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Chandra Kanodia

Carlson School of Management
University of Minnesota
USA
ckanodia@umn.edu

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Accounting Disclosure and Real Effects

Chandra Kanodia

Carlson School of Management, University of Minnesota, USA,
ckanodia@umn.edu

Abstract

In this paper I advocate and illustrate a new approach to the study of
accounting measurement and disclosure that is strikingly different from
the usual studies of disclosure in pure exchange economies. This new
approach studies the "real effects" of accounting disclosure, arguing
that how accountants measure and report firms' economic transactions,
earnings and cash flows to capital markets has strong effects on firms'
real decisions and on resource allocation in the economy. I explicitly
study the real effects of accounting for firms' intangible investments
and accounting for firms' derivatives/hedge activities. I also shed new
light on more fundamental accounting issues such as the real effects
of imprecision in accounting measurement and the real effects of peri-
odic performance reporting. Studies of real effects have the potential
to inform accounting policy debates since they are built around very
specific economic transactions and their accounting treatment.

Contents

1

Introduction

In this paper, I advocate and illustrate a new approach to the study of accounting measurement and disclosure that is markedly different from the usual approach taken in the extant accounting literature. This new approach, which I call the "real effects" perspective, argues that how accountants measure and report firms' economic transactions, earnings, and cash flows to capital markets has substantial effects on firms' real decisions and, more generally, on resource allocation in the economy. In most of the extant literature, firms are exogenously endowed with liquidating dividends that are independent of the accounting regime, and the role of accounting disclosure is to provide information about these liquidating dividends. When real effects are present, they arise in one of two ways, contractual efficiency or proprietary costs. The former perspective is that contracts among economic agents with conflicting interests are often based on accounting data and better information makes these contracts more efficient. For example, information provided to a firm's board of directors for evaluating and rewarding managerial performance could enhance the efficiency of compensation contracts, decrease risk premiums paid to managers, change managerial effort, and hence have real effects. The proprietary cost perspec-

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tive is that disclosures have real effects because they inform competing firms in product markets whose actions decrease the cash flows of the disclosing firm (Dye, 1986; Gigler, 1994). While both these perspectives have merit, they do not address the usual kind of disclosures that accounting standard setters are concerned with — disclosures made to a faceless crowd of investors and traders that collectively constitute a capital market or a futures market, i.e., disclosures made to the public at large. The real effects perspective I wish to develop is that accounting measurements and disclosure matter not merely because they facilitate more efficient contracts with employees and suppliers or because they inform rival firms but, more fundamentally, because the capital market's pricing of the firm is the main vehicle by which the economic benefits of the firm's activities are transferred to the firm's shareholders.

Most traditional studies of disclosure assume that the payoff to holding a firm's shares consists of an exogenously specified liquidating dividend $\widetilde{u}$ that is paid by the firm soon after shareholders have bought into the firm. Disclosure to the capital market is modeled as a noisy signal $\widetilde{y}$ of the firm's liquidating dividend, e.g., $\widetilde{y} = \widetilde{u} + \widetilde{\epsilon}$. Like any other simplifying assumption made by analytical researchers, the artifact of a liquidating dividend would be justified if it did not throw out the proverbial baby with the bath water, i.e., if it did not preclude a study of the key economic forces that are unleashed by disclosure. I will argue that such is not the case: In fact, much of what is interesting in the study of disclosure is lost by invoking the economic abstraction of exogenous liquidating dividends. Since, realistically, liquidating dividends are almost never paid, investors satisfy their consumption, saving, or liquidity needs by periodically buying and selling firms' shares in the capital market. Thus their payoff to holding shares is determined by the endogenous time path of capital market prices, rather than the payment of liquidating dividends. In turn, this implies that when making its decisions, a firm must be concerned with how those decisions are perceived and priced in the capital market. Thus, not only must market prices reflect corporate decisions and their assessed consequences but also corporate decisions must be affected by market pricing. We should think of the *simultaneous* determination of market prices and

corporate decisions and how *both* are affected by the information contained in public disclosures.

I am not suggesting that the periodic financial statements released by firms are the only source of information, or even the main source of information, to capital markets. A vast community of financial analysts and voluntary disclosure by corporate managers likely inform the capital market on a more timely basis. However, it is difficult to imagine how such information could be learned or verifiably communicated without systematic measurements and records. Since the systematic recording, aggregation, classification, and reporting of the events and economic transactions that affect a firm *is* the acknowledged domain of accounting, we should study the real effects of accounting measurements regardless of the specific channels through which such information is released to capital markets.

A study of the real effects of disclosure can be built around very specific economic transactions and accounting measurements. Such studies can shed light on the following kinds of questions: How does the manner in which we account for firms' derivative transactions change a firm's risk management, speculation and production policies; How does the measurement or non-measurement of intangibles change a firm's mix of tangibles and intangible investments; Does the manner in which we account for executive compensation change the compensation package and the incentives of managers; Does fair value accounting for bank portfolios change its lending and portfolio strategies; Does accounting conservatism increase the efficiency of debt contracting? The answers to such questions have the potential to inform accounting regulators and corporate managers who struggle with alternative accounting standards and disclosure requirements.

Contrast these questions to the issues studied in the extant literature where accounting is viewed as providing noisy signals on a firm's exogenous liquidating dividend. In a recent survey, Verrecchia (2001) described disclosure studies as belonging to one of three categories: (i) Association-based studies that document the effect of disclosure on equilibrium asset prices and trading volume through capital market traders' reassessment of firms' liquidating dividends. (ii) Discretionary-based disclosure which examines a firm's incentives for voluntarily

disclosing or withholding information about its liquidating dividend. (iii) Efficiency-based disclosure where a firm makes *ex ante* commitments to publicly disclose or withhold information to reduce the costs of private information search by investors or to reduce the information asymmetry component of its cost of capital. All of these studies are conducted in the framework of pure exchange economies where the objects being traded are claims to *exogenously* given distributions of liquidating dividends. In these studies, the effect of public disclosure is simply to move prices, generate trading volume, decrease information asymmetry between informed and uninformed traders, or discourage costly private information search. It is difficult to see how studies of such effects would inform policy debates regarding alternative ways of measuring and disclosing specific economic transactions, or even debates regarding general principles of accounting measurement such as accounting conservatism, imprecision in measurement, or relevance versus reliability tradeoffs. Besides the lack of policy implications, predictions of the price effects of disclosure would be seriously in error if disclosure also has real effects on corporate decisions.

Another strand of the literature views accounting measurement and disclosure as *inconsequential* to both capital market pricing or to corporate decisions. This extreme view of accounting disclosure is best exemplified by the many empirical studies on "value relevance" which assume that alternative accounting measurements only affect the correlation between accounting numbers and observed security returns, but leave the latter unchanged. The value relevance school argues that those accounting measurements that produce higher correlations are more desirable because they are apparently more consistent with the information actually used by investors to determine valuations in the capital market. Similarly, using the insights provided by the Capital Asset Pricing Model (CAPM), Beaver (1972), Gonedes (1976), and more recently Lambert et al. (2007) view accounting signals as providing information on the *true* systematic risk of securities, i.e., on the covariance of a security's returns with the returns on the market portfolio.

Any advocacy of new research directions must point out the limitations of extant research paradigms. I briefly discuss my view of these

limitations in Chapter 2 and illustrate my arguments in subsequent chapters of the paper. But, for the most part, I focus on surveying some of the work that I have been associated with that concerns the real effects of very specific kinds of disclosures. I do not attempt a comprehensive survey of the extant disclosure literature in pure exchange settings. Such a survey is contained in Verrecchia (2001) and supplemented by Dye (2001). Instead, I dwell exclusively on the real effects approach to the study of disclosure, an approach that is also advocated by Dye (2001), but inadequately discussed in Verrecchia's survey.

2

A Conceptual Framework for Understanding Real Effects

Think of the economy as consisting of three components, a real sector, a financial/households sector, and an information sector. The real sector is populated by firms that produce goods and services and invest in land, buildings, machines, research and development, information technology, etc. The financial/households sector is populated by individuals who make consumption, savings and portfolio decisions, and by financial intermediaries such as banks and venture capitalists who channel household savings to firms. For our purposes, it is not essential to explicitly model consumption goods and product markets. It suffices to think of the firm as producing intertemporal distributions of cash flows (or intertemporal distributions of some numeraire good such as corn) through its production and investment choices. Similarly, it suffices to think of households as choosing intertemporal distributions of consumption of the numeraire good through their consumption and portfolio decisions.

The real sector, the financial sector, and the information sector interact in many complex ways, as described in Figure 2.1.

The link from information to the financial sector indicates that the arrival of new information causes households to reassess the
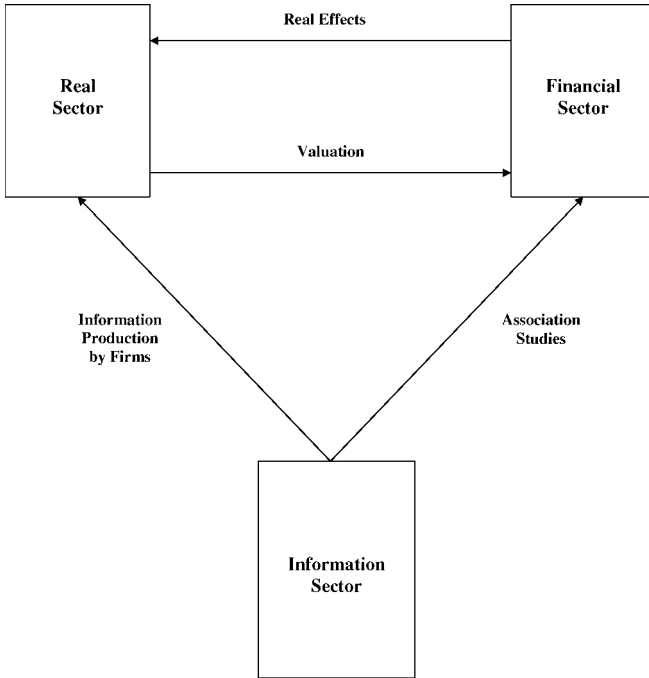
Fig. 2.1 A conceptual framework.

intertemporal distributions of cash flows produced by firms thus causing revisions in their consumption and portfolio decisions. It also results in the destruction of risk sharing opportunities and thereby impairs the social value of information, as first pointed out in Hirshleifer (1971) and Hakannson et al. (1982). Such revisions result in changes in the security prices and trading volumes that are observed in the capital market. This is the link that has been most extensively studied in the accounting research on disclosure and it encompasses what Verrecchia describes as "association-based studies," such as Holthausen and Verrecchia (1988), Kim and Verrecchia (1991), and many others. It also includes the early empirical studies of Ball and Brown (1968), Beaver (1968), and numerous other empirical studies that document information content, earnings response coefficients, and anomalies such as post earnings-announcement drifts, the accrual anomaly, and so on. There is also a reverse link from the financial sector to the information sector,

since prices in the capital market could convey information to heterogenously informed traders, as in Grossman (1976), Diamond and Verrecchia (1981), and many other studies.

The link from the real sector to the financial sector indicates that the revenues, costs, and profits earned by individual firms and their choice of investment projects affects their values in the capital market. Should the firm alter its production–investment policies and thereby alter its intertemporal distribution of future cash flows, its value as determined in the capital market will change. Lucas (1978) provides the most comprehensive theory of how cash flow distributions are converted into equilibrium valuations in the capital market through the intertemporal consumption and portfolio decisions of individual traders and market clearing requirements. The valuation models described in Ohlson and Gao (2006), such as the present value of expected dividends model, the residual income valuation model, the earnings growth model, etc. are also concerned with this issue. Unlike Lucas, these valuation models do not rely upon the optimizing behavior of individual households and do not determine values as capital market clearing prices. Instead, values are determined by discounting expected future cash flows at an exogenously specified cost of capital. Ohlson (1995), Feltham and Ohlson (1995), Ohlson and Zhang (1999), Ohlson and Juettner-Nauroth (2005) show how accounting constructs and exogenous information dynamics that provide information on future earnings and growth factors can be embedded into these valuation models.

The literature on voluntary/discretionary disclosure, where managers decide whether to disclose or withhold information to the capital market as in Dye (1985), provides insights into the link from the real sector to the information sector. The reverse link from information to the real sector reflects firms' information search and information production activities. Such information production by firms certainly has real effects, but the discovery of new information by a firm should be carefully distinguished from the *disclosure* of information by the firm. A farmer deciding whether to plant wheat or rice, or the quantities of each, will obviously be influenced by information about the quantity of rainfall that will occur during the growing season. This effect is obvious because the cash flows produced by the farmer belong to the farmer

and he/she bears the full consequence of his/her decisions. However, a corporation that is traded in the capital market makes decisions on behalf of its stakeholders, not on behalf of itself, and the payoff to these stakeholders depends on the valuations determined in the capital market and only indirectly on the cash flows produced by the firm. Accounting disclosure is concerned with the revelation of information to the capital market and not with the discovery of information by the firm. Disclosure presumes that the information is already known to the disclosing entity. Accounting disclosure is to *external parties* and the disclosure is about the firm's economic transactions and cash flows, information that is already possessed inside the firm by its managers. In this paper, I am concerned with the real effects of disclosure not with the real effects of information production.

The key link, in Figure 2.1, that is missing from the discussion so far is the link from the financial sector to the real sector. It is this link that leads to investigations of the real effects of accounting disclosure. Despite its importance to accounting, this link is not very well understood. Yet, it must exist. The real sector does not function independently of the financial sector. The dependence of the real sector on the financial sector is often viewed as arising from firms' needs to raise additional capital from external sources to finance new investment projects. While such a dependence does exist, the effect of the financial sector on the real sector is much more comprehensive and much more subtle.

Consider the problem of a firm that needs to choose a production–investment policy. Alternative production–investment policies result in alternative intertemporal distributions of cash flows. The firm has opportunities to change its decisions over time as the uncertain future evolves and new opportunities arise. How is the firm to make its choices? Unlike individual households, firms do not have preferences, so expected utility theory does not apply. Now, add to this scenario a multitude of individual households with diverse preferences for consumption over time and possibly diverse beliefs about how the future will evolve. Each household has a stochastic stream of income from employment and accumulated wealth from past savings and investment activities. An individual household's task is to choose a consumption path over

time without violating a sequence of budget constraints. At each point of time, a household chooses how much to consume immediately and how much to save for future consumption. Savings are translated into future consumption by acquiring and selling shares in the intertemporal distributions of cash flows that are produced by firms. When choosing a portfolio of shares in individual firms, each household must assess how the distributions of cash flows produced by firms will unfold over time. It must also assess how its income stream and its consumption needs will change probabilistically over time. It should be obvious that individual households face a daunting task, but they must cope with it. At each point of time, the solution to an individual household's problem yields a current level of consumption and a portfolio of securities (representing shares in each firm) that is held by that household. Now, add the market clearing conditions that must hold in a competitive equilibrium — at each point of time all of the securities of all firms must be held and all of the current consumption goods produced by firms must be consumed by the population of households. There is a set of prices at which markets clear, one price for each security (or equivalently each firm) and one for each consumption good produced. It is this kind of equilibriating process that determines valuations in the capital market.

Notice that the complex dynamic optimization problems solved by households together with market clearing reduces each intertemporal distribution of cash flows produced by firms into a *deterministic* valuation that is observed in the capital market. As observed by Lucas and Prescott (1971), in a competitive equilibrium, the burden of evaluating the cash flow streams produced by firms is borne not by firms but by traders in the capital market. The presence of valuations in the capital market considerably simplifies a firm's decision problem: A seemingly difficult dynamic optimization problem gets reduced to a sequence of single period optimizations. At each point of time a firm merely chooses among its feasible set of production–investment policies, that policy that yields the intertemporal distribution of cash flows that is valued most highly in the capital market. The first welfare theorem (see Debreu (1954)) guarantees that when firms maximize their value at each point of time the economy achieves a Pareto optimal allocation

of resources. In other words, an injunction to firms to maximize their capital market values is equivalent to an injunction to firms to choose those intertemporal distributions of consumption that households collectively prefer the most.

I have argued above that just as prices in static product markets serve as an invisible hand that guides and coordinates producers and consumers, prices in a capital market serve as an invisible hand that guides and coordinates firms' intertemporal choices with the intertemporal choices of individual households. These choices include the raising of new capital, but is not limited to it. What is different in capital markets, relative to static product markets, is the *overwhelming* role of expectations of the future. How well the invisible hand of the market works in guiding corporate decisions depends crucially upon whether the relevant information about the future is appropriately aggregated and reflected in capital market prices. It is this invisible hand role that makes public disclosure of information to capital markets so fundamentally important, and provides the real effects perspective I wish to develop. The invisible hand role of accounting disclosure is akin to a corporate governance role except that it does not rely on a possible misalignment of the personal goals of corporate managers with the goals of the firm's stakeholders.

Refer again to Figure 2.1. I have argued that the real sector affects the financial sector and the financial sector affects the real sector, and both are affected by the information available to the capital market. Therefore, in order to understand the effect of changing the information available to traders in the capital market one must understand the *simultaneous* determination of equilibrium in the real and financial sectors. Hence the need for dynamic general equilibrium theories of corporate decisions and asset pricing. Such theories were formulated concurrently and independently by Kanodia (1980), Prescott and Mehra (1980), and Brock (1982). The methodologies used in these papers differ considerably, but fundamentally all three are concerned with the dynamic simultaneous evolution of corporate decisions and asset prices. Kanodia (1980) additionally illustrated the equilibrium effects of informational imperfections in the capital market caused by incom-

plete accounting systems and thus established the foundation for the study of the real effects of accounting disclosure.

