilde{\alpha}^l = 0 \).

Substituting this value for \( \alpha^l \) into \((IC_\alpha)\) yields the following cost minimization program for the principal:

\[
\min_{s(y)} \quad p^h s(y^H) + (1 - p^h) s(y^L)
\]

s.t.

\[
p^h U(s(y^H)) + (1 - p^h)U(s(y^L)) - v \geq U \quad (IR)
\]

\[
p^h U(s(y^H)) + (1 - p^h)U(S(y^L)) - v \geq (1 - \phi) [p^l_m U(s(y^H)) + (1 - p^l_m)U(s(y^L))] + \phi [p^l U(s(y^H)) + (1 - p^l)U(s(y^L))] \quad (IC)
\]
The solution is the earnings-contingent contract outlined in the Lemma.

Since the (in equilibrium) LHS of (IC\(\alpha\)) does not depend on \(\alpha^h\) it is safe to assume that the (benevolent) agent chooses \(\alpha^h = 1\) as that maximizes the principal’s expected profit. The principal will therefore use the earnings-contingent contract in Lemma 2 to elicit \(e^h\) if and only if the expected net profit given \(\alpha^h = 1\) is higher than the maximum expected net profit from eliciting \(e^l\).

**Proof of Lemma 5**

Following Lemma 4 when the MAS is relevant either IC2 or IC4 binds or both IC2 and IC4 bind. Suppose first that only IC2 binds. Then, from IC2 and IC3,

\[
\frac{\phi \lambda^A}{(1 - \phi)(1 - \lambda^B)} > 1.
\]

The principal’s expected residual under the optimal contract is

\[
ER = \Pi[\phi \lambda^A + (1 - \phi)\lambda^B] - p_b G(U(s(y^H))) - (1 - p_b)G(U(s(y^L))).
\]

Using Lemma 4 again the first-order conditions for an optimal MAS when only IC4 binds then are

\[
\Pi = \frac{p_b(1 - p_b)\nu}{(p_b - p_m^l)(1 - \phi)(1 - \lambda^B)} \left( G'(U(s(y^H))) - G'(U(s(y^L))) \right)
\]

and

\[
\Pi = \frac{p_b(1 - p_b)\nu \phi \lambda^A}{(p_b - p_m^l)(1 - \phi)^2(1 - \lambda^B)^2} \left( G'(U(s(y^H))) - G'(U(s(y^L))) \right)
\]

or equivalently

\[
\frac{\phi \lambda^A}{(1 - \phi)(1 - \lambda^B)} = 1,
\]

which contradicts that only IC4 binds when the MAS is chosen optimally.
Suppose now instead IC4 was the only binding IC-constraint. Then, from IC4 and IC5,

\[
\frac{(1 - \phi) \lambda^B}{\phi(1 - \lambda^A)} > 1.
\]

Then for some fixed value of \( \frac{(1 - \phi) \lambda^B}{\phi(1 - \lambda^A)} > 1 \), say \( \tilde{M} \),

\[
\frac{d\lambda^B}{d\lambda^A} = -\frac{(1 - \phi) \lambda^B}{\phi(1 - \lambda^A)^2} = -\frac{\lambda^B}{1 - \lambda^A} \left( = \frac{1}{\frac{d\lambda^A}{d\lambda^B}} \right)
\]

Thus, for any finite value of \( \tilde{M} \) consistent with IC4 being binding,

\[
\frac{dER}{d\lambda^A} = \phi + \frac{d\lambda^B}{d\lambda^A} (1 - \phi)
\]

\[
= \phi - \frac{(1 - \phi) \lambda^B}{1 - \lambda^A} < 0,
\]

Similarly, \( \frac{dER}{d\lambda^B} > 0 \). The optimal MAS then has

\[
(\lambda^A, \lambda^B) = \left( 1 - \frac{(1 - \phi)}{\phi \tilde{M}}, 1 \right)
\]

contradicting that IC4 can be the only binding IC-constraint. Accordingly, for the optimal MAS, both IC2 and IC4 bind. The result now follows directly from IC2 and IC4.