The unified perspective described above is very different from the framework underlying traditional disclosure studies where asset pricing and corporate decisions are detached and treated in piece meal fashion. Asset pricing is usually viewed through the lens of the Capital Asset Pricing Model (CAPM) which derives the current prices of assets from an assumed distribution of future asset prices, without any reference to corporate activities. Thus, within the framework of CAPM, in order to understand why current asset prices are what they are, it is necessary to somehow know the *equilibrium* distribution of future asset prices, but CAPM has nothing to say about this latter distribution. Thus CAPM yields only consistency requirements among the returns of different securities that must be satisfied at any given point of time, but does not provide a theory of how asset prices evolve over time or a theory of how asset prices depend on the fundamentals of what firms do or the fundamentals of the economy. Within the confines of CAPM, accounting information is necessarily viewed as providing signals on the exogenous *true* distribution of future asset prices, or liquidating dividends, or on firms' *true* beta. This implies that any change in the information available to traders in the capital market is equivalent to the substitution of one arbitrary distribution of future asset prices (or liquidating dividends) by a different, but equally arbitrary distribution, which in turn leads to different current prices. The perspective that accounting information helps in the assessment of firms' *true* beta values is particularly difficult to comprehend. The behavioral theory underlying CAPM is that investors form portfolios based on an *assessed* distribution of future asset prices or asset returns. The aggregate demand for such portfolios together with market clearing requirements determines equilibrium relationships among the prices of individual securities. These relationships can be stated in terms of beta values, the risk free rate of return, and the aggregate expected return on all securities (the market portfolio). But these beta values are the ones that are already implicit in investor assessments of the joint distribution of future asset prices or asset returns. There is no theory of *true* beta values independent

of investor assessments, nor a theory of how investors choose port-
folios based on assessments of true beta. Such perspectives provide
rather limited insights into the economic consequences of accounting
disclosure.

When the focus is on corporate decisions, it is assumed that the
discounting of expected future cash flows at an "appropriate" cost of
capital yields a firm's *intrinsic* value. Firm's make decisions to maxi-
mize their intrinsic values and thus choose among investment projects
by calculating and comparing their net present values, using the infor-
mation about expected future cash flows available to its managers.
The role of the capital market is not apparent except perhaps when
the firm needs to raise new capital to finance its investments. It is
assumed that intrinsic valuations and market pricing are reconciled via
the firm's cost of capital,[1] with the latter somehow determined in the
capital market. It is difficult to see how this reconciliation would occur
if managers calculate expected future cash flows based on their infor-
mation and the market arrives at a cost of capital number based on
information in the capital market, and the two sets of information do
not coincide. Nevertheless, it is postulated that more precise (higher
quality) public disclosure must affect corporate decisions by decreasing
the firm's cost of capital. The claim that higher quality public disclo-
sure decreases the firm's cost of capital comes from a study of asset
pricing in CAPM-like models of pure exchange where the distribution
of future asset prices is replaced by distributions of liquidating divi-
dends, and the cost of capital of a firm is defined to be the equilibrium
expected return on that firm's risky security. In these models, higher
quality disclosure consists of more precise public information about the
firms liquidating dividend that decreases its assessed variance. Because
risk averse investors would increase their demand for a risky security
if the assessed risk of its liquidating dividend is decreased, the equi-
librium price of the security increases in response to such information,

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[1] Indeed, there are many empirical studies that estimate a firm's cost of capital by cal-
culating the discount rate that would equate observed prices in the capital market with
the discounted value of expected future cash flows. Expectations of future cash flows are
proxied by the forecasts provided by financial analysts combined with assumed rates of
growth in these cash flows. See Easton et al. (2002) and Gebhardt et al. (2001).

thereby decreasing its expected return. A slightly more subtle argument is that the release of public information reduces the information asymmetry between informed and uninformed traders which, in turn, decreases the aggregate risk aversion in the capital market through improved risk sharing (Easley and O'Hara, 2004). Thus the risk premium built into security prices falls and expected returns decline. But, given the absence of an equilibrium theory where firms and individual households make demand and supply decisions for capital that are aligned via market adjustments to a firms' cost of capital, there is a leap of faith here. The firm could be making decisions under the belief that its choices will impact its value in a certain way while observed valuations in the capital market could be quite different.

It is readily apparent from the general equilibrium theories of Kanodia (1980), Prescott and Mehra (1980), and Brock (1982) that the disconnect between corporate activities and market pricing disappears when the distribution of future prices is endogenously derived in equilibrium, rather than assumed as in CAPM like models. Further, these models yield the insight that the relationship between firms' investment policies and their pricing in the capital market is not sequential; Asset pricing affects corporate investment and corporate investment affects asset pricing. This interrelationship implies that as scientific observers we cannot hope to understand disclosure issues by simply holding the firm's decisions fixed when studying asset pricing, and holding the parameters of asset pricing fixed when studying the firm's decisions. Insights derived from such partial equilibrium models regarding the economic consequences of accounting disclosure are incomplete at best, and could even seriously misguide policy discussions of alternative measurement and disclosure standards.

In the remainder of this paper, I survey some of the published literature on the real effects of accounting disclosure that explicitly incorporates the interaction between corporate decisions and their pricing in the capital market. The survey ranges over issues of general interest such as the economic consequences of imprecision in accounting measurement to very specific issues such as the measurement and reporting of intangibles.

3

Real Effects of Imprecision in Accounting Measurements

Accounting measurements have an aura of precision, but in reality the only asset of a firm that can be measured precisely is the firm's cash balance. Any departure from cash accounting is necessarily based on judgments, estimates, and conventions that may not fully fit the economic facts. D. R. Beresford, chairman of the Financial Accounting Standards Board (FASB) (1987–1997) observed, "*There is virtually no standard that the FASB has ever written that is free from judgement in its application.*" Thus, at best, accounting provides outsiders with a noisy representation of a firm's operations and the economic events that affect the firm's future. Given this fact, it is of fundamental importance to study the question: What are the economic consequences of imprecision in accounting measurements and reports?

Noise in an information signal decreases its information content, so it may seem intuitive that imprecision in accounting measurement is necessarily harmful and should be eliminated to the extent possible. This intuition is confirmed in asset pricing models of pure trade, such as CAPM, where accounting is viewed as providing information about exogenous distributions of future asset prices or exogenous liquidating dividends. It is also confirmed in principal-agent models of contracting

where noise in performance measurement imposes risk on the agent and thereby increases the risk premium built into the agent's compensation. However, disclosure of information to external parties who are not contractually obligated to respond in prespecified ways is quite different from information that is used in contracts. Also, disclosure of information that sheds light on a party's actions, as is often the case with accounting disclosure, is quite different from information about the state of nature. These distinctions are important to a real effects study of disclosure, but they are not commonly recognized in the traditional literature. From a real effects perspective, the key question is how imprecision in accounting disclosure that is used in a sequentially rational way impacts the actions of the party about whom the disclosure is being made.

Kanodia, Singh and Spero (KSS) (2005) studied the real effects of imprecision in measuring and disclosing a firm's real investment. The discussion here draws heavily on that article. The discussion here will also serve to illustrate how the general equilibrium models of asset pricing and corporate decisions that I have mentioned earlier can be simplified to yield a tractable analysis that yields insights into specific accounting disclosure issues. I will also highlight the key differences in methodology and results between disclosure in settings of pure trade, as in the traditional studies of disclosure, and the real effects perspective.

I begin with a simple benchmark model of the firm's investment decision when the capital market and the firm are symmetrically and perfectly informed. Assume that an investment of k units by the firm generates a short-term return of $\theta k - c(k)$ and long-term returns which evolve stochastically over time. Short-term returns are consumed directly and privately by the firm's shareholders, while long-term returns are consumed through the pricing of the firm in the capital market. The valuation rule in the capital market, net of short-term returns, is described by some *exogenous* function $v(k, \theta)$. The parameter θ is firm specific and captures the profitability of its investment. It affects both the short-term return as well as the distribution of long-term returns. Initially, I assume that the parameter θ is known to both the firm's managers and to investors in the capital market and the firm's investment is directly observable — so there is no scope for accounting

disclosure. The function $c(k)$, assumed to be increasing and strictly convex, is the real cost of investment (which should not be confused with the cost of capital). In principle, the valuation function $v(k, \theta)$ is derived from the optimizing intertemporal consumption and portfolio decisions of investors in the capital market and it reflects some aggregation of their beliefs of future cash flows, future investment opportunities for the firm, and their individual preferences (including their discounting of future consumption quantities). Kanodia (1980) shows how $v(k, \theta)$ would be generated endogenously from such intertemporal considerations. By assuming an exogenous valuation rule, I have simplified the dynamic general equilibrium treatment of the firm's investment decision, but have gained considerable tractability which allows later consideration of the accounting imprecision issue that we wish to study. I assume $v_k > 0$, $v_{kk} \leq 0$ so that the firm's value is increasing in a concave fashion in the level of its investment. I also assume $v_\theta > 0$ and $v_{k\theta} \geq 0$, which is consistent with an assumption that higher profitability shifts the distribution of future cash flows to the right (in the sense of first-order stochastic dominance), and an assumption that higher profitability increases the marginal long-term return to investment. These assumptions on the capital market's valuation rule are reasonable, in the sense that they would likely arise endogenously from a general equilibrium analysis.

The firm's investment problem can be succinctly stated as

$$\text{Max}_k \{\theta k - c(k) + v(k, \theta)\} \tag{3.1}$$

Several observations are in order. First, the above formulation of the firm's investment decision is consistent with my earlier observation that in dynamic general equilibrium the burden of evaluating the firm's future cash flows is borne by traders in the capital market not by the firm, and the firm's problem is reduced to a sequence of single period optimizations. Second, it may appear that I have departed from the traditional wisdom that the firm chooses its investment to maximize its net present value which is arrived at by discounting its expectations of future cash flows at a suitable cost of capital. Rather than assuming some exogenous risk adjusted cost of capital, I use the general equilibrium perspective that firm's seek to maximize their values in the

capital market as incorporated in known valuation rules $v(k,\theta)$. Since equilibrium valuation rules reflect the time preferences and risk aversion of individuals who trade and consume the firm's cash flows, firms' value maximizing actions implicitly take into account all appropriate present value considerations. More importantly, the capital market's valuation rule reflects the *information and beliefs* of traders in the capital market which, in a market economy, should in principle impact the firm's investment decision. The usual partial equilibrium formulation of the firm's investment decision with the cost of capital empirically calculated from the capital asset pricing model would not capture such informational effects. It is unclear that a general equilibrium formulation with endogenous costs of capital is even feasible when there are informational differences between the firm and the capital market.

The first-order condition to (3.1) describing the firm's optimal investment schedule is

$$c'(k) = \theta + v_k(k,\theta). \tag{3.2}$$

This first-order condition indicates that the firm invests till the point where its marginal real cost of investment equals its marginal short-term return plus its marginal long-term return, where the latter is described by the marginal effect of investment on the capital market's valuation. Notice that (3.1) and (3.2) capture, in a parsimonious way, the two sided interaction between the firm and the capital market that is the foundation for a real effects study of accounting disclosure. The firm's investment affects its valuation in the capital market as described by the nontrivial presence of k in the valuation rule $v(k,\theta)$, and the capital market's valuation affects the firm's investment as described by v_k in (3.2). Since $v_{k\theta} \geq 0$, (3.2) indicates that the firm's investment increases with its profitability parameter θ. Let $k_{\text{FB}}(\theta)$ be the solution to (3.2) where the subscript FB denotes first best.

In this benchmark model of the firm's investment decision, there are two potential sources of information asymmetry between the capital market and the firm's managers. First, managers are likely to possess superior information about firm specific profitability parameters, such as θ, that affect the distribution of future cash flows from investment. Much of what goes under the name "managerial talent" consists

of expertize in judging and forseeing how future events and opportunities that affect the firm will unfold and, empirically, managers are observed to expend enormous time and resources to collect and analyze information about the profitability of alternative investments. Much of this information is sensitive and non-verifiable and can only be communicated in broad imprecise language. Second, the assumption that the firm's actual investment can be precisely and directly observed by traders in the capital market is highly suspect. Accountants and auditors expend a great deal of effort into separating a firm's cash outflows between investment and operating expenses and much of this separation is judgmental, contentious, and prone to random error. These facts indicate that, rather than observing the firm's investment first hand and rather than *a priori* knowing the value of θ, outside parties must rely on inferences drawn from noisy accounting reports and their own limited understanding of the economic opportunities facing the firm. I will examine the real effects of accounting imprecision in this kind of setting.

However, before studying the problem in all its complexity it is useful to build intuition by studying two simpler settings. In each of these simpler settings only one of the two information asymmetries that I have described are present. First, I consider a setting where the profitability parameter θ is common knowledge to both the firm's managers and the capital market, but the firm's actual investment is measured imprecisely and this imprecise measurement is communicated to the capital market. Next, I examine a setting where θ is private information to the firm's managers, but the firm's investment is measured and reported perfectly by the accounting process. Finally, I analyze the more realistic setting where both information asymmetries exist.

Consider the first setting. Let $\widetilde{s}$ denote the accounting report of the firm's investment. Since the report is subject to random error, but is stochastically related to the firm's true investment, outsiders view $\widetilde{s}$ as a drawing from a family of distributions $F(s|k)$ that have density $f(s|k)$ and fixed support $[\underline{s}, \overline{s}]$. It seems reasonable to assume that the accounting measurement process has the property that *on average* the accounting report is higher when the firm's true investment is higher, and that the accounting report is free from bias. To capture these claims

I assume that higher values of k shift the distribution of the accounting signal to the right in the sense of first-order stochastic dominance and that $E(s|k) = k$ for all values of k. Since θ is known and since the firm's true investment k is unobservable, the pricing rule in the capital market must be a function only of θ and the accounting measurement s. Denote this pricing rule $\varphi(s, \theta)$. Assuming that all agents in the economy are risk neutral, the following definition describes the essential requirements of an equilibrium.

Definition of equilibrium: An equilibrium consists of two schedules, an investment schedule $k_M(\theta)$ and a pricing schedule $\varphi(s, \theta)$ that satisfy:

(i) Given $\varphi(s, \theta)$, the firm's investment policy is value maximizing, i.e., for each θ, $k_M(\theta)$ solves

$$\text{Max}_k \left\{ \theta k - c(k) + \int_{\underline{s}}^{\overline{s}} \varphi(s, \theta) f(s|k) \, ds \right. \qquad (3.3)$$

(ii) $\varphi(s, \theta) = E[v(k_M(\theta), \theta)|s, \theta]$.

Condition (ii) is a rational expectations requirement. It says that the price in the capital market is consistent with the firm's investment incentives and consistent with the firm's intrinsic value $v(k, \theta)$ that would prevail in a full information setting. It might seem that the effect of measurement noise on the firm's investment would be marginal. The firm's optimization problem described in (3.3) differs from (3.1) only in that the valuation $v(k, \theta)$ has been replaced by its expectation. If φ is strictly increasing in s and $f(s|k)$ satisfies first-order stochastic dominance then the market's valuation $\int_{\underline{s}}^{\overline{s}} \varphi(s, \theta) f(s|k) \, ds$ would be a strictly increasing function of k, just as v is a strictly increasing function of k. However, in order to determine the effect of measurement noise, it is crucial to understand the inferential process that must occur in the capital market if beliefs are formed rationally. The sensitivity of the equilibrium pricing schedule φ to the accounting signal s depends entirely on the information that traders extract from it.

To see what incremental information is contained in the accounting measurement s notice that, regardless of how φ is affected by s,

(3.3) indicates that the firm's equilibrium investment is a function only of θ. Since θ is *a priori* known to traders in the capital market they can *perfectly* anticipate the firm's equilibrium investment. Given such perfect anticipation, the noisy accounting measurement $\tilde{s}$ conveys no incremental information and the conditioning effect of s in (ii) is vacuous. Thus, the equilibrium pricing rule φ that prevails in the capital market cannot be a function of s and is described by some schedule $\hat{\varphi}(\theta)$ that incorporates the market's anticipation of the firm's investment. Given the equilibrium valuation schedule $\hat{\varphi}(\theta)$ the firm's investment choice problem becomes $\text{Max}_k\{\theta k - c(k) + \hat{\varphi}(\theta)\}$, which yields the first-order condition $c'(k) = \theta$. I have established,

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Proposition 3.1. When the firm's investment is measured imprecisely and its profitability parameter θ is common knowledge, the firm's equilibrium investment schedule is described by $c'(k_M(\theta)) = \theta$ and the equilibrium price schedule in the capital market is $v(k_M(\theta), \theta), \forall s$.

Proposition 3.1 says that the real effect of noise in the accounting measurement of investment is that it induces the firm to invest myopically so as to maximize only the short-term return to investment and completely ignore the effect of its investment on long-term returns. If the marginal effect of investment on long-term returns is large the magnitude of underinvestment would be substantial. The market is not fooled by the cutting back of investment from first best levels — so the equilibrium I have characterized is fully consistent with the efficient markets hypothesis. The market correctly anticipates myopic investment and prices the firm accordingly. In turn, the firm optimally responds to market pricing and invests myopically. The firm and its shareholders are trapped in a very bad, but fully rational, equilibrium where substantial value is destroyed. Any noise in the accounting measurement of investment completely destroys its information content, even though there is a well defined statistical relationship between the accounting signal and the level of the firm's investment. The intuition for why the accounting report is ignored is that, given their knowledge of θ, traders in the capital market can

step into the shoes of management and solve the investment problem of the firm. Thus, the capital market rationally believes it *perfectly* knows the firm's investment even though it cannot actually see that investment. When the market observes an accounting report of investment that does not coincide with its perfect anticipation it attributes the difference to measurement noise and ignores the accounting report.

To get a sense of magnitudes, suppose the real investment cost is quadratic and the perfect information pricing rule is linear in investment, i.e., $c(k) = \frac{1}{2}ck^2$ and $v(k,\theta) = \gamma k\theta$, $\gamma > 0$. Then first best investment is $k_{\text{FB}}(\theta) = \left(\frac{1+\gamma}{c}\right)\theta$, while myopic investment is $k_M(\theta) = \left(\frac{1}{c}\right)\theta$. Thus if $\gamma = 10$, corresponding to a price earnings multiple of 10, myopic investment would be one-eleventh of first best investment and the value of the firm would be one-eleventh of its first best value.

The results obtained here are *starkly* different from the insights provided by models of pure trade, such as CAPM, that have been used in traditional studies of disclosure. In these models the distribution of the firm's liquidating dividend is exogenous and independent of measurement noise, which is equivalent to holding the firm's investment fixed. The effect of measurement noise is to simply decrease the precision with which the firm's liquidating dividend is estimated. When traders in the capital market are risk averse, this decreased precision of estimates is translated into higher risk premiums and therefore lower equilibrium market valuations. But the higher risk premium which arises due to measurement noise is at most a small second-order effect on market valuations, while the real effect of reduced investment on market valuations is an order of magnitude larger first-order effect. The simple model developed here illustrates my earlier claim that the disclosure insights obtained from models of pure trade could be seriously in error.

The myopia result described in Proposition 3.1 is logically consistent but unrealistic. Although imprecision in accounting measurement of investment is an undeniable empirical fact, it is unlikely that such noisy measurements are completely ignored in the capital market and it is unlikely that firm's invest in such an extreme myopic fashion. This

suggests that the environment modeled here is not rich enough to yield empirically sustainable results regarding the real effects of accounting imprecision. The most unrealistic feature of this model is that it permits outsiders to step into the shoes of management and perfectly anticipate the firm's investment. A likely reason why outsiders are realistically unable to perfectly anticipate managerial actions is that they do not have full access to the information that managers collect and use in making their decisions. The market has been assumed to know too much! Shareholders delegate decision making to corporate managers precisely because they do not have the time, expertise and incentives to continually keep track of new information and emerging opportunities. This suggests that a much more plausible setting for the study of accounting imprecision is one where the profitability parameter θ is privately known only to the firm's managers and this information cannot be directly communicated to the capital market. Notice that in such settings an investment policy $k(\theta)$ in conjunction with an assessed prior distribution on θ would yield a prior distribution on the firm's investment. Imprecise measurement of the firm's investment would then acquire information content and would be used in a Bayesian fashion to update the capital market's assessment of how much investment has occurred.

Before we study the effects of accounting imprecision in this setting, let us determine the equilibrium that would be achieved if accounting measurements of investment were infinitely precise. Now, by assumption, when the firm invests k the market perfectly observes this fact, but the market also knows that the manager chooses investment in the light of information about its profitability θ that the market does not know. Thus, in evaluating the cash flow consequences of an investment of k, traders in the capital market must necessarily make inferences about the value of θ that must have been observed by managers when they chose k units of investment. Thus, in addition to affecting the distribution of future cash flows, the firm's investment acquires an informational value. This raises the possibility of a Spence-type (1974) signalling equilibrium, where perfect measurement of the firm's investment results in perfect inferences of the firm's profitability parameter θ.

Indeed such an equilibrium exists[1] and is defined and characterized below.

Definition of equilibrium: A fully revealing signalling equilibrium is a triple of schedules, an investment schedule $k(\theta)$, a pricing schedule $\varphi(k)$, and an inference schedule $I(k)$ that satisfy:

(i) $k(\theta) = \arg \max_k \{\theta k - c(k) + \varphi(k)\}$
(ii) $\varphi(k) = v(k, I(k))$, and
(iii) $I(k(\theta)) = \theta, \forall \theta$.

Notice that the equilibrium pricing schedule in the capital market must be a function of k alone because θ is unknown to the capital market. However, embedded in this pricing schedule are the capital market's inferences about the underlying value of θ that the firm's manager must have observed when k was chosen. Condition (ii) of equilibrium says that if the market makes the perfect inference that the value of θ is $I(k)$, then the equilibrium price in the capital market must correspond to the equilibrium price in a fully informed market given the observed k and the inferred value of θ, i.e., $\varphi(k) = v(k, I(k))$. Condition (iii) of equilibrium is the standard rational expectations requirement of any fully revealing signalling equilibrium — the inferred value of θ from any observed k is indeed the true value of θ that produced that k. Condition (i) of the equilibrium says that the firm takes the pricing schedule in the capital market as given and chooses investment to maximize its cum-dividend value.

There appears to be a misconception in the accounting literature that in a signalling equilibrium the informed agent seeks to consciously signal his/her information to the uninformed and looks for ways to do so. Such a deliberate attempt to communicate would be more in the spirit of cheap talk games, as in Crawford and Sobel (1982). Here, the firm is not choosing to consciously signal its information. The firm

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[1] Technically, a fully revealing signalling equilibrium requires the satisfaction of a single crossing property (equivalently, the Spencian cost condition) in the firm's payoff structure. The existence of short-term returns to investment, as modeled, and their private consumption guarantees that this condition is met.

simply responds optimally to the way in which its investment is priced in the capital market and does not even need to be aware of the fact that the capital market is making inferences from the investment it chooses. Moreover, the capital market *must* form beliefs about the profitability of investment in order to rationally price the firm, and the rational expectations (or efficient markets) hypothesis requires that these beliefs are not arbitrary, but are consistent in some sense with the investment policy actually chosen by the firm. The structure of payoffs here is such that the interrelationship between rationality of beliefs and the optimality of investment is fulfilled at a fully revealing equilibrium.[2]

Given the fully revealing nature of the equilibrium, an empirical study of a new accounting standard that somehow required the firm to verifiably disclose its information about θ to the capital market before choosing its investment, would reveal that the new disclosure has no incremental information content. It would be deceptive to conclude that such a disclosure requirement serves no purpose. It will become obvious momentarily that such a disclosure policy, if it could be implemented, would significantly change the firm's invest-ment policy and its capital market price and thus have substantial real effects, *without changing the information in the capital market.* How information reaches the capital market, through an inferential process or through direct disclosure, is of fundamental importance. It is not enough to simply assess and compare the information in the capital market in a pre-disclosure regime to a post-disclosure regime.

Proposition 3.2. When the profitability of investment θ is known to the firm's manager but unknown to the capital market, perfect mea-surement of investment induces the firm to over-invest relative to first best levels. The firm's equilibrium investment is characterized by the

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[2] In settings such as we are studying, there is usually also a degenerate equilibrium where the capital market simply uses the prior mean of θ to evaluate the firm's investment and the firm responds by choosing the same level of investment for every value of θ. How-ever, the off-equilibrium beliefs required to sustain such equilibria are implausible, given that there is also a fully revealing equilibrium.

first-order differential equation,

$$k'(\theta)[c'(k(\theta)) - \theta - v_k(k(\theta),\theta)] = v_\theta(k(\theta),\theta) \tag{3.4}$$

$$k'(\theta) > 0, \quad k(\underline{\theta}) = k_{\mathrm{FB}}(\underline{\theta}), \tag{3.5}$$

where the support of the prior distribution of θ is the interval $[\underline{\theta},\overline{\theta}]$

Proof. It is convenient to use the mechanism design methodology to characterize the equilibrium.[3] Since *any* equilibrium allocation (fully revealing or not) must be incentive compatible, the equilibrium investment schedule $k(\theta)$ must be such that if θ' and $\widehat{\theta}$ are two values of $\theta \in [\underline{\theta},\overline{\theta}]$ then the manager who observes θ' must prefer to invest $k(\theta')$ to an investment of $k(\widehat{\theta})$ and when the manager observes $\widehat{\theta}$ he/she would rather invest $k(\widehat{\theta})$ than $k(\theta')$. If, in addition, the equilibrium is fully revealing then an investment of $k(\theta')$ must lead to the inference that $\theta = \theta'$, and an investment of $k(\widehat{\theta})$ must lead to the inference that $\theta = \widehat{\theta}$. Thus any fully revealing equilibrium investment schedule must satisfy the incentive compatibility (IC) requirements:

$$\theta k(\theta) - c(k(\theta)) + v(k(\theta),\theta) \geq \theta k(\widehat{\theta}) - c(k(\widehat{\theta})) + v(k(\widehat{\theta}),\widehat{\theta}), \quad \forall \theta,\widehat{\theta}. \tag{3.6}$$

Denote the left-hand side of (3.6) by $\Omega(\theta)$, so that the incentive compatibility constraints can be equivalently expressed as

$$\Omega(\theta) \geq \Omega(\widehat{\theta}) - k(\widehat{\theta})[\widehat{\theta} - \theta], \quad \forall \theta,\widehat{\theta}. \tag{3.7}$$

Reversing the roles of θ and $\widehat{\theta}$ yields an equivalent reverse IC constraint,

$$\Omega(\widehat{\theta}) \geq \Omega(\theta) - k(\theta)[\theta - \widehat{\theta}], \quad \forall \theta,\widehat{\theta}. \tag{3.8}$$

Equations (3.7) and (3.8) together imply that the equilibrium schedules $\Omega(\theta), k(\theta)$ must satisfy,

$$k(\theta)[\widehat{\theta} - \theta] \leq \Omega(\widehat{\theta}) - \Omega(\theta) \leq k(\widehat{\theta})[\widehat{\theta} - \theta], \quad \forall \theta,\widehat{\theta}. \tag{3.9}$$

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[3] The equivalence of the Spence-Riley methodology and the mechanism design methodology for constructing a signalling equilibrium is developed in Kanodia and Lee (1998).

I now claim that an investment schedule $k(\theta)$ is incentive compatible and fully revealing if and only if (i) $\Omega'(\theta) = k(\theta)$ and (ii) $k(\theta)$ is increasing. The claim that $k(\theta)$ is necessarily increasing follows directly from the left-hand and right-hand side inequalities in (3.9). In turn, this implies that $k(\theta)$ must be continuous almost everywhere. Dividing (3.9) by $(\widehat{\theta} - \theta)$, taking the limit as $\widehat{\theta} \to \theta$ and using the continuity of $k(\theta)$ yields the result that $\Omega(\theta)$ is differentiable almost everywhere and $\Omega'(\theta) = k(\theta)$. This establishes the necessity part of claims (i) and (ii).

Now to establish sufficiency it must be shown that the satisfaction of (i) and (ii) imply that incentive compatibility is satisfied. From (i) it follows that

$$\int_\theta^{\widehat{\theta}} \Omega'(t)dt = \int_\theta^{\widehat{\theta}} k(t)dt. \tag{3.10}$$

Consider $\widehat{\theta} > \theta$. Then (3.10) implies,

$$\Omega(\widehat{\theta}) = \Omega(\theta) + \int_\theta^{\widehat{\theta}} k(t)dt. \tag{3.11}$$

Now if $k(\theta)$ is increasing, as claimed in (ii), (3.11) implies $\Omega(\widehat{\theta}) \leq \Omega(\theta) + k(\widehat{\theta})[\widehat{\theta} - \theta]$. Rearranging terms yields the incentive compatibility condition $\Omega(\theta) \geq \Omega(\widehat{\theta}) - k(\widehat{\theta})[\widehat{\theta} - \theta]$, $\forall \widehat{\theta} > \theta$. Now, consider $\widehat{\theta} < \theta$. Then from (3.10) it follows that $\Omega(\theta) = \Omega(\widehat{\theta}) + \int_{\widehat{\theta}}^\theta k(t)dt \geq \Omega(\widehat{\theta}) + k(\widehat{\theta})[\theta - \widehat{\theta}]$, where the last inequality follows from claim (ii).

Since claims (i) and (ii) are necessary and sufficient for incentive compatibility, any fully revealing equilibrium investment schedule must satisfy those claims. From (i) it follows that,

$$\Omega(\theta) = \Omega(\underline{\theta}) + \int_{\underline{\theta}}^\theta k(t)dt. \tag{3.12}$$

Replacing the left-hand side of (3.12) by the definition of $\Omega(\theta)$, it follows that $k(\theta)$ must satisfy,

$$\theta k(\theta) - c(k(\theta)) + v(k(\theta), \theta) = \Omega(\underline{\theta}) + \int_{\underline{\theta}}^\theta k(t)dt. \tag{3.13}$$

Differentiating (3.13) with respect to θ gives

$$k(\theta) + \theta k'(\theta) - c'(k(\theta))k'(\theta) + v_k(k(\theta),\theta)k'(\theta) + v_\theta(k(\theta),\theta) = k(\theta).$$

Rearranging and collecting common terms yields (3.4).

The result that the firm over-invests at every $\theta > \underline{\theta}$ follows directly from (3.4). Since $k'(\theta) > 0$ in any fully revealing signalling equilibrium and since $v_\theta > 0$ it is necessary that $c'(k(\theta)) - \theta - v_k(k(\theta),\theta) > 0$ whereas first best investment satisfies $c'(k(\theta)) - \theta - v_k(k(\theta),\theta) = 0$. This completes the proof. $\square$

Again, to get a sense of magnitudes let us return to the example I considered earlier. Assume $c(k) = \frac{1}{2}ck^2$ and $v(k,\theta) = \gamma k\theta$, $\gamma > 0$. For this example, and with the additional assumption that $\underline{\theta} = 0$, the solution to the differential equation (3.4) is

$$k_{\text{PS}}(\theta) = \left(\frac{1 + 2\gamma}{c}\right)\theta.$$

Thus, if $\gamma = 10$, the investment that is induced by perfect measurement is almost twice as much as in the first best setting. Once again the firm is trapped in a bad equilibrium. I have shown that when the profitability parameter θ is publicly known, imprecise measurements of investment induce the firm to under-invest, and when θ is privately known only to the firm's manager perfect measurements of the firm's investment induce the firm to over-invest. These results suggest that perhaps some ignorance of θ in the capital market and some imprecision in the measurement of investment may actually *improve* the equilibrium and sustain investment levels that are closer to first best. Ignorance of the project's profitability prevents perfect anticipation of the firm's investment and allows imprecise measurements to acquire information content, thus alleviating the under-investment problem. Imprecision in measuring the firm's investment counteracts the firm's incentive to over-invest when the project's profitability is unknown to the capital market and the market is forced to make inferences about it. The results derived below confirm this intuition.

Assume, now, that the manager privately observes the profitability parameter θ before choosing the firm's investment and that investment

is measured imprecisely and reported to the capital market. The market views θ as a drawing from a probability distribution with density $h(\theta)$ and support Θ, and observes only the imprecise measurement s of the firm's investment where the measurement noise is described by the probability density $f(s|k)$ described earlier. Now the price in the capital market will be a function only of the accounting report s, say $\varphi(s)$, since that is only variable observed by capital market traders. Embedded in this price schedule is the market's inferences about both the firm's investment and the profitability parameter θ, conditional on the observed value of s.

Let us first examine the nature of inferences that the capital market will need to make. Given that the accounting measurement s is noisy, it is clear that the capital market is unable to make *perfect* inferences of either k or θ. The capital market will need to assess posterior distributions of k and θ conditional on s. In order to do this, the market needs to conjecture an investment *policy* $k(\theta)$ that describes beliefs about how the firm would choose an investment level contingent on each value of θ that the manager could observe. Given such a conjectured investment policy, an assessed posterior distribution on θ would *statistically* imply a posterior distribution on k, so no further assessments are needed. Let $g(\theta|s)$ be the assessed posterior density of θ. Rational assessments must satisfy Bayes rule,

$$g(\theta|s) = \frac{f(s|k(\theta))h(\theta)}{\int_{\Theta} f(s|k(t))h(t)dt}. \qquad (3.14)$$

Notice that the investment policy conjectured by the market is embedded in this posterior calculation and the probability density function of s at θ is described by the measurement noise $f(s|k)$ and the belief that at θ the firm will invest $k(\theta)$. Expectations are rational (equivalently, markets are efficient) if the investment policy conjectured by the market is the same as the investment policy induced by the market's Bayesian assessments that are incorporated into market valuations. This leads to the following definition of equilibrium.

Definition of equilibrium: An equilibrium is a triple of functions, an investment schedule $k(\theta)$, Bayesian posteriors $g(\theta|s)$, and a valuation schedule $\varphi(s)$ that satisfy:

(i) Given $\varphi(s)$, the investment policy of the firm is value maximizing, i.e., $k(\theta)$ solves:

$$\text{Max}_k \left[\theta k - c(k) + \int_{\underline{s}}^{\bar{s}} \varphi(s) f(s|k) ds \right]$$

(ii) $g(\theta|s)$ satisfies (3.14), and

(iii) $\varphi(s) = \int_{\Theta} v(k(\theta), \theta) g(\theta|s) d\theta$.

This definition describes a *noisy signalling* equilibrium. The firm's choice of investment has information content since it affects the accounting measurement of s, but this information content is diluted by the measurement noise in $f(s|k)$. Because of this noise, the inferences made by the market are probabilistic in nature and these probabilistic inferences are reflected in the equilibrium valuation schedule $\varphi(s)$. As described in (iii), the valuation schedule in the market reflects a pooling of types but this is not the usual kind of pooling. The weights $g(\theta|s)$ are *equilibrium* weights that emerge endogenously. They depend not only on the prior density $h(\theta)$, but also on the measurement noise in $f(s|k)$ and the endogenous investment policy of the firm $k(\theta)$. Since the investment policy affects these weights, it affects the firm's valuation in the capital market, thus stimulating the firm to invest more than the myopic amount (see KSS, Corollary to Proposition 3).