**Proof of Proposition 1**

First recall from Lemma 5 that if it is optimal to introduce a relevant MAS, the optimal relevant MAS will satisfy \( \frac{\lambda^A (1 - \lambda^A)}{1 - \lambda^B} = \frac{(1 - \phi)^2}{\phi^2} \). Further notice from Lemma 3 limiting case of a relevant MAS (which is exactly an irrelevant one) has

\[
\frac{1 - \lambda^A}{\lambda^B} = \frac{1 - \phi}{\phi} = \frac{\lambda^A}{1 - \lambda^B},
\]
and thus satisfies the condition in Lemma 5. Then as \( \frac{1-\lambda^A}{\lambda^B} \rightarrow \frac{\lambda^A}{1-\lambda^B} \rightarrow \frac{1-\phi}{\phi} \), \( E\Pi = \Pi[\phi\lambda^A + (1-\phi)\lambda^B] \rightarrow \phi\Pi \), the \( E\Pi \) when no MAS is in place, from above while the optimal contract is approaching

\[
U(s(y^H)) = U + v + \frac{2(1-p_b)v}{p_b-p_m},
\]

\[
U(s(y^L)) = U + v - \frac{2p_bv}{p_b-p_m},
\]

which is strictly less risky and thus cheaper than the equivalent optimal no-MAS contract summarized in Lemma 2. Thus, since \( \phi > .5 \), there exists some MAS that satisfies Lemma 5 as well as the first condition of Lemma 3 with strict inequalities for which the \( ER \) is strictly greater than the maximum \( ER \) achievable without a relevant MAS.

**Proof of Proposition 2**

Following Lemma 5 the optimal management accounting system satisfies

\[
\frac{\phi\lambda^A}{(1-\phi)(1-\lambda^B)} = \frac{(1-\phi)\lambda^B}{\phi(1-\lambda^A)} = \hat{M} > 1
\]

Thus,

\[
\lambda^A = \frac{\hat{M}^2 - \hat{M}^{1-\phi}}{\hat{M}^2 - 1}
\]

and

\[
\lambda^B = \frac{\hat{M}^2 - \hat{M}^{1-\phi}}{\hat{M}^2 - 1}
\]

Again, the principal’s expected residual under the optimal contract is

\[
ER = \Pi[\phi\lambda^A + (1-\phi)\lambda^B] - p_bG(U(s(y^H))) - (1-p_b)G(U(s(y^L))).
\]
Accordingly,

$$\frac{dER}{dM} = \Pi(\phi \frac{d\lambda^A}{dM} + (1 - \phi) \frac{d\lambda^B}{dM}) - \frac{p_b(1 - p_b)v}{(p_b - p'_m)} \left( G'(U(s(y^H))) - G'(U(s(y^L))) \right).$$

Using the expressions for $\lambda^A$ and $\lambda^B$ it is straightforward to verify that the first term is concavely increasing while the second is convexly increasing in $M$. Further that the first is independent of $p_b$ and $p'_m$, while the second is strictly decreasing (increasing) in $p_b$ ($p'_m$). Thus for values of $p_b$ and $p'_m$ for which some $M > 1$ solves the $\frac{dER}{dM} = 0$, the signs of these derivatives are straightforward to establish.