The first-order condition to the firm's optimization problem is

$$\theta - c'(k) + \int_{\underline{s}}^{\bar{s}} \varphi(s) f_k(s|k) ds = 0.$$

Inserting the equilibrium conditions (ii) and (iii) into this first-order condition yields:

$$\int_{\underline{s}}^{\bar{s}} \left[\int_{\Theta} v(k(t), t) \frac{f(s|k(t))h(t)}{\int_{\Theta} f(s|k(\tau))h(\tau)d\tau} dt \right] f_k(s|k(\theta)) ds = c'(k(\theta)) - \theta$$

$$(3.15)$$

Equation (3.15) is an integral equation with a single unknown, the investment schedule $k(\theta)$. KSS (see their Proposition 3) establish that any investment schedule that is increasing in θ and satisfies (3.15) is an equilibrium investment schedule. In order to shed light on the economic consequences of accounting imprecision it is necessary to examine how the equilibrium investment schedule would change with the amount of noise in $f(s|k)$. Unfortunately, the integral equation (3.15) is too complex to accomplish this task without additional specificity to the model. Therefore, I make the following additional assumptions, which are slightly stronger than those made in KSS.

(A1) $\widetilde{s} = k + \widetilde{\epsilon}$, where $\widetilde{\epsilon}$ is Normally distributed noise with $E(\widetilde{\epsilon}) = 0$, $\text{var}(\widetilde{\epsilon}) = \sigma_\epsilon^2$.

(A2) The prior distribution of $\widetilde{\theta}$ is Normal with $E(\widetilde{\theta}) = 0$, $\text{var}(\widetilde{\theta}) = \sigma_\theta^2$.

(A3) $v(k,\theta) = \gamma k\theta$, $\gamma > 0$.

(A4) $c(k) = \frac{1}{2}ck^2$.

The assumption of Normally distributed random errors allows a precise specification of the amount of noise (σ_ϵ^2) that is present in accounting measurements of investment. Assumption (A2) together with (A1) facilitates Bayesian updating, and Assumptions (A3) and (A4) permit linear investment schedules to be sustained as equilibria. With these assumptions, the integral equation (3.15) can be explicitly solved, as shown below.[4]

To construct the equilibrium described by (3.15), let us begin with the conjecture (to be confirmed later) that the equilibrium investment schedule is linear in θ, i.e., $k(\theta) = a + b\theta$, $b > 0$. Given such an investment schedule the noisy measurement $\widetilde{s}$ can be represented as:

$$\widetilde{s} = k(\theta) + \widetilde{\epsilon} = a + b\theta + \widetilde{\epsilon}.$$

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[4] The literature on noisy signalling is extremely sparse. There is no standard methodology for constructing and analyzing such equilibria. The approach taken by KSS is new in the literature.

Thus the joint distribution of $(\widetilde{\theta}, \widetilde{s})$ is Normal, and the conditional density $g(\theta|s)$ is also Normal with parameters:

$$E(\widetilde{\theta}|s) = \beta\left(\frac{s-a}{b}\right), \quad \text{var}(\widetilde{\theta}|s) = (1-\beta)\sigma_\theta^2, \qquad (3.16)$$

where $\beta = \frac{b^2\sigma_\theta^2}{b^2\sigma_\theta^2 + \sigma_\epsilon^2}$. Additionally,

$$\varphi(s) = E_\theta[\gamma k(\theta)\theta|s] = a\gamma E(\theta|s) + b\gamma E(\theta^2|s).$$

Since $E(\theta^2|s) = \text{var}(\theta|s) + E^2(\theta|s)$, it follows from (3.16) that

$$\varphi(s) = a\gamma\beta\left(\frac{s-a}{b}\right) + b\gamma(1-\beta)\sigma_\theta^2 + b\gamma\beta^2\left(\frac{s-a}{b}\right)^2, \qquad (3.17)$$

which has the quadratic form:

$$\varphi(s) = \alpha_0 + \alpha_1 s + \alpha_2 s^2. \qquad (3.18)$$

The parameters $\alpha_0, \alpha_1, \alpha_2$ can be calculated by matching the coefficients in (3.18) with the corresponding coefficients in (3.17). Also, if $f(s|k)$ is a Normal density with mean k and variance σ_ϵ^2, $f_k(s|k) = f(s|k)[\frac{s-k}{\sigma_\epsilon^2}]$.

Using these facts, the left-hand side of the integral equation (3.15) can be expressed as

$$\begin{aligned}
\int \varphi(s) f_k(s|k)ds &= \frac{1}{\sigma_\epsilon^2}\big[\alpha_0 E(s-k|k) + \alpha_1[E(s^2|k) - kE(s|k)] \\
&\qquad + \alpha_2[E(s^3|k) - kE(s^2|k)]\big] \\
&= \frac{1}{\sigma_\epsilon^2}\big[\alpha_1(\sigma_\epsilon^2 + k^2 - k^2) \\
&\qquad + \alpha_2(k^3 + 3k\sigma_\epsilon^2 - k^3 - k\sigma_\epsilon^2)\big] \\
&= \alpha_1 + 2\alpha_2 k.
\end{aligned}$$

The above characterization together with (3.15) implies that equilibrium investment at each θ is characterized by the equality $\alpha_1 + 2\alpha_2 k = ck - \theta$, or equivalently,

$$k(\theta) = \frac{\alpha_1}{c - 2\alpha_2} + \left(\frac{1}{c - 2\alpha_2}\right)\theta, \qquad (3.19)$$

which confirms the linear conjecture made earlier.

In order to obtain insights into how accounting imprecision affects sustainable investment levels, it is necessary to relate the coefficients a and b of the linear investment schedule $k(\theta) = a + b\theta$ to the imprecision parameter σ_ϵ^2. It is convenient to do this in a backdoor way by characterizing the values of β, a, and σ_ϵ^2 in terms of b. From (3.19), $b = \left(\frac{1}{c - 2\alpha_2}\right)$ and $a = \alpha_1 b$. By matching coefficients in (3.17) and (3.18), we determine that $\alpha_2 = \frac{\gamma\beta^2}{b}$ and $\alpha_1 = \frac{a\gamma\beta}{b} - \frac{2a\gamma\beta^2}{b}$. Inserting the value of α_2 into the equation for b yields $bc - 2\gamma\beta^2 = 1$, or equivalently,

$$\beta = \sqrt{\frac{bc - 1}{2\gamma}}. \tag{3.20}$$

Inserting the value of α_1 into the equation for a gives,

$$a\left[1 - \gamma\beta + 2\gamma\beta^2\right] = 0. \tag{3.21}$$

Inserting $\beta = \frac{b^2\sigma_\theta^2}{b^2\sigma_\theta^2 + \sigma_\epsilon^2}$ in (3.20) and solving for σ_ϵ^2 gives,

$$\sigma_\epsilon^2 = b^2\sigma_\theta^2 \left[\sqrt{\frac{2\gamma}{bc - 1}} - 1\right]. \tag{3.22}$$

Equilibrium investment schedules are constructed by choosing a "sustainable" value of b, then solving for β from (3.20), then solving for a from (3.21) and lastly solving for σ_ϵ^2 from (3.22). Sustainable values of b are those that result in values of σ_ϵ^2 that lie in the interval $(0, \infty)$. I first characterize the values of b that are sustainable by corresponding values of σ_ϵ^2. From (3.22), $\sigma_\epsilon^2 \geq 0$ if and only if $\sqrt{\frac{2\gamma}{bc-1}} - 1 \geq 0$ which, in turn, requires that $b \leq \frac{1 + 2\gamma}{c}$. Also since it is necessary that $bc - 1 \geq 0$, sustainable values of b must satisfy $b \geq \frac{1}{c}$. Any value of b intermediate to these two extremes is also sustainable since (3.22) will yield a positive and finite value of σ_ϵ^2 for all such intermediate values. However, the equilibrium investment schedule is not necessarily unique for exogenously given values of σ_ϵ^2, since the solution for b is not always unique. The remaining parameter a of the linear equilibrium investment schedule must satisfy (3.21), from which it follows that if the quantity $[1 - \gamma\beta + 2\gamma\beta^2] \neq 0$ then the intercept a must necessarily be zero. Since $[1 - \gamma\beta + 2\gamma\beta^2]$ is a quadratic expression it can

attain a value of zero for at most two values of β, in which case there are multiple equilibria. However, any plausible equilibrium investment schedule must have $a = 0$, since otherwise the firm would be investing even though the profitability of investment θ is zero. We have thus established:

Proposition 3.3. Given assumptions (A1) through (A4), when the profitability of investment θ is known to the firm's manager but unknown to the capital market, and the firm's investment is measured imprecisely, the equilibrium investment schedule has the linear form $k(\theta) = b\theta$. The value of the parameter b depends on the amount of noise (σ_ϵ^2) in accounting measurements. Any b in the interval $\frac{1}{c} \leq b \leq \frac{1+2\gamma}{c}$ is sustainable by some corresponding value of σ_ϵ^2.

Notice that $b = \frac{1}{c}$ corresponds to managerial myopia and $b = \frac{1+2\gamma}{c}$ corresponds to perfect signalling. These two extremes are realized when $\sigma_\epsilon^2 \to \infty$ and when $\sigma_\epsilon^2 \to 0$, respectively. Since the first best investment schedule corresponds to $b = \frac{1+\gamma}{c}$, Proposition 3.3 indicates that there is some level of accounting imprecision that would stimulate the firm to invest at first best levels. This is, indeed, the *optimal* level of imprecision in accounting measurements and that optimal level is not zero. Substituting $b = \frac{1+\gamma}{c}$ in (3.22) and solving for σ_ϵ^2 yields the optimal level of imprecision characterized in the proposition below.

Proposition 3.4. Given assumptions (A1) through (A4), when the profitability of investment θ is known to the firm's manager but unknown to the capital market, there is an optimal non-zero degree of imprecision (σ_ϵ^2) in accounting measurements of investment, characterized by:

$$\sigma_\epsilon^2 = \sigma_\theta^2 \left(\frac{1+\gamma}{c} \right)^2 \left[\sqrt{2} - 1 \right]. \qquad (3.23)$$

The greater the degree of information asymmetry (σ_θ^2) between the manager and the market regarding the profitability of the firm's investment and the higher the price-earnings multiple (γ) the greater is the optimal degree of imprecision.

What is important in the above results is not the precise algebraic calculations that are essential to any scientific investigation of accounting issues, but the *qualitative* insights that are obtained from them. It would clearly be difficult for a regulatory body like the FASB to mandate a certain level of imprecision in accounting measurements, or even to calculate the optimal level of imprecision. However, the guiding principle, suggested by traditional studies of disclosure, that imprecision in accounting measurements is always harmful and should be eliminated to the extent possible, does not hold up in many plausible settings when the real effects of such imprecision are taken into account. In such settings, some degree of accounting imprecision is actually value enhancing. More often than not, while accounting reports can communicate managerial actions the informational basis for those actions remains hidden from the market and cannot immediately be reflected in accounting reports. The market must necessarily make inferences about the hidden information in order to assess the cash flow consequences of managerial actions and price the firm accordingly. Proposition 3.4 yields the qualitative insight that the greater the information asymmetry regarding the information underlying managerial actions, the greater should be our tolerance for imprecision in measuring and reporting those actions.

4

Real Effects of Measuring Intangibles

Examples of intangible investments are expenditures on research and development, information technology, human capital, brand equity, process improvements, etc. The last decade witnessed an explosive growth in such intangible investments reflecting their increased importance in the new economy. It is now felt that many firms derive their competitive advantage mostly from investments in intangibles. The current accounting treatment of intangible assets requires a firm's R&D expenditures to be listed as a separate line item in the income statement but does not allow its capitalization. All other expenditures on intangibles are left comingled with operating expenses with no attempt to measure and report them separately.

In the academic literature there is a great deal of dissatisfaction with the current accounting treatment of intangibles. Lev and Zarowin (1999), Healy et al. (2002), and many others using the "value relevance" approach to disclosure, have shown that empirically the capital market appears to price the firm as if expenditures on intangibles are assets. Hence, they argue, accountants' refusal to measure and capitalize such expenditures has caused a serious decline in the relevance and usefulness of financial statements. On the other hand, the FASB has argued

that attempts to capitalize intangibles would seriously impair the reliability of accounting statements because intangible assets cannot be measured with reasonable precision, and attempts to measure them would open the floodgates to earnings management by unscrupulous managers. The debate remains unsettled.

Kanodia, Sapra and Venugopalan (KSV) (2004) investigated the real effects of measuring intangibles. They *assume* that intangibles are value relevant, in the sense that such investments stochastically increase future cash flows. They also assume that attempts to measure intangibles would introduce several kinds of noise in accounting data. Thus, their analysis gives credence to both sides of the debate. KSV argue that the value relevance approach is inconclusive because statistical associations between accounting data and stock prices do not by themselves identify economic consequences. If the statistical associations change depending on the accounting treatment of intangibles but nothing else in the economy changes such as firms' investments, cash flows and stock prices, then these statistical associations are of purely academic interest and lack any policy significance. Insights into the controversy are better developed by exploring the real economic consequences of measurement versus non-measurement taking into account both the value relevance of intangibles and the noise introduced by their measurement. My discussion here is based on the KSV article.

Consider a setting where a firm is choosing how much to invest in tangible and intangible assets. The marginal return to each kind of asset depends on how much the firm has invested in the other. This assumption is consistent with the intuition that tangible and intangible assets compliment each other rather than substitute for each other. More specifically, KSV assume that tangible and intangible assets combine in a Cobb Douglas like fashion to form the capital stock of the firm and future cash flows are stochastically related to the firm's capital stock. Let

q = the firm's capital stock,
K = the firm's investment in tangible assets, and
$N + \widetilde{\gamma}$ = the firm's expenditure on intangible assets.

The random variable $\widetilde{\gamma}$, distributed Normally with zero mean and variance σ_γ^2, captures an assumption that some random component $\widetilde{\gamma}$ of expenditures on intangibles is wasteful and unproductive[1] — the productive component is N. I assume,

$$q = K^\alpha N^\beta, \ \ \alpha > 0, \ \ \beta > 0, \ \ \alpha + \beta < 1. \tag{4.1}$$

The assumption $\alpha + \beta < 1$ is inconsistent with the Cobb Douglas technology, but guarantees the strict concavity of q in K and N. The firm chooses its investments at date 0. At dates 1 and 2, these investments yield stochastic cash flows $\widetilde{x}_1$ and $\widetilde{x}_2$, respectively. Assume that $(\widetilde{x}_1, \widetilde{x}_2)$ is joint Normally distributed with,

$$E(\widetilde{x}_1) = E(\widetilde{x}_2) = q\mu,$$
$$\mathrm{Cov}\,(\widetilde{x}_1, \widetilde{x}_2) = \rho > 0,$$
$$\mathrm{Var}(\widetilde{x}_1) = \sigma_x^2$$
$$\rho \leq \sigma_x^2$$

In the above specification $\mu > 0$ is a commonly known profitability parameter. The larger the value of μ the more value relevant is the firm's investments. To keep the analysis simple, I have assumed that the firm's capital stock increases expected cash flows but does not affect the covariance or variance of cash flows. The assumption that the covariance of cash flows is positive is essential to the analysis, and the assumption $\rho \leq \sigma_x^2$ implying that $\mathrm{Cov}\,(\widetilde{x}_1, \widetilde{x}_2) \leq \mathrm{Cov}\,(\widetilde{x}_1, \widetilde{x}_1)$ can be replaced by a weaker but more messy assumption, but it seems reasonable.

The firm maximizes its expected date 1 price, taking the market's valuation rule as given, and this date 1 price P is specified as,

$$P = \text{ Net cash assets at date } 1 + E(\widetilde{x}_2 | \text{information}).$$

This specification assumes risk neutral pricing in the market and any known cash balance in the firm is valued dollar for dollar. The net cash balance at date 1 is,

$$z = x_1 - K - N - \gamma. \tag{4.2}$$

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[1] The realism of this feature of intangible investments is apparent to any one who has engaged in research or human capital development. It is essential to the analysis, as will become apparent later.

Since cash balances are measured perfectly and reported in virtually every accounting regime, I assume that the date 1 cash balance z, but not necessarily its components, is publicly known in each of the informational regimes to be discussed.

At date 1, the primitives describing the firm's operations are:

$K =$ the firm's tangible assets,
$N =$ the firm's productive intangible assets,
$N + \gamma =$ the total expenditure on intangibles,
$x_1 =$ the true operating income of the firm in the first period.

None of these primitive variables are observed directly by the capital market. Instead, the market observes accounting reports consisting of

$I_K =$ measured tangible assets,
$I_N =$ measured intangible assets,
$z =$ the firm's cash balance at date 1, and
$y =$ reported income.

These measurements will differ from one informational regime to another in the manner specified below. I examine three informational regimes: a Utopian full information regime where accounting is perfect, an expensing regime where no attempt is made to measure the firm's intangible assets, and an intangibles measurement regime where the firm's intangibles are measured and reported with noise. I use the superscripts u, e, and m to denote measurements in the Utopian regime, the expensing regime and the intangibles measurement regime, respectively.

In the Utopian regime, tangible investments are measured perfectly, accountants can perfectly observe the total expenditure on intangibles and can perfectly discriminate between unproductive and productive expenditures. Hence, the accounting reports produced are:

$$I_K^u = K,$$
$$I_N^u = N,$$

$y^u = x_1 - \gamma$, where γ is reported separately from the true operating income of x_1, and

$$z^u = x_1 - K - N - \gamma.$$

Of course, the Utopian regime never exists. It is included here to provide a benchmark against which more realistic accounting regimes can be compared.

In the expensing regime, I continue to assume that tangible assets can be measured perfectly, but since no attempt is made to measure and analyze the expenditures on intangibles, such expenditures remain comingled with the operating expenditures that when deducted from revenues determines the firm's operating income. The expression for net cash balance z is unchanged. Thus the accounting reports produced in the expensing regime are

$$I_K^e = K,$$
$$y^e = x_1 - N - \gamma, \text{ and}$$
$$z^e = x_1 - K - N - \gamma.$$

The measurement of intangibles is limited by several factors, and each of them introduces noise in accounting reports. First, there is no reason to believe that accountants have the ability to discriminate between productive and unproductive expenditures on intangibles. So I assume that both are treated the same way. Second, consistent with the concerns of the FASB, I assume that the boundary between operating expenditures and expenditures on intangible assets is fuzzy so attempts to measure intangibles will result in some operating expenditures being classified as assets and some intangible assets being classified as operating expenditures. Third, an accounting regime that seeks to measure intangibles is much more permissive than an expensing regime. In an expensing regime any doubt about the nature of an observed cash outflow results in immediate expensing of that cash outflow. In a more permissive regime such is not the case, causing contamination in the measurement of tangible assets also. I model this as random misclassification between tangible and intangible assets. Thus, the accounting reports produced in the intangibles measurement regime are

$$I_K^m = K + \widetilde{\eta}$$
$$I_N^m = N + \widetilde{\gamma} - \widetilde{\eta} + \widetilde{\omega}$$
$$z^m = \widetilde{x}_1 - K - N - \widetilde{\gamma}$$

$$y^m = z + I_K + I_N$$
$$= \widetilde{x}_1 - K - N - \widetilde{\gamma} + (K + \widetilde{\eta}) + (N + \widetilde{\gamma} - \widetilde{\eta} + \widetilde{\omega})$$
$$= \widetilde{x}_1 + \widetilde{\omega}.$$

I have introduced two new random variables, $\widetilde{\eta}$ and $\widetilde{\omega}$. The random variable $\widetilde{\eta}$ represents classification errors between tangible and intangible assets. Therefore, its effect is offsetting in the measurements I_K^m and I_N^m. The random variable $\widetilde{\omega}$ represents misclassifications between operating expenditures and expenditures on intangible assets. I assume that $\widetilde{\eta}$ and $\widetilde{\omega}$ are Normally distributed with zero means and finite variances σ_η^2 and σ_ω^2, respectively. They are independent of each other and independent of $\widetilde{\gamma}$. Consistent with the way in which accountants calculate a firm's earnings, reported income is always specified as observed net cash flow adjusted by accruals. The only accruals here are measured tangible and intangible assets.

There are important informational differences between the the expensing regime and the intangibles measurement regime. In the expensing regime the firm's net cash flow can also be expressed as $z^e = y^e - K$. Since K is perfectly reported, the firm's net cash flow contains no information incremental to that contained in the reported income number. As in our previous discussion of imprecision in accounting measurements of investment, it will turn out that the stock market will form rational beliefs of the firm's investment in intangibles so that, in equilibrium, both reported income y^e and net cash flow z^e will communicate the noisy estimate $\widetilde{x}_1 - \widetilde{\gamma}$ of the firm's true operating income. In the intangibles measurement regime the firm's net cash flow z^m communicates $\widetilde{x}_1 - \widetilde{\gamma}$, while reported income y^m communicates $\widetilde{x}_1 + \widetilde{\omega}$. Since $\widetilde{\gamma}$ and $\widetilde{\omega}$ are independent, the firm's net cash flow contains information incremental to that contained in reported income. Because of this feature, the intangibles measurement regime provides strictly more information about the firm's true operating income $\widetilde{x}_1$ than the expensing regime. However, the measurement of intangibles contaminates the measurement of tangible investments, so there is less information about the latter. Thus the two regimes are not Blackwell comparable.

Let us now examine the firm's investment choices in the three informational regimes. In the Utopian regime, at date 1 the capital market

perfectly knows the values of $\{z, x_1, K, N\}$, so that the date 1 price of the firm is

$$P(z, x_1, K, N) = z + E(\widetilde{x}_2 | x_1, K, N).$$

At date 0, the firm chooses K and N to maximize the expected date 1 price, i.e.,

$$\text{Max}_{K,N} \{E_0(\widetilde{x}_1 - K - N - \widetilde{\gamma}) + E_0(E(\widetilde{x}_2 | x_1, K, N))\},$$

where E_0 denotes an expectation taken at date 0. Since $E_0(E(\widetilde{x}_2 | x_1, K, N)) = E_0(\widetilde{x}_2 | K, N) = E_0(\widetilde{x}_1 | K, N)) = \mu K^\alpha N^\beta$, the firm's optimization collapses to

$$\text{Max}_{K,N} \{2\mu K^\alpha N^\beta - K - N\}.$$

The first-order conditions describing the firm's optimal investments are

$$2\mu\alpha K^{\alpha-1} N^\beta = 1, \qquad (4.3)$$
$$2\mu\beta K^\alpha N^{\beta-1} = 1 \qquad (4.4)$$

and the firm invests in tangibles and intangibles in the efficient ratio,

$$\frac{K}{N} = \frac{\alpha}{\beta}. \qquad (4.5)$$

This implies that the technological parameters α and β also indicate the relative importance of each kind of investment. The larger is the value of β relative to α, the greater will be the proportion of intangibles in the firm's capital stock.

Let us now turn our attention to the expensing regime. I earlier indicated that the information contained in the accounting reports can be summarized by the tuple $\{K, y^e\}$. Since the net cash assets of the firm at date 1 is $z^e = y^e - K$, the date 1 price schedule in the capital market is

$$P(K, y^e) = y^e - K + E(\widetilde{x}_2 | K, y^e).$$

In order to assess the expectation in this price schedule, the capital market needs to assess the joint distribution of $(\widetilde{x}_2, \widetilde{y}^e)$. But the firm's reported income $\widetilde{y}^e = \widetilde{x}_1 - N - \widetilde{\gamma}$ contains an unknown quantity N of

intangible investments that is not a random variable and its distribution cannot be assessed. This implies that assessment of the joint distribution of $(\tilde{x}_2, \tilde{y}^e)$ *requires* that the unknown quantity N be replaced by some conjecture or point estimate that the market must make. We will find that indeed the market will be able to rationally and perfectly anticipate the firm's investment in intangibles. Our discussion of the Utopian regime suggests that, because of the complimentary nature of tangibles and intangibles, such a rational anticipation will take the form of a schedule $N(K)$. Now, given $N(K)$, the market perceives reported income as

$$\tilde{y}^e = \tilde{x}_1 - \tilde{\gamma} - N(K),$$

where for each K the quantity $N(K)$ is a given constant. The market must therefore assess the joint distribution of $(\tilde{x}_2, \tilde{y}^e)$ as Normal with,

$$\text{Cov}(\tilde{x}_2, \tilde{y}^e) = \text{Cov}(\tilde{x}_2, \tilde{x}_1 - \tilde{\gamma} - N(K)) = \text{Cov}(\tilde{x}_2, \tilde{x}_1) = \rho > 0.$$

Additionally, the market must assess $E(\tilde{y}^e) = E(\tilde{x}_1) - N(K) = \mu K^\alpha N(K)^\beta - N(K)$, $\text{Var}(\tilde{y}^e) = \sigma_x^2 + \sigma_\gamma^2$, and $E(\tilde{x}_2) = \mu K^\alpha N(K)^\beta$.

Inserting these assessments into the market's price schedule, yields:

$$\begin{aligned} P(K, y^e) &= y^e - K + \mu K^\alpha N(K)^\beta \\ &\quad + \frac{\rho}{\sigma_x^2 + \sigma_\gamma^2} \left[y^e - \mu K^\alpha N(K)^\beta + N(K) \right]. \end{aligned} \qquad (4.6)$$

From the firm's perspective, at date 0, the only random variable in (4.6) is the income $\tilde{y}^e$ that will be reported at date 1. Conditional on choosing an intangible investment of N and a tangible investment of K, the firm must expect reported income at date 1 to be $E_0(\tilde{y}^e) = E_0(\tilde{x}_1) - N = \mu K^\alpha N^\beta - N$. It is important to distinguish N from $N(K)$. N is the firm's *true* investment in intangibles and this quantity is controlled by the firm, while $N(K)$ is a market assessment that is embedded in the market's price schedule and is taken as given by the firm.

Since the firm maximizes its expectation of the date 1 price, it solves:

$$\begin{aligned} \text{Max}_{K,N} \ &\mu K^\alpha N^\beta - K - N + \mu K^\alpha N(K)^\beta \\ &+ \frac{\rho}{\sigma_x^2 + \sigma_\gamma^2} \left[\mu K^\alpha N^\beta - N - \mu K^\alpha N(K)^\beta + N(K) \right] \end{aligned} \qquad (4.7)$$

The first-order condition with respect to N yields,

$$\mu\beta K^\alpha N^{\beta-1} - 1 + \frac{\rho}{\sigma_x^2 + \sigma_\gamma^2}[\mu\beta K^\alpha N^{\beta-1} - 1] = 0$$

or, equivalently,

$$\mu\beta K^\alpha N^{\beta-1} = 1 \tag{4.8}$$

Equation (4.8) defines a relationship between N and K that the market can readily anticipate. Therefore the market's anticipation of intangible investments $N(K)$ must satisfy (4.8). The properties of $N(K)$ can be found by differentiating (4.8) with respect to K. This yields,

$$\mu\alpha\beta K^{\alpha-1} N(K)^{\beta-1} + \mu\beta(\beta-1)K^\alpha N(K)^{\beta-2} N'(K) = 0$$

or, equivalently,

$$N'(K) = \frac{\alpha}{1-\beta}\frac{N(K)}{K} > 0. \tag{4.9}$$

The first-order condition to (4.7) with respect to K yields,

$$2\mu\alpha K^{\alpha-1} N^\beta + N'(K) = 1. \tag{4.10}$$

Let us compare the firm's investments in the expensing regime to those in the Utopian regime. Analysis of (4.8), (4.9), and (4.10) provides the following results.

Proposition 4.1. The economic consequences of not measuring a firm's investment in intangibles are:

(i) The firm under-invests in both tangibles and intangibles.
(ii) The mix of tangibles and intangibles is inefficient and biased toward a greater proportion of tangibles in the firm's capital stock.
(iii) The degree of under-investment is independent of the noise in accounting measurements and depends only on the technological parameters, α and β.

Proof. First, I express equilibrium investments in the Utopian regime in a manner that facilitates comparison to the expensing regime. From (4.5), $N^\beta = K^\beta \left(\frac{\beta}{\alpha}\right)^\beta$. Substituting this expression into (4.3) gives,

$$K^{1-\alpha-\beta} = 2\mu\alpha^{1-\beta}\beta^\beta. \tag{4.11}$$

Similarly,

$$N^{1-\alpha-\beta} = 2\mu\alpha^\alpha\beta^{1-\alpha}. \tag{4.12}$$

Turning to the expensing regime, (4.8) yields $N^\beta = \frac{1}{\mu\beta}\frac{N}{K^\alpha}$. Inserting this expression into (4.10), using (4.9), and simplifying yields,

$$N = \frac{\beta}{\alpha}\left(\frac{1-\beta}{2-\beta}\right)K. \tag{4.13}$$

Inserting (4.13) back into (4.8) gives $\mu\beta K^\alpha \left(\frac{\beta}{\alpha}\right)^{\beta-1}\left(\frac{1-\beta}{2-\beta}\right)^{\beta-1}K^{\beta-1} = 1$, which upon simplification yields,

$$K^{1-\alpha-\beta} = \mu\alpha^{1-\beta}\beta^\beta\left(1 + \frac{1}{1-\beta}\right)^{1-\beta}. \tag{4.14}$$

Also, from (4.13), $N^{1-\alpha-\beta} = \left[\frac{\beta}{\alpha}\left(\frac{1-\beta}{2-\beta}\right)\right]^{1-\alpha-\beta}K^{1-\alpha-\beta}$. Substituting (4.14) into this expression and simplifying gives,

$$N^{1-\alpha-\beta} = \mu\alpha^\alpha\beta^{1-\alpha}\left(1 + \frac{1}{1-\beta}\right)^\alpha. \tag{4.15}$$

Comparing (4.14) to (4.11), it is clear that tangible investment in the expensing regime is strictly smaller than in the Utopian regime if $\left(1 + \frac{1}{1-\beta}\right)^{1-\beta} < 2$. This inequality follows from the fact that in general the function $f(x) = \left(1 + \frac{1}{x}\right)^x$ is strictly increasing in x and $1 < f(x) < 2$ for $0 < x < 1$. Also, $\left(1 + \frac{1}{1-\beta}\right)^\alpha < \left(1 + \frac{1}{1-\beta}\right)^{1-\beta}$ since the assumption $\alpha + \beta < 1$ implies $\alpha < 1 - \beta$. Therefore, it is clear from a comparison of (4.15) to (4.12) that intangible investments are also strictly smaller in the expensing regime than in the Utopian regime. Part (ii) of the proposition is proved by dividing (4.14) by (4.15) which yields,

$$\frac{K}{N} = \frac{\alpha}{\beta}\left(1 + \frac{1}{1-\beta}\right) > \frac{\alpha}{\beta}.$$

Finally, part (iii) of the proposition follows from visual inspection of (4.14) and (4.15). This completes the proof.   □

The intuition for why the expensing of intangibles causes under-investment is as follows. When investment in intangibles is not separated from true operating income, any such investment decreases reported income and a lower reported income is rationally interpreted as bad news by the market. Thus, there is an *informational* cost associated with investments in intangibles apart from the cash cost. In casual conversations, corporate managers report that the expensing of intangibles allows them to directly and immediately impact the bottom line by scaling back on intangible investments and that such earnings flexibility is valuable to them. Graham et al. (2005) find evidence that manager's sacrifice profitable projects that would reduce the chance of meeting short-term earnings targets. In an efficient market such incentives for scaling back are fully anticipated by the market, and the firm is priced accordingly. Rather than providing value, such earnings flexibility actually destroys value by adversely affecting the firm's future cash flows. The under-investment in tangible investments occurs because of the complimentarity with intangibles — the decrease in intangibles drags down the investment in tangibles by reducing its marginal returns. In a classic value relevance study, Lev and Sougiannis (1996) find that regressions that include an estimate of intangibles provide a better fit with observed prices and returns in the capital market than regressions that do not include such an estimate. This result is fully consistent with the analysis here, which indicates that the market forms a rational estimate of intangible investments and prices the firm in accordance with such an estimate. In fact, a regression that does not include an estimate of intangibles is misspecified, since it arbitrarily assumes that the investment in intangibles is zero. But by focusing *exclusively* on statistical correlations, value relevance studies *completely* miss the real effect of not measuring intangibles, viz., the actual investment in intangibles and therefore the object that is being estimated itself becomes smaller.

I now analyze the intangibles measurement regime. Recall that in this regime the measurement of both tangibles and intangibles is contaminated by noise. Therefore, the market must form beliefs about both kinds of investments in order to interpret and extract information from the reported cash balance and the reported income at date 1.

Let $\widehat{K}$, $\widehat{N}$ be the market's beliefs regarding investments in tangibles and intangibles, respectively. Given these beliefs, the market must perceive the reported cash balance as $\widetilde{z}^m = \widetilde{x}_1 - \widehat{K} - \widehat{N} - \widetilde{\gamma}$. As argued earlier, the market must also perceive the reported income as $\widetilde{y}^m = \widetilde{x}_1 + \widetilde{\omega}$. Thus, both $\widetilde{z}^m$ and $\widetilde{y}^m$ contain information about $\widetilde{x}_1$ and therefore about $\widetilde{x}_2$. Given $\widehat{K}$, $\widehat{N}$ the random vector $(\widetilde{z}^m, \widetilde{y}^m, \widetilde{x}_2)$ is joint Normally distributed with,

$$\mathrm{cov}(\widetilde{z}^m, \widetilde{x}_2) = \mathrm{cov}(\widetilde{x}_1, \widetilde{x}_2) = \rho$$
$$\mathrm{cov}(\widetilde{y}^m, \widetilde{x}_2) = \mathrm{cov}(\widetilde{x}_1, \widetilde{x}_2) = \rho$$
$$\mathrm{cov}(\widetilde{z}^m, \widetilde{y}^m) = \sigma_x^2$$
$$\mathrm{var}(\widetilde{y}^m) = \sigma_x^2 + \sigma_\omega^2$$
$$\mathrm{var}(\widetilde{z}^m) = \sigma_x^2 + \sigma_\gamma^2.$$

Additionally, the market must assess the prior expectations:

$$E(\widetilde{x}_2) = \mu \widehat{K}^\alpha \widehat{N}^\beta$$
$$E(\widetilde{z}^m) = \mu \widehat{K}^\alpha \widehat{N}^\beta - \widehat{K} - \widehat{N}$$
$$E(\widetilde{y}^m) = \mu \widehat{K}^\alpha \widehat{N}^\beta.$$

These assessments imply,

$$E(\widetilde{x}_2 | z^m, y^m, \widehat{K}, \widehat{N}) = \mu \widehat{K}^\alpha \widehat{N}^\beta + b_1(z^m - \mu \widehat{K}^\alpha \widehat{N}^\beta + \widehat{K} + \widehat{N})$$
$$+ b_2(y^m - \mu \widehat{K}^\alpha \widehat{N}^\beta), \qquad (4.16)$$

where

$$b_1 = \frac{\rho \sigma_\omega^2}{\sigma_x^2[\sigma_\omega^2 + \sigma_\gamma^2] + \sigma_\omega^2 \sigma_\gamma^2} \qquad (4.17)$$

$$b_2 = \frac{\rho \sigma_\gamma^2}{\sigma_x^2[\sigma_\omega^2 + \sigma_\gamma^2] + \sigma_\omega^2 \sigma_\gamma^2}. \qquad (4.18)$$

Since the equilibrium price in the market is $P(z^m, y^m, \widehat{K}, \widehat{N}) = z^m + E(\widetilde{x}_2 | z^m, y^m, \widehat{K}, \widehat{N})$, the firm chooses its actual investments K and N to solve:

$$\mathrm{Max}_{K,N}(1 + b_1)E_0(\widetilde{z}^m) + b_2 E_0(\widetilde{y}^m). \qquad (4.19)$$

In specifying the firm's problem in this manner, I have treated the market's estimates $\widehat{K}$ and $\widehat{N}$ as constants that are beyond the firm's control, consistent with the assumption that the firm takes the market's valuation rule as given. Thus the firm's problem collapses to the maximization of a weighted sum of its expected date 1 cash balance and its expected date 1 reported income. Inserting $E_0(\widetilde{z}^m) = \mu K^\alpha N^\beta - K - N$ and $E_0(\widetilde{y}^m) = \mu K^\alpha N^\beta$ into (4.19) and differentiating with respect to K and N yields the following characterization of the firm's equilibrium investments:

$$\mu \alpha K^{\alpha-1} N^\beta \left[1 + \frac{b_2}{1 + b_1} \right] = 1, \tag{4.20}$$

$$\mu \beta K^\alpha N^{\beta-1} \left[1 + \frac{b_2}{1 + b_1} \right] = 1. \tag{4.21}$$

Dividing (4.20) by (4.21) gives $\frac{N}{K} = \frac{\beta}{\alpha}$ which implies that in the intangibles measurement regime the firm combines tangible and intangible investments in the same efficient proportion that was derived for the Utopian regime. However, from (4.18), it is clear that the assumption $\rho \leq \sigma_x^2$ guarantees that $b_2 < 1$ which implies that the firm under-invests in both tangibles and intangibles relative to the Utopian regime. The weight on cash flows, $1 + b_1$, deters investment, while the weight on reported income b_2 encourages investment. This is because both higher net cash balance and higher reported income are viewed as good news by the market. Investments decrease a firm's net cash balance but increase a firm's reported income, hence the deterrence and encouragement noted above.