**Proof of Lemma 6**

The optimal contract when a MAS provides signal $x^i$ privately to the agent, and the principal contracts with the agent to match $x^i$ in decision making $d^i$ and to provide $e^h$ in a general financial reporting regime is the solution to the following program:

$$\min_{s(y)} p_m^h s(y^H) + (1 - p_m^h) s(y^L) - \Delta(s(y^H) - s(y^L))$$

s.t.

$$
p_m^h U(s(y^H)) + (1 - p_m^h) U(s(y^L))$$

$$-(1 - C)q_b \left[ U(s(y^H)) - U(s(y^L)) \right] \left( (1 - \lambda^A) \phi + (1 - \lambda^B)(1 - \phi) \right) - v \geq U$$  \hspace{1cm} (IR)

$$U(s(y^H)) - U(s(y^L)) \geq 0$$  \hspace{1cm} (IC1)

$$U(s(y^H)) - U(s(y^L)) \geq v \left[ \frac{\phi \lambda^A + (1 - \phi)(1 - \lambda^B)}{\phi \lambda^A (1 - C)q_b + (1 - \phi)(1 - \lambda^B)(C(p_m^h - p'_m) - (1 - C)q_b)} \right]$$  \hspace{1cm} (IC2)

$$U(s(y^H)) - U(s(y^L)) \geq v \left[ \frac{\phi \lambda^A + (1 - \phi)(1 - \lambda^B)}{C(p_m^h - p'_m) \phi \lambda^A} \right]$$  \hspace{1cm} (IC3)

$$U(s(y^H)) - U(s(y^L)) \geq v \left[ \frac{(1 - \phi) \lambda^B + \phi(1 - \lambda^A)}{(1 - \phi) \lambda^B (1 - C)q_b + \phi(1 - \lambda^A)(C(p_m^h - p'_m) - (1 - C)q_b)} \right]$$  \hspace{1cm} (IC4)

$$U(s(y^H)) - U(s(y^L)) \geq v \left[ \frac{(1 - \phi) \lambda^B + \phi(1 - \lambda^A)}{C(p_m^h - p'_m)(1 - \phi) \lambda^B} \right]$$  \hspace{1cm} (IC5)

IC1 ensures that, when $e^h$ is exerted, the agent will choose $d^i$ upon observing $x^i$. IC2 ensures that, when the Agent observes $x^A$, his utility from implementing the appropriate operational decision $d^A$ and providing high effort exceeds that of (inappropriately) implementing $d^B$ and providing low effort. IC3 ensures that, when the Agent observes $x^A$, his utility from implementing $d^A$ and providing high effort is higher than that of implementing $d^A$ but only providing low effort. IC4 and IC5 impose similar conditions
on the contract as IC2 and IC3 for the case where the Agent observes $x^B$.

It can be shown that when $C \leq \frac{q_h}{p_m - p_m^* + q_h}$ both IC3 and IC5 bind; and that when $C \geq \frac{q_h}{p_m - p_m^* + q_h}$ both IC2 and IC4 bind. The solution then follows. Further details are available from the authors on request.

**Proof of Proposition 4**

First, from Lemma 5 we know that for $C = 1$ the optimal MAS is imperfect. Next, then, we establish that for $C \leq \frac{2q_h}{p_m - p_m^* + 2q_h}$, the optimal MAS is perfect. To see this first recall that $\frac{dE}{d\lambda} > 0$. Thus, a sufficient condition for a perfect MAS being optimal is that

$$
\frac{dES}{d\lambda} = -\frac{d\Delta}{d\lambda} [s(y^H) - s(y^L)] + \frac{dU(s(y^L))}{d\lambda} G'(U(s(y^L)))
$$

$$
+ (p_m^h - \Delta) \left( \frac{dU(s(y^H))}{d\lambda} G'(U(s(y^H))) - \frac{dU(s(y^L))}{d\lambda} G'(U(s(y^L))) \right)
$$

$$
< 0, \ j = A, B,
$$

where $\Delta \equiv (1 - C) q_h \left[ \phi (1 - \lambda^A) + (1 - \phi) (1 - \lambda^B) \right]$. Since for $C \leq \frac{2q_h}{p_m - p_m^* + 2q_h}$, $\frac{dU(s(y^L))}{d\lambda} \geq 0$, then due to the convexity of $G$,

$$
\frac{dES}{d\lambda} < -\frac{d\Delta}{d\lambda} [s(y^H) - s(y^L)] + \frac{dU(s(y^L))}{d\lambda} G'(U(s(y^H)))
$$

$$
+ (p_m^h - \Delta) \left( \frac{dU(s(y^H))}{d\lambda} G'(U(s(y^H))) - \frac{dU(s(y^L))}{d\lambda} G'(U(s(y^L))) \right), \ j = A, B,
$$

which has the same sign as

$$
-\frac{d\Delta}{d\lambda} s(y^H) - s(y^L) + \frac{dU(s(y^L))}{d\lambda} + (p_m^h - \Delta) \left( \frac{dU(s(y^H))}{d\lambda} - \frac{dU(s(y^L))}{d\lambda} \right), \ j = A, B,
$$

as $G'(U(s(y^H))) > 0$. Because the IR always binds here, we have

$$
\frac{dEU}{d\lambda} = -\frac{d\Delta}{d\lambda} \left[ U(s(y^H)) - U(s(y^L)) \right] + \frac{dU(s(y^L))}{d\lambda} + (p_m^h - \Delta) \left[ \frac{dU(s(y^H))}{d\lambda} - \frac{dU(s(y^L))}{d\lambda} \right]
$$

$$
= 0, \ j = A, B.
$$
Accordingly, since due to the concavity of $U$, $U'(s(y^H)) < \frac{U(s(y^H)) - U(s(y^L))}{s(y^H) - s(y^L)}$, and since $\frac{d^2U}{d\lambda^2} < 0$, $j = A, B$, $\frac{dES}{dC} < \frac{dEU}{dC} = 0$, $j = A, B$. $\hat{C} > \frac{2q_h}{p_m - p_m + q_h}$ now follows by continuity.

**Proof of Lemma 7**

As $C \to 0$, by Lemma 6 the incentive compatibility constraints that must be satisfied for the agent to choose high effort (combined with a matching production decision) are IC3 and IC5. However, when $C \to 0$, the RHS of these constraints approaches infinity, and it becomes impossible to incentivize high effort. The principal will therefore only be able to contract for low effort.

**Proof of Proposition 5**

By Proposition 4, when $C < \hat{C}$ the optimal MAS is perfect (i.e. $\lambda^A = \lambda^B = 1$). A perfect MAS maximizes profit from decision-making since $E^*\Pi \equiv \Pi[\phi \lambda^A + (1 - \phi)\lambda^B] = \Pi$. Therefore, changes in the principal’s expected residual caused by changes in $C$ are solely determined by changes in expected compensation paid to the agent caused by changes in $C$, or $\frac{dER}{dC} = - \frac{dES}{dC}$. Under perfect information,

$$ES = p_m^h G(U(s(y^H))) + (1 - p_m^h)G(U(s(y^L)))$$

and

$$\frac{dES}{dC} = p_m^h G'(U(s(y^H))) \frac{dU}{dC} (s(y^H)) + (1 - p_m^h)G'(U(s(y^L))) \frac{dU}{dC} (s(y^L)).$$

From the contract derived in Lemma 6, for $C \le \frac{q_h}{p_m - p_m + q_h}$,

$$\frac{dES}{dC} = \frac{(1 - p_m^h)p_m^h v}{(p_m^h - p_m^h) C^2} \left( G'(U(s(y^L))) - G'(U(s(y^H))) \right) < 0.$$  

For $C \ge \frac{q_h}{p_m - p_m + q_h}$,

$$\frac{dES}{dC} = \frac{(1 - p_m^h)p_m^h v}{q_h(1 - C)^2} \left( G'(U(s(y^H))) - G'(U(s(y^L))) \right) > 0.$$  

40
Proof of Proposition 6

First, notice that $\Delta$ as defined in Lemma 6 is equal to zero both at $C = 1$ and at $C = \hat{C}$ as in the latter case the optimal MAS is perfect. Then consider the effect of $p^h_m - p^l_m \to 0$ on $D$ as defined in Lemma 6. Specifically, it can be verified that $D(C = 1) \to D(C = \hat{C})$ which, with $\Delta = 0$ in either case, implies that $ES(C = 1) \to ES(C = \hat{C})$. Finally, to establish the first part of this Proposition note that by Proposition 3 the quality of the optimal MAS decreases as $p^h_m - p^l_m$ decreases.