The relative weights that equilibrium market prices assign to reported cash flows and reported income is a very important statistic that begs additional empirical analysis. There is strong empirical evidence that both weights are positive (Bowen et al., 1987), but time series, cross sectional and inter-country comparisons are missing. In general, cash flows acquire information content when the accounting accruals embedded in reported income are noisy — so the variation in this statistic over time and across industries is indicative of differences in the "quality" of accounting. The reason why this statistic is important is that a greater relative weight on cash flows is a deterrent to

all actions taken by firms that decrease current cash flows but increase future cash flows, i.e., it promotes managerial myopia. This is the fundamental reason why it is so important for the accounting process to separate investments from cash flows due to operations. Kanodia and Mukherji (1996) develop this idea more fully.

I have argued earlier that the measurement of intangibles introduces two additional sources of noise in accounting data. The noise $\widetilde{\omega}$ arises from misclassifications of operating expenditures and investments, and this source of noise is one of the principal concerns expressed by FASB. The noise $\widetilde{\eta}$ arises due to misclassifications of tangible and intangible assets. Notice, from (4.17) and (4.18) that the noise due to the presence of $\widetilde{\eta}$ has no effect on the coefficients b_1 and b_2 that impact the firm's investment choices. This is because the effect of such noise is completely washed out in the calculation of reported cash flows and income. Yet the presence of $\widetilde{\eta}$ is essential to our analysis because if $\widetilde{\eta} \equiv 0$, the intangibles measurement regime would Blackwell dominate the expensing regime. The noise due to $\widetilde{\omega}$, that concerns FASB, does have an important effect on the firm's investments. From visual inspection of (4.17) and (4.18), it is apparent that an increase in σ_ω^2 increases the coefficient b_1 and decreases the coefficient b_2, thus decreasing the firm's investments.

Having characterized equilibrium investments in all three informational regimes, we can now shed light on the important policy question of whether intangibles should be measured or left comingled with operating expenses. The first important observation that emerges from our analysis is that policy questions are vacuous if the real effect of how changes in the disclosure regime affect the firm's investments is not taken into account. From a policy perspective, any disclosure regime must be evaluated *ex ante* to the release of accounting reports. If it is *assumed* that the firm's investments remain unchanged at some prespecified levels, say K^*, N^* then the *ex ante* value of the firm would be $2\mu(K^*)^\alpha(N^*)^\beta - K^* - N^*$ in all three disclosure regimes. Thus it would be moot whether intangibles are measured or expensed, even though the statistical associations between accounting data and stock prices would change with the disclosure regime. Different ways

of studying the issue may identify different sources of real effects, but consideration of such real effects is essential to the debate.

In order to compare the firm's investments in the intangibles measurement regime to those in the expensing regime, it is necessary to restate the investments characterized in (4.20) and (4.21) entirely in terms of the exogenous parameters, as we did for the Utopian regime and the expensing regime. Proceeding in analogous fashion, it can be verified that investments in the intangibles measurement regime are described by

$$K^{1-\alpha-\beta} = \mu \alpha^{1-\beta} \beta^{\beta} \left(1 + \frac{b_2}{1 + b_1} \right) \tag{4.22}$$

$$N^{1-\alpha-\beta} = \mu \alpha^{\alpha} \beta^{1-\alpha} \left(1 + \frac{b_2}{1 + b_1} \right). \tag{4.23}$$

Comparing (4.22) and (4.23) to (4.14) and (4.15), and noting that $\alpha < 1 - \beta$, investments in both tangibles and intangibles are smaller in the intangibles measurement regime if and only if:

$$\left(1 + \frac{b_2}{1 + b_1} \right) \leq \left(1 + \frac{1}{1 - \beta} \right)^{\alpha}.$$

Also, both kinds of investments are larger in the intangibles measurement regime than in the expensing regime if and only if,

$$\left(1 + \frac{b_2}{1 + b_1} \right) \geq \left(1 + \frac{1}{1 - \beta} \right)^{1-\beta}.$$

In the remaining case, defined by the inequalities:

$$\left(1 + \frac{1}{1 - \beta} \right)^{\alpha} < \left(1 + \frac{b_2}{1 + b_1} \right) < \left(1 + \frac{1}{1 - \beta} \right)^{1-\beta}$$

intangible investment is higher and tangible investment is lower in the intangibles measurement regime than in the expensing regime. All three cases can be evaluated in terms of the overall capital stock, which is $q = K^{\alpha} N^{\beta}$. Calculating the value of q for the expensing regime, from (4.14) and (4.15) and the value of q for the intangibles measurement

regime from (4.22) and (4.23) gives,

$$q^e = \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\mu^{\alpha+\beta} \alpha^\alpha \beta^\beta\right)^{\alpha+\beta-1} \qquad (4.24)$$

$$q^m = \left(1 + \frac{b_2}{1+b_1}\right)^{\frac{\alpha+\beta}{1-\alpha-\beta}} \left(\mu^{\alpha+\beta} \alpha^\alpha \beta^\beta\right)^{\alpha+\beta-1}. \qquad (4.25)$$

The following proposition follows immediately from inspection of (4.24) and (4.25).

Proposition 4.2. The firm's capital stock is larger (smaller) in the intangibles measurement regime than in the expensing regime if and only if:

$$\left(1 + \frac{b_2}{1+b_1}\right) > (<) \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{\alpha+\beta}}. \qquad (4.26)$$

Notice that the profitability parameter μ affects both disclosure regimes in the same way, and therefore says nothing about the measurement versus expensing debate. Arguments based on the profitability or magnitudes of investment are fallacious. The left-hand side of (4.26) depends only upon the amounts of measurement noise in the intangibles measurement regime, while the right-hand side depends only upon the technological parameters α and β. The key variable on the left-hand side is σ_ω^2, which represents the amount of measurement noise due to the confounding of intangible investments and operating expenditures, that is of concern to the FASB. The left-hand side decreases as σ_ω^2 becomes larger. The key variable on the right-hand side is the *proportion* of intangibles in the firm's capital stock if tangibles and intangibles were combined efficiently as in the Utopian regime. To see this, hold $\alpha + \beta$ fixed at some value $r < 1$, and consider variations in β alone. Thus an increase in β would imply a decrease in α which, in turn, would mean that in the Utopian regime the firm would have a larger proportion of intangibles in its capital stock. In terms of such variations, the result contained in Proposition 4.2 can be stated as

$$q^m > q^e \text{ if and only if } \left(1 + \frac{b_2}{1+b_1}\right) > \left(1 + \frac{1}{1-\beta}\right)^{\frac{r-\beta}{r}}. \qquad (4.27)$$

We can now prove the following result:

Proposition 4.3. Given any fixed level of noise (σ_ω^2) in the measurement of intangibles, measurement is preferred to expensing if the proportion of intangibles in the firm's capital stock is large enough. Conversely, given the proportion of intangibles in the firm's capital stock, measurement is preferred to expensing if the noise associated with measuring intangibles is small enough. In all other cases, expensing of intangibles is preferred to the measurement of intangibles.

Proof. Let $f(\beta)$ denote the right-hand side of (4.27). It can be shown that $f(\beta)$ is strictly decreasing in β. Since r is fixed, the range of β is the interval $[0, r]$. At $\beta = 0$, $f(\beta) = 2$ and at $\beta = r$, $f(\beta) = 1$. Let $T(\sigma_\omega^2)$ denote the left-hand side of (4.27) and note that T is strictly decreasing in σ_ω^2. As $\sigma_\omega^2 \to \infty$, $b_2 \to 0$ so that $T(\sigma_\omega^2) \to 1$. The upper bound on T is 2 which is attained when $\sigma_\omega^2 = 0$ and $\rho = \sigma_x^2$. Thus both $T(\sigma_\omega^2)$ and $f(\beta)$ vary over the interval $[1, 2]$. Since $f(\beta)$ is strictly decreasing, for each fixed value of σ_ω^2 there exists $\beta^*(\sigma_\omega^2)$ such that $\beta > \beta^* \Rightarrow q^m > q^e$. Conversely, since $T(\sigma_\omega^2)$ is strictly decreasing, for any fixed value of β there exists σ_ω^{2*} such that $\sigma_\omega^2 < \sigma_\omega^{2*} \Rightarrow q^m > q^e$. In all other cases, $T(\sigma_\omega^2) < f(\beta)$. This completes the proof. $\qquad\square$

I have expressed Proposition 4.3 in terms of a welfare statement, although strictly speaking it should be expressed in terms of capital stock being higher or lower in one disclosure regime than the other. Some justification for this is needed. Since the only economic agents in our analysis are current and prospective shareholders, welfare must relate to their payoffs. Within the confines of the current model, prospective shareholders always break even regardless of the disclosure regime because the equilibrium price in the market always reflects the expected cumulative cash flows to the firm's wealth creation activities. The economic agents who *are* affected by a change in the firm's wealth creation activities are the firm's current shareholders and their collective expected payoff is simply the expected date 1 price in the capital market which is $2\mu q - K - N$. Arguably, the higher this quantity is the higher is their welfare. We have examined variations in

q across disclosure regimes, but since capital stock is built efficiently in the intangibles measurement regime and inefficiently in the expensing regime, the amount of capital stock is not a perfect proxy for welfare. Proposition 7 in KSV (2004) examine welfare in terms of the aggregate payoffs to current shareholders. The calculations turn out to be more messy, but the results are qualitatively identical to our Proposition 4.3.

From a real effects perspective, I have shown that intangibles should be measured and reported separately only if the proportion of intangibles in the firm's capital stock (proxied by the fraction $\frac{\beta}{r}$) is large and if intangibles can be measured with sufficient precision. However, if measurement noise is large or if the proportion of intangibles is low then expensing of intangibles is the preferred accounting treatment. Aboody and Lev (1998) provide partial empirical support for these results. They find that firms with a larger software development intensity, proxied by the ratio of software development expenditure to sales, are more likely to choose capitalization over expensing of such expenditures. Our results are intuitively appealing. They also provide substance to the popular wisdom that there is a tradeoff between relevance and reliability that must be taken into account in the determination of disclosure requirements.

5

Real Effects of Periodic Performance Reports

In this chapter, I study another question that is of fundamental importance to accounting. What is the rationale for providing periodic performance reports, such as earnings statements, to the capital market? The obvious knee jerk reaction to this question is that such reports allow the capital market to make more accurate assessments of the firm's future cash flows, thereby making markets more efficient. From an *ex ante* perspective, this reasoning does not go far enough since the law of iterated expectations says that current expectations of updated expectations is equal to current expectations, i.e., it is logically inconsistent to expect future expectations to be different from what they currently are. In fact, if updating of beliefs is the *only* effect of releasing such reports, we will show it is socially optimal not to release them because they inhibit the transfer of risk and inhibit risky actions to be taken by the firm.

Two other answers that have greater merit are readily apparent. First, periodic performance reports could facilitate contracting between shareholders and the firm's manager for the purpose of better aligning the incentives of managers with those of shareholders. However, while this explanation has some obvious appeal, it fails to explain why

periodic performance reports such as earnings statements are widely dissemination to the public at large. Information that is used in private contracts with managers does not need this kind of public dissemination. Another apparent rationale for the periodic provision of earnings reports is that they allow the investment community to compare profitabilities across firms when there is need to allocate additional capital among competing firms who need it to fund new projects. Here, new investment occurs after release of the report. Hence, this kind of information is analogous to providing information about the quantity of rainfall to farmers who must choose which of different crops to plant. The troubling feature of this explanation is that the issuance of new equity in capital markets is a relatively rare event for any specific firm. The predominant source of funds for new investment projects is a firm's retained earnings.

Kanodia and Lee (KL) (1998) identify and develop a more subtle real effects role for the public dissemination of periodic performance reports. They show that such reports discipline a firm's investment made *a priori* to the release of these reports. Such a disciplinary role is obvious when performance reports are used for contracting purposes. However, KL show that even when the manager has no goal conflicts with the firm's current shareholders and benevolently strives to maximize the firm's value in the capital market, the anticipation of the performance report disciplines the manager's incentives and thereby changes not only the firm's investment but also allows that investment to convey incremental information to the capital market. In the absence of such reports, value maximizing managers would be encouraged to substitute the market's expectations for their own superior judgments, resulting in inefficient decisions. Thus, periodic performance reports alleviate the perversity of market-driven incentives (see Brandenburger and Polak (1996)) when the market is less informed than the firm's manager. KL also develop insights into how precise the performance report should be, given its disciplinary role. The discussion here is based on the Kanodia and Lee (1998) article.

Consider a setting where a small group of entrepreneurs initially own the firm and choose how much to invest in a technology whose returns are stochastic. The return horizon exceeds the consumption

horizon of the entrepreneurs, so that ownership of the firm changes
hands, at some interim date that lies between making the investment
and the realization of the final cash flow from that investment. The
price at which the firm is sold is determined in a competitive capi-
tal market. Since transfer of risk is an important consideration in the
present analysis, KL assume that both the firm's current owners and
the prospective buyers in the capital market are collectively risk averse.
Both groups have constant absolute risk aversion with aggregate risk
aversion parameter ρ for the entrepreneurs and λ for buyers in the cap-
ital market. Since potential buyers in the capital market constitute a
very large pool of investors each buying only a small fraction of the
firm, it is likely that the aggregate risk aversion in the capital market
is much smaller than the aggregate risk aversion of the entrepreneurs.
Specifically, KL assume that $\rho > 2\lambda$.

Let k denote the firm's investment and assume that the invest-
ment is publicly observed. However, the information underlying the
entrepreneurs choice of investment is known only to them and is hid-
den from the market. This information is summarized in a parameter μ.
Outsiders, not knowing μ, assess its probability density as $f(\mu)$ whose
support is the interval $[\underline{\mu}, \overline{\mu}]$ with $\underline{\mu} > 1$. The return to the firms invest-
ment $\widetilde{\theta}$ is described by,

$$\widetilde{\theta} = k[\mu + \widetilde{\gamma}], \tag{5.1}$$

where $\widetilde{\gamma}$ is a Normally distributed random variable with mean 0 and
variance σ_γ^2. Thus, conditional on knowing μ, $\widetilde{\theta}$ is Normally distributed,
the expected return to investment is $k\mu$ and the variance of return is
$k^2\sigma_\gamma^2$. Let P be the price at which the firm is sold. The entrepreneurs
consume $P - k$ while the new owners consume $\theta - P$.

Before the firm is sold, but after the investment has occurred, there
is a public release of a performance report $\widetilde{y}$. This performance report
should be thought of in the following way. Once the investment has
been made, sales and costs of whatever good is being manufactured
occur in a continuous fashion and get accumulated to arrive at the final
return of $\widetilde{\theta}$. The performance report reflects the accumulation that has
occurred till the point at which the firm is sold. Thus, the performance

report would usually contain information incremental to that contained in the initial information μ known to the entrepreneurs at the time of investment. Statistically, the performance report is described by

$$\widetilde{y} = k[\mu + \widetilde{\gamma} + \widetilde{\epsilon}], \tag{5.2}$$

where $\widetilde{\epsilon}$ is Normally distributed noise with mean 0 and variance σ_ϵ^2 and $\widetilde{\epsilon}$ is independent of $\widetilde{\gamma}$. Thus the performance report is an unbiased but noisy preview of the return to be ultimately realized. The objective function of the entrepreneurs is

$$\text{Max} - k + E(\widetilde{P}|\mu) - \frac{1}{2}\rho\,\text{var}(\widetilde{P}|\mu). \tag{5.3}$$

Given constant absolute risk aversion, this mean–variance specification is justified if the distribution of $\widetilde{P}$ is Normal, as will turn out to be the case.

I first examine the case where the *sole* purpose of the performance report is to update beliefs in the capital market regarding the return $\widetilde{\theta}$ to be realized in the future. This is the case when the parameter μ is *a priori* known in the capital market, rather than it being private information to the entrepreneurs. In this case, conditional on observation of the performance report y, the assessed distribution of $\widetilde{\theta}$ is Normal, with:

$$E(\widetilde{\theta}|y,k,\mu) = \beta y + (1-\beta)k\mu, \tag{5.4}$$

$$\text{var}(\widetilde{\theta}|y,k,\mu) = (1-\beta)k^2\sigma_\gamma^2, \tag{5.5}$$

where

$$\beta = \frac{\text{cov}(\widetilde{y},\widetilde{\theta})}{\text{var}(\widetilde{y})} = \frac{\sigma_\gamma^2}{\sigma_\gamma^2 + \sigma_\epsilon^2}. \tag{5.6}$$

Then, using standard results in Finance, the equilibrium price in the capital market is

$$\begin{aligned} P(y,k,\mu) &= E(\widetilde{\theta}|y,k,\mu) - \lambda\,\text{var}(\widetilde{\theta}|y,k,\mu) \\ &= \beta y + (1-\beta)k\mu - \lambda(1-\beta)k^2\sigma_\gamma^2. \end{aligned} \tag{5.7}$$

Thus entrepreneurs assess,

$$E(\widetilde{P}) = k\mu - \lambda(1 - \beta)k^2\sigma_\gamma^2,$$

$$\text{var}(\widetilde{P}) = \beta^2\text{var}(\widetilde{y}) = \frac{k^2\sigma_\gamma^4}{\sigma_\gamma^2 + \sigma_\epsilon^2} = \beta k^2\sigma_\gamma^2.$$

Inserting these assessments into (5.3), the firm's objective function becomes

$$\text{Max} - k + k\mu - k^2\sigma_\gamma^2\left[\beta\frac{1}{2}\rho + (1 - \beta)\lambda\right]. \tag{5.8}$$

Notice that the risk aversion incorporated into the firm's objective function is a weighted average of the aggregate risk aversion of the firm's current owners and the aggregate risk aversion in the capital market. Since $\rho > 2\lambda$, the payoff to the firm's current owners is a strictly decreasing function of β, regardless of the investment that is chosen. This implies that, if the firm's current owners were to choose the precision of the performance report, they would make σ_ϵ^2 arbitrarily large thus reducing the value of β to zero, which is equivalent to not releasing any performance report. If we explicitly model the preferences of the new owners and derive their optimal portfolios and their equilibrium payoffs, it would turn out that the new owners also do not want a performance report to be released.

Additionally, the performance report has an adverse impact on the firm's optimal investment. The firm's choice of investment is described by the first-order condition to (5.8):

$$k = \frac{\mu - 1}{2\sigma_\gamma^2[\beta\frac{1}{2}\rho + (1 - \beta)\lambda]}.$$

Notice that the firm's investment is strictly decreasing in β. The reason for these perverse consequences of releasing a performance report is that it inhibits the transfer of risk.[1] To see this more clearly, consider the case where $\sigma_\epsilon^2 = 0$, so that the performance report perfectly reveals the value of θ. In this case the equilibrium price of the firm would be θ, and all of the risk associated with the firm's investment would be

---

[1] The result that the release of information destroys risk sharing was first derived in Hirshleifer (1971) and subsequently exploited in Diamond (1985).

borne by the firm's current owners. But, since the firm's current owners have higher risk aversion than the aggregate risk aversion in the capital market, it is more efficient for the risk to be transferred to the capital market than for the firm's current owners to bear it. It is also more efficient for investment to be governed by the lower risk aversion in the capital market than the higher risk aversion of the firm's current owners, as would be the case if there were no performance report. These results are summarized in:

Proposition 5.1. If the sole purpose of periodic performance reports is to allow the capital market to form more accurate assessments of the firm's future cash flows from investments that have already been made, then it is socially desirable that there be no performance reports.

The message contained in Proposition 5.1 is inconsistent with one of the central features of accounting and the common sense wisdom that periodic performance reports are very important to the smooth functioning of the capital market. Yet, if performance reports are viewed purely as post-decision signals of how well the firm is doing, there would be no external demand for such reports. Of course, it is inevitable that performance reports will trigger Bayesian revisions of future cash flows. But the result here suggests that there must be some other role that is simultaneously fulfilled by performance reports. This additional role, disciplinary in nature, is developed below.

Suppose, now, that the *ex ante* profitability μ of the firm's investment is privately known only to the current owners of the firm. In order to gain some insight into the tradeoffs determining the optimal precision of the performance report, we allow the firm's current owners to choose both the precision of the performance report as well as the firm's investment after observing μ, and assume that both these choices are observed by the capital market. Since there is a one-to-one correspondence between σ_ϵ^2 and β, as calculated in (5.6), we will, with some abuse of notation, think of β as the precision of the performance report and imagine that the current owners choose β rather than σ_ϵ^2. $\beta = 1$ corresponds to infinite precision of the performance report and $\beta = 0$ is equivalent to the absence of a performance report.

In this setting, the firm's decision policy is described by two schedules $\{k(\mu), \beta(\mu)\}$. If these are non-trivial functions of μ they would contain information on the value of μ that must have been observed by the firm's current owners. In addition the performance report $\widetilde{y} = k[\mu + \widetilde{\gamma} + \widetilde{\epsilon}]$ contains information on μ. Since the information content of $\{k, \beta\}$ is endogenously determined, it may seem difficult to specify the inferential problem that the capital market faces. However, suppose that, in equilibrium, either $k(\mu)$ or $\beta(\mu)$ or some function of k and β is strictly monotone in μ. Then, in equilibrium, the capital market would make a perfect inference of μ from the firm's observed choices. If, given such an inference, the performance report contained no additional information about θ, the performance report would be ignored, and if it is ignored it will turn out that the firm's choices would contain no information about μ. But notice that, as specified, the performance report is incrementally informative even if the capital market believes it knows the precise value of μ. Suppose the market infers that the value of μ is $\widehat{\mu}$. Then the market must believe that the *prior* distribution of $\widetilde{\theta}$ is Normal with mean $k\widehat{\mu}$ and variance $k^2\sigma_\gamma^2$, and given observation of a performance report y the *posterior* distribution of $\widetilde{\theta}$ is also Normal with $E(\widetilde{\theta}|y) = \beta y + (1 - \beta)k\widehat{\mu}$ and $\text{var}(\widetilde{\theta}|y) = (1 - \beta)k^2\sigma_\gamma^2$, as specified in (5.4) and (5.5). In other words, I am conjecturing an inferential process where the market infers the prior distribution of $\widetilde{\theta}$ from the firm's observed choices, and uses this inferred prior distribution together with the performance report to calculate a posterior distribution of $\widetilde{\theta}$. I will show that this inferential process is sustained only because the performance report disciplines the firm's choices while simultaneously providing incremental information about $\widetilde{\theta}$.

Before constructing an equilibrium, it is useful to precisely develop the disciplinary role of performance reports. Suppose the capital market believed that the firm of type μ' would choose the pair $\{k', \beta'\}$ and that the firm of type $\widehat{\mu} > \mu'$ would choose the pair $\{\widehat{k}, \widehat{\beta}\}$, $\widehat{k} > k'$. Then if the firm of type μ' chooses $\{\widehat{k}, \widehat{\beta}\}$, the market would infer that it is of type $\widehat{\mu}$ and would price the firm accordingly, even though its true type is μ'. Thus,

$$P(y, \widehat{k}, \widehat{\beta}) = \widehat{\beta}y + (1 - \widehat{\beta})\widehat{k}\widehat{\mu} - \lambda(1 - \widehat{\beta})\widehat{k}^2\sigma_\gamma^2.$$

But, at the time the firm chooses an investment of $\widehat{k}$, the performance report $\widetilde{y}$ is a random variable. The firm knowing that it is truly of type μ' must expect the performance report to have value $E(\widetilde{y}|\widehat{k}, \mu') = \widehat{k}\mu'$. Therefore, at the time the firm chooses an investment of $\widehat{k}$, it must *expect* a market price of

$$
\begin{aligned}
E[P(\widetilde{y}, \widehat{k}, \widehat{\beta})|\mu'] &= \widehat{\beta}\widehat{k}\mu' + (1 - \widehat{\beta})\widehat{k}\widehat{\mu} - \lambda(1 - \widehat{\beta})\widehat{k}^2\sigma_\gamma^2 \\
&= E[P(\widetilde{y}, \widehat{k}, \widehat{\beta})|\widehat{\mu}] - \widehat{\beta}\widehat{k}[\widehat{\mu} - \mu'].
\end{aligned}
$$

Because the distribution of the performance report is affected by the firm's *true* profitability not by the profitability assessed by the market, *in expectation* the firm of type μ' is precluded from receiving the price that the higher type $\widehat{\mu}$ would receive, even if it were to choose the actions that type $\widehat{\mu}$ would choose. The term $\widehat{\beta}\widehat{k}[\widehat{\mu} - \mu']$ is like a punishment inflicted on the firm for masquerading to be of higher type than it truly is. When the firm behaves as if it were some higher type $\widehat{\mu}$, the firm bears all of the costs of the higher investment of type $\widehat{\mu}$, and all of the costs of (possibly) a more precise level of disclosure, but does not receive the full benefit of doing so. In the absence of a performance report there would be no such punishment and therefore no discipline on the firm's choices. Notice that the bigger the value of $\widehat{\beta}$, i.e., the more precise the performance report, the more severe is the punishment. Thus, there is an endogenous cost-benefit tradeoff that would determine the precision of the performance report. Greater precision is costly because it results in a greater inhibition of risk transfer, but is beneficial because it provides greater discipline on the firm's choices.

There is another way in which the disciplinary role of performance reports can be visualized. The net expected payoff to the firm's current owners from any $\{k, \beta\}$ choice when the firm's true profitability is μ' and the inferred profitability is $\widehat{\mu}$ is

$$
\begin{aligned}
&- k + E[P(\widetilde{y}, k, \beta)|\mu'] - \frac{1}{2}\rho\,\text{var}(P(\cdot)|\mu') \\
&= -k + \beta k\mu' + (1 - \beta)k\widehat{\mu} - \lambda(1 - \beta)k^2\sigma_\gamma^2 - \frac{1}{2}\rho\beta k^2\sigma_\gamma^2 \\
&= \beta\left[k\mu' - k - \frac{1}{2}\rho k^2\sigma_\gamma^2\right] + (1 - \beta)\left[k\widehat{\mu} - k - \lambda k^2\sigma_\gamma^2\right].
\end{aligned}
$$

Thus, given a performance report of precision β and given that the firm's current owners sell their holdings before the returns to investment are realized, the expected payoff to the firm's current owners is a weighted average of two expected payoffs. The term multiplying β is the expected payoff to current shareholders if they did not sell their holdings at the interim date and held the firm until its liquidation, and the term multiplying $(1 - \beta)$ is the expected payoff to prospective shareholders if their assessment of profitability is $\widehat{\mu}$ and if they had owned the firm from inception till liquidation. In effect, a performance report issued prior to sale partially binds the firm's current shareholders to the consequences of their actions even though the firm is sold before those consequences are realized. It is as if the current shareholders retain the fraction β of the firm for themselves and sell only the remaining fraction $(1 - \beta)$. Leland and Pyle (1977) show that the fraction of equity retained by insiders is a useful signalling device when insiders are better informed than outsiders. However, in the Leland and Pyle analysis the firm's cash flows are exogenous and there are no decisions that insiders make other than the fraction of equity retained by them. In our analysis the firm's observable investment is endogenously chosen and therefore could by itself communicate information. In fact, we will show that the firm's investment serves as the primary signal while the performance report plays a disciplinary role that sustains the investment signal.

I now proceed to characterize the equilibrium investment and disclosure schedules $\{k(\mu), \beta(\mu)\}$. Given the discipline imposed by performance reporting, it is a good guess that the equilibrium will have the form of a fully revealing signalling equilibrium. However, in constructing such an equilibrium we must resolve a difficult technical problem. In the usual signalling equilibria, characterized by Spence (1974) and many others, the action that conveys information is *a priori* known (for example, the level of education in Spence's model, the fraction of equity retained by insiders in the Leland and Pyle (1977) model, and the dividends paid by a firm in the Bhattacharya (1979) model). In the setting under study, the firm takes two actions (k and β) and its type is one dimensional. Thus, unlike the usual signalling models, we must determine an efficient *mix* of signals, and we must face the possibility

that information is extracted from some unknown endogenous function of k and β. KL show that such signalling equilibria can be constructed by using optimal control theory techniques to solve mechanism design problems. This technique, which may be of independent interest, is illustrated below.

Any fully revealing equilibrium schedules $\{k(\mu), \beta(\mu)\}$ must satisfy the following incentive compatibility constraints:

$$
\begin{aligned}
-k(\mu) &+ k(\mu)\mu - \lambda(1 - \beta(\mu))k^2(\mu)\sigma_\gamma^2 - \frac{1}{2}\rho\beta(\mu)k^2(\mu)\sigma_\gamma^2 \\
&\geq -k(\widehat{\mu}) + \beta(\widehat{\mu})k(\widehat{\mu})\mu + (1 - \beta(\widehat{\mu}))k(\widehat{\mu})\widehat{\mu} - \lambda(1 - \beta(\widehat{\mu}))k^2(\widehat{\mu})\sigma_\gamma^2 \\
&\quad - \frac{1}{2}\rho\beta(\widehat{\mu})k^2(\widehat{\mu})\sigma_\gamma^2, \quad \forall \mu, \widehat{\mu}.
\end{aligned} \tag{5.9}
$$

The left-hand side of (5.9) is the expected payoff to the firm's current owners if they choose the $\{k, \beta\}$ pair that corresponds to their true type μ, while the right-hand side of (5.9) is their expected payoff if they choose the $\{k, \beta\}$ pair that corresponds to some other type $\widehat{\mu}$. Define $\alpha \equiv \frac{1}{2}\rho - \lambda > 0$. Then the incentive compatibility constraints can be rewritten as:

$$
\begin{aligned}
k(\mu)[\mu - 1] &- k^2(\mu)\sigma_\gamma^2[\lambda + \alpha\beta(\mu)] \\
&\geq k(\widehat{\mu})[\widehat{\mu} - 1] - k^2(\widehat{\mu})\sigma_\gamma^2[\lambda + \alpha\beta(\widehat{\mu})] - \beta(\widehat{\mu})k(\widehat{\mu})[\widehat{\mu} - \mu].
\end{aligned} \tag{5.10}
$$

Define $V(\mu) \equiv$ the left-hand side of (5.10). Then the incentive compatibility constraints are equivalent to

$$
V(\mu) \geq V(\widehat{\mu}) - \beta(\widehat{\mu})k(\widehat{\mu})[\widehat{\mu} - \mu], \quad \forall \mu, \widehat{\mu}.
$$

The following lemma is established using exactly the same techniques we earlier used to prove Proposition 3.2.

Lemma 5.2. The schedules $\{k(\mu), \beta(\mu)\}$ are fully revealing and incentive compatible if and only if:

    (i) $V'(\mu) = \beta(\mu)k(\mu)$, and
    (ii) $\beta(\mu)k(\mu)$ is strictly increasing in μ.

Now consider the optimal control problem:

$$\text{Max}_{\{k(\mu),\beta(\mu)\}} \int_{\underline{\mu}}^{\overline{\mu}} V(\mu)f(\mu)d\mu$$

subject to

$$V(\mu) = k(\mu)[\mu - 1] - k^2(\mu)\sigma_\gamma^2[\lambda + \alpha\beta(\mu)]$$
$$V'(\mu) = \beta(\mu)k(\mu).$$

(5.11)

Lemma 5.2 guarantees that the solution to this control problem is optimal and incentive compatible, provided that the solution has the property that the product βk is strictly increasing in μ. Let $L(\mu)$ be the Lagrange multiplier associated with the differential constraint $V'(\mu) = \beta(\mu)k(\mu)$. Then differentiating the Hamiltonian to the above control problem with respect to $k(\mu)$ and $\beta(\mu)$, respectively, yields the necessary conditions:

$$\{\mu - 1 - 2k(\mu)\sigma_\gamma^2[\lambda + \alpha\beta(\mu)]\}f(\mu) + L(\mu)\beta(\mu) = 0, \text{ and}$$
$$\{-k^2(\mu)\alpha\sigma_\gamma^2\}f(\mu) + L(\mu)k(\mu) = 0.$$

In specifying the second of these necessary conditions as an equality, I have claimed that the solution for β is interior. This claim will be verified later. Dividing the first of the necessary conditions by the second, yields

$$\frac{\mu - 1 - 2k(\mu)\sigma_\gamma^2[\lambda + \alpha\beta(\mu)]}{-k^2(\mu)\alpha\sigma_\gamma^2} = \frac{\beta(\mu)}{k(\mu)}.$$

(5.12)

Solving (5.12) for $k(\mu)$ gives

$$k(\mu) = \frac{\mu - 1}{\sigma_\gamma^2[2\lambda + \alpha\beta(\mu)]}.$$

(5.13)

Equation (5.12) is a requirement on the marginal rate of substitution between k and β at each value of μ. Solving it gives the *optimal relationship*, (5.13), between the level of investment and the precision of the performance report at each value of μ, taking into account the need for incentive compatibility. Equation (5.13) also indicates that the firm over-invests at each μ. To see this, suppose the value of β is exogenously fixed at some positive level, and suppose we optimize over k alone ignoring the need for incentive compatibility. In this case the

firm's optimal investment would be,

$$k(\mu) = \frac{\mu - 1}{2\sigma_\gamma^2[\lambda + \alpha\beta]},$$

which is a smaller level of investment than that described by (5.12). The over-investment is not solely due to the usual need to deter lower types from mimicking higher types. It is also motivated by the need to combine the two signals k and β in an efficient manner. At the exogenously fixed β, $\partial V/\partial\beta < 0$ and at first best investment levels $\partial V/\partial k = 0$. Therefore, starting from first best investment, an increase in k has only a small second-order effect on the expected payoff of the firm's current owners, while a decrease in β has a larger first-order effect. Thus efficiency dictates that the firm should increase its investment above first best and decrease the precision of its disclosure upto the point at which the marginal costs of each are appropriately balanced.