To establish the second part consider the extreme case of $q_b = 0$. In this case notice that again $\Delta = 0$ but that for fixed values of $\lambda^j$, $j = A, B$, $dD/dC > 0$. Then $dES/dC < 0$. To complete the proof it is now straightforward to verify that $dES/dC$, $j = A, B$, is strictly increasing in $C$ while $\partial E\Pi/\partial C = 0$ which implies that $d\Delta/dC < 0$, $j = A, B$.

Proof of Proposition 7

As $Pr(\Pi) = \phi \lambda^A + (1 - \phi) \lambda^B$, $Pr(y^H|\Pi) = p^h_m$ and $Pr(\Pi|y^H) = \frac{Pr(y^H|\Pi) Pr(\Pi)}{Pr(y^H)}$ it follows that

$$Pr(\Pi|y^H) = \frac{p^h_m (\phi \lambda^A + (1 - \phi) \lambda^B)}{P_m (\phi \lambda^A + (1 - \phi) \lambda^B) + (p^h_m - (1 - C) q_b) (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}.$$ 

Therefore,

$$r^H = \frac{p^h_m (\phi \lambda^A + (1 - \phi) \lambda^B) + (p^h_m - (1 - C) q_b) (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}{p^h_m (\phi \lambda^A + (1 - \phi) \lambda^B) + (p^h_m - (1 - C) q_b) (1 - \phi \lambda^A - (1 - \phi) \lambda^B)} - 1$$

or

$$r^H = \frac{(1 - C) q_b (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}{p^h_m - (1 - C) q_b (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}.$$ 

Similarly,

$$Pr(\Pi|y^L) = \frac{(1 - p^h_m) (\phi \lambda^A + (1 - \phi) \lambda^B)}{(1 - p^h_m) (\phi \lambda^A + (1 - \phi) \lambda^B) + (1 - p^h_m - (1 - C) q_b) (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}$$

and

$$r^L = \frac{(1 - p^h_m) (\phi \lambda^A + (1 - \phi) \lambda^B) + (1 - p^h_m - (1 - C) q_b) (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}{(1 - p^h_m) (\phi \lambda^A + (1 - \phi) \lambda^B) + (1 - p^h_m - (1 - C) q_b) (1 - \phi \lambda^A - (1 - \phi) \lambda^B)} - 1$$

or

$$r^L = \frac{-(1 - C) q_b (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}{(1 - p^h_m) + (1 - C) q_b (1 - \phi \lambda^A - (1 - \phi) \lambda^B)}.$$
Note that when $C = 1$, $r^i = 0$. When $C \leq \hat{C}$, Proposition 4 showed that $\lambda^A = \lambda^B = 1$, from which follows again that $r^i = 0$. For $C \in (\hat{C}, 1)$,

$$\frac{dr^H}{dC} = \frac{p''_m q_b [(1-C)(1-\phi \frac{dA}{dC}-(1-\phi)\frac{dB}{dC})-(1-\phi \lambda^A-(1-\phi)\lambda^B)]}{[p''_m -(1-C)q_b(1-\phi \lambda^A-(1-\phi)\lambda^B)]^2}$$

$$\frac{dr^L}{dC} = \frac{(1-p''_m)q_b [(1-\phi \lambda^A-(1-\phi)\lambda^B)-(1-C)(1-\phi \frac{dA}{dC}-(1-\phi)\frac{dB}{dC})]}{[(1-p''_m)+(1-C)q_b(1-\phi \lambda^A-(1-\phi)\lambda^B)]^2}$$

The condition in the second part of the Proposition follows from this.