In order to claim that the solution to (5.11) describes the equilibrium investment and disclosure schedules, we must verify that the solution has the monotone property required in Lemma 5.2, i.e., we must verify that the product $k\beta$ is strictly increasing in μ. This is proved in the following proposition.

Proposition 5.3. The solution to (5.11) has the following properties:

$$k'(\mu) = \frac{\beta(\mu)}{2\lambda\sigma_\gamma^2} \tag{5.14}$$

$$\frac{\partial\{\beta(\mu)k(\mu)\}}{\partial\mu} = \frac{1 - \beta(\mu)}{\alpha\sigma_\gamma^2}. \tag{5.15}$$

Proof. We earlier defined $V(\mu) \equiv k(\mu)[\mu - 1] - k^2(\mu)\sigma_\gamma^2[\lambda + \alpha\beta(\mu)]$. Inserting the solution for $k(\mu)$ described in (5.13) gives

$$V(\mu) = \frac{(\mu - 1)^2}{\sigma_\gamma^2[2\lambda + \alpha\beta(\mu)]} - \frac{(\mu - 1)^2(\lambda + \alpha\beta(\mu))}{\sigma_\gamma^2[2\lambda + \alpha\beta(\mu)]^2}$$

$$= \lambda\sigma_\gamma^2\frac{(\mu - 1)^2}{[2\lambda + \alpha\beta(\mu)]^2} = \lambda\sigma_\gamma^2 k^2(\mu). \tag{5.16}$$

Differentiating with respect to μ,

$$V'(\mu) = 2\lambda\sigma_\gamma^2 k(\mu)k'(\mu).$$

But, since $k(\mu)$ is incentive compatible it must satisfy $V'(\mu) = \beta(\mu)k(\mu)$. Equating the right-hand sides of these last two equations gives (5.14). Now, to prove (5.15) rewrite (5.13) as,

$$k(\mu)[2\lambda + \alpha\beta(\mu)] = \frac{(\mu - 1)}{\sigma_\gamma^2}.$$

Differentiating this expression with respect to μ gives,

$$k'(\mu)[2\lambda + \alpha\beta(\mu)] + k(\mu)\alpha\beta'(\mu) = \frac{1}{\sigma_\gamma^2},$$

which is equivalent to,

$$k'(\mu)\beta(\mu) + k(\mu)\beta'(\mu) = \frac{1}{\alpha\sigma_\gamma^2} - \frac{k'(\mu)2\lambda}{\alpha}.$$

But from (5.14), $k'(\mu)2\lambda = \frac{\beta(\mu)}{\sigma_\gamma^2}$. Substituting this into the right-hand side of the previous equation gives (5.15).

Equation (5.14) of Proposition 5.3 establishes that the optimal investment schedule $k(\mu)$ is strictly increasing at each μ where $\beta(\mu) > 0$, and Equation (5.15) establishes that the product βk is strictly increasing at each μ where $\beta(\mu) < 1$. We will establish below that $0 < \beta(\mu) < 1$ at each $\mu > \underline{\mu}$ and $\beta(\underline{\mu}) = 0$. Thus the optimal investment schedule, by itself, is fully revealing. $\qquad\square$

Proposition 5.4.
    (i) $\beta(\underline{\mu}) = 0$
    (ii) $\beta(\mu) > 0, \forall \mu > \underline{\mu}$

Proof. From (i) of Lemma 5.2,

$$V(\mu) = V(\underline{\mu}) + \int_{\underline{\mu}}^{\mu} \beta(t)k(t)dt.$$

Therefore $\{\beta(\underline{\mu}), k(\underline{\mu})\}$ affect $V(\mu)$ only through $V(\underline{\mu})$, and the bigger the value of $V(\underline{\mu})$ the bigger is $V(\mu)$ at each $\mu > \underline{\mu}$. Therefore

$\{\beta(\underline{\mu}), k(\underline{\mu})\}$ must maximize $V(\mu)$, implying that they must be the first best quantities: $\beta(\underline{\mu}) = 0$ and $k(\underline{\mu}) = \frac{\mu - 1}{2\lambda\sigma_\gamma^2}$. Now, consider any pair of types $\mu_2 > \mu_1$. The incentive compatibility constraints require,

$$V(\mu_1) \geq V(\mu_2) - \beta(\mu_2)k(\mu_2)[\mu_2 - \mu_1]. \tag{5.17}$$

Suppose, to the contrary that $\beta(\mu_2) = 0$. Then using (5.16), the right-hand side of (5.17) becomes,

$$\begin{aligned}
V(\mu_2) - \beta(\mu_2)k(\mu_2)[\mu_2 - \mu_1] &= \lambda\sigma_\gamma^2 \frac{(\mu_2 - 1)^2}{[2\lambda]^2} \\
&> \lambda\sigma_\gamma^2 \frac{(\mu_1 - 1)^2}{[2\lambda]^2} \\
&\geq \lambda\sigma_\gamma^2 \frac{(\mu_1 - 1)^2}{[2\lambda + \alpha\beta(\mu_1)]^2} = V(\mu_1).
\end{aligned}$$

Therefore if $\beta(\mu_2) = 0$ the incentive compatibility requirement (5.17) cannot be satisfied, and necessarily $\beta(\mu_2) > 0$.

I now proceed to precisely characterize the equilibrium $\beta(\mu)$ schedule. Since (5.13) characterizes the optimal investment schedule as a function of the optimal disclosure schedule, the latter schedule is that specific $\beta(\mu)$ that reconciles (5.13) with the incentive compatibility requirements. Since, by definition, $V(\mu) \equiv k(\mu)[\mu - 1] - k^2(\mu)\sigma_\gamma^2[\lambda + \alpha\beta(\mu)]$,

$$\begin{aligned}
V'(\mu) = {}&k'(\mu)[\mu - 1] + k(\mu) - 2\sigma_\gamma^2 k(\mu)k'(\mu)[\lambda + \alpha\beta(\mu)] \\
&- k^2(\mu)\sigma_\gamma^2\alpha\beta'(\mu).
\end{aligned}$$

Therefore the incentive compatibility requirement $V'(\mu) = \beta(\mu)k(\mu)$ is equivalent to:

$$k'(\mu)\left[\frac{\mu - 1}{k(\mu)} - 2\sigma_\gamma^2[\lambda + \alpha\beta(\mu)]\right] = \beta(\mu) - 1 + \alpha\sigma_\gamma^2 k(\mu)\beta'(\mu).$$

Substitute for $k(\mu)$ from (5.13) and for $k'(\mu)$ from (5.14) in the left-hand side of the proceeding equation. This yields,

$$\beta' k\alpha\sigma_\gamma^2 2\lambda = 2\lambda - 2\lambda\beta - \alpha\beta^2, \tag{5.18}$$

where the arguments of functions have been suppressed. Equation (5.18) is used to prove the following result. $\qquad\square$

Proposition 5.5. There exists an upper bound $\beta_{\max}$, $0 < \beta_{\max} < 1$ such that $\beta(\mu) \leq \beta_{\max}$, $\forall \mu$. $\beta'(\mu) > 0$ whenever $\beta(\mu) < \beta_{\max}$.

Proof. The right-hand side of (5.18) is strictly decreasing in β, strictly positive at $\beta = 0$, and strictly negative at $\beta = 1$. Therefore the equation $2\lambda - 2\lambda\beta - \alpha\beta^2 = 0$ has a unique solution $\beta_{\max}$ that satisfies $0 < \beta_{\max} < 1$. For each $\beta < \beta_{\max}$ the right-hand side of (5.18) is strictly positive indicating that $\beta'(\mu) > 0$. Additionally, (5.18) implies that if there exists some $\widehat{\mu}$ such that $\beta(\widehat{\mu}) = \beta_{\max}$ then $\beta(\mu) = \beta_{\max}$ at each $\mu > \widehat{\mu}$.

Inserting the expression for $k(\mu)$ derived in (5.13) into (5.18) yields the first-order nonlinear differential equation:

$$\beta'(\mu)\alpha(\mu - 1) = \left(\frac{2\lambda + \alpha\beta(\mu)}{2\lambda}\right)\left[2\lambda - 2\lambda\beta(\mu) - \alpha\beta^2(\mu)\right]. \quad (5.19)$$

The equilibrium disclosure schedule is the solution to this differential equation with the added initial condition $\beta(\underline{\mu}) = 0$. The solution is characterized in the following proposition. $\qquad\square$

Proposition 5.6. The equilibrium disclosure schedule $\beta(\mu)$ is characterized by:

$$\text{Log}\left[\frac{2\lambda + \alpha\beta}{\sqrt{2\lambda}\sqrt{2\lambda - 2\lambda\beta - \alpha\beta^2}}\right]$$
$$-\frac{\lambda}{\sqrt{\lambda^2 + 2\lambda\alpha}}\left[\tanh^{-1}\frac{\lambda + \alpha\beta}{\sqrt{\lambda^2 + 2\lambda\alpha}} - \tanh^{-1}\frac{\lambda}{\sqrt{\lambda^2 + 2\lambda\alpha}}\right]$$
$$= \text{Log}\left[\frac{\mu - 1}{\underline{\mu} - 1}\right]. \quad (5.20)$$

Proof. See Kanodia and Lee (1998), Theorem 4.

Since (5.20) describes the optimal values of β entirely in terms of exogenous parameters, the equilibrium can be constructed by first solving (5.20) for β at each μ, inserting that solution into (5.13) and solving for the value k at each μ. $\qquad\square$

I have shown that the equilibrium has the following features. Firms with higher profitability will want to release more precise performance reports. However, there is an endogenous upper bound to the precision of performance reports that arises from the desire to transfer risk from the firm's current owners to a less risk averse capital market. The main function served by the performance report is to make the firm's current owners accountable for their actions when they sell out before the consequences of those actions are realized. Thus, the performance report disciplines the actions of current owners and the discipline is such that those actions acquire information content. Without this disciplinary role, performance reports would serve no useful purpose. More precise performance reports provide greater discipline, and enhanced discipline is valuable because it allows the firm to decrease its over-investment. However, greater precision in the performance report more severely inhibits the transfer of risk. The optimal precision of performance reports is determined by trading off these costs and benefits.

6

Real Effects of Accounting for Derivatives

Accounting for derivatives and hedging activities is currently governed by SFAS 133. Two years prior to the June 1998 adoption of SFAS 133 the FASB issued an exposure draft ED 162-B that produced considerable controversy and criticism from industry leaders. Under the new standard, firms are required to account for derivatives as assets and liabilities and measure them at fair market value. Fluctuations in fair market value are recorded as gains or losses in the income statement (or comprehensive income). To the extent that derivatives are used as hedging instruments the gains or losses on derivatives are offset by corresponding gains or losses on the underlying assets, liabilities or future transactions whose cash flows are being hedged. However, ED 162-B allowed such offsets to be recorded only under very stringent verifiability conditions. These conditions were somewhat relaxed in response to industry pressure, but still exclude many genuine hedging activities such as cash flow hedges. Industry leaders pointed out that most derivative transactions are used for hedging of external financial risks arising from interest rates, currency exchange rates, commodity and equity prices. They argued that the non-recognition of offsetting effects would lead to a significant increase in the volatility of reported income which

is not reflective of the true risks undertaken by firms. It was argued that requiring firms to report in the manner prescribed by ED 162-B would have the *real effect* of discouraging prudent risk management.

The FASB was treating derivatives as *incremental* risks undertaken by firms while industry leaders were arguing that they use derivatives mainly to manage their business risk *downwards*. Perhaps the FASB was responding to the scandals of Orange County, Barings Bank and other incidents of large derivative losses that received much public visibility. Unfortunately, it is true that derivatives can be used both for speculation and for hedging purposes and it is difficult to separate the two contributing factors. I will show that whenever a firm's expectation of the future spot price does not coincide with the current price in the futures market, some component of its derivative position will be speculative in nature even though the firm is primarily motivated by hedging needs. I will show that the confounding of speculative and hedge components of firms' derivative positions has many harmful *real* consequences that have not been adequately considered in accounting policy debates. The fair value treatment of derivatives, without recognition of corresponding offsets arising from inherent risk exposures, does not alleviate this confounding problem and in some circumstances could actually exacerbate the harmful consequences. The expressed concern for increased volatility of reported income is only the tip of an iceberg.

Kanodia, Mukherji, Sapra and Venugopalan (KMSV) (2000) studied the effect of such confounding on the informational efficiency of futures prices and the resultant effect on the production decisions of firms in the industry. Melumad et al. (1999) studied how comprehensive fair value hedge accounting would change a firm's risk management strategy. Sapra (2001) studied the effect of hedge accounting on firms' speculation policies, and Gigler et al. (2007) studied how the confounding of hedging and speculation would sometimes lead to perverse inferences regarding firms' financial viability in the presence of large reported losses on derivatives. I focus here on the KMSV (2000) paper to illustrate how a study of real effects sheds light on hedge accounting issues.

Consider an industry, such as wheat farming, populated by a large number of farmers behaving as price takers. Farmers commit resources

to wheat planting today (date 1) but the wheat is harvested and sold in a spot market nine months later (date 2). The date 2 price, $\widetilde{p}$, that will prevail in the spot market is uncertain, due to random shocks to wheat demand and wheat production. Farmers are risk averse with identical constant absolute risk aversion ρ. At date 1, there is a futures market in wheat in which farmers can hedge the spot price uncertainty and/or take speculative positions. The price in the futures market, p_f, will be determined endogenously. If farmer i produces q_i units of wheat and sells z_i units of wheat futures, the farmer's profit is the random quantity,

$$\widetilde{\omega}_i = z_i p_f + (q_i - z_i)\widetilde{p} - \frac{q_i^2}{2k}. \tag{6.1}$$

I use the convention that positive amounts of z_i denote sales of wheat futures and negative amounts denote purchases of wheat futures. Having sold z_i units in the futures market, the quantity $(q_i - z_i)$, which could be positive or negative, represents the amount of wheat that the farmer trades in the spot market. The quantity $\frac{q_i^2}{2k}$ represents the cost of wheat production. If $\widetilde{p}$ is Normally distributed with assessed mean $E_i(\widetilde{p})$ and assessed variance $\text{var}_i(\widetilde{p})$, the farmer's objective function can be written as

$$\text{Max}_{q_i, z_i} \left(z_i p_f + (q_i - z_i)E_i(\widetilde{p}) - \frac{q_i^2}{2k} - \frac{1}{2}\rho(q_i - z_i)^2 \text{var}_i(\widetilde{p}) \right) \tag{6.2}$$

I now establish a key separation result[1] that underlies all of the analysis here.

Proposition 6.1. A farmer's choice of production is independent of his risk aversion and his beliefs about the spot price $\widetilde{p}$, and depends only upon his marginal cost of production and the futures price p_f. His optimal production is described by,

$$q_i = k p_f \tag{6.3}$$

---

[1] This separation result was first derived by Danthine (1978). It holds for all risk averse utilities and all distributions of $\widetilde{p}$, and depends only upon the ability to make a perfect hedge. The result, as stated here, is specialized to the case of constant absolute risk aversion and Normal distributions of $\widetilde{p}$.

and his optimal futures trade is described by,

$$z_i = q_i - \frac{E_i(\widetilde{p}) - p_f}{\rho \text{var}_i(\widetilde{p})}. \tag{6.4}$$

Proof. The first-order conditions to (6.2) with respect to q_i and z_i, respectively, are

$$E_i(\widetilde{p}) - \frac{q_i}{k} - \rho(q_i - z_i)\text{var}_i(\widetilde{p}) = 0,$$

$$p_f - E_i(\widetilde{p}) + \rho(q_i - z_i)\text{var}_i(\widetilde{p}) = 0.$$

Solving for $\rho(q_i - z_i)\text{var}_i(\widetilde{p})$ from the second equation and substituting this expression into the first equation gives,

$$E_i(\widetilde{p}) - \frac{q_i}{k} + p_f - E_i(\widetilde{p}) = 0,$$

which yields (6.3). Also, simple rearrangement of terms in the first-order condition for z_i yields (6.4). □

The separation result indicates that the farmer's wheat production is independent of his beliefs about the spot price that will prevail in the future and independent of his risk aversion. His production decision is governed entirely by the currently observed price in the wheat futures market. The intuition underlying this result is as follows. Suppose that an individual farmer privately believes that the spot market for wheat will be booming and that the spot price will be higher than the futures price. It may seem that this farmer would respond by producing a large amount of wheat. This intuition is misleading. What is true is that the farmer would want to enter the spot market with a large amount of wheat in hand. But there are two ways of acquiring wheat, producing it and buying it in the futures market. As long as the marginal cost of wheat production is less than the futures price, it is cheaper to produce wheat than to acquire it in the futures market. Beyond this point, it is cheaper to acquire wheat in the futures market than to produce it. Similar reasoning applies when the farmer privately believes that the spot market for wheat will be in a slump. In all cases, the farmer's wheat production is entirely determined by the futures price and his marginal cost of production. However, the separation result does not

imply that the farmer's private information about the spot price $\widetilde{p}$ is lost. Rather than affecting his production decision the farmer's private information about the spot price affects his trade in the derivatives market.

Equation (6.4) indicates that the derivatives trade of an individual farmer has two components, a pure hedge component that equals the farmer's inherent risk exposure q_i and a speculative component that I denote s_i, where $s_i = \frac{E_i(\widetilde{p}) - p_f}{\rho \operatorname{var}_i(\widetilde{p})}$. Thus, whenever the farmer's private beliefs about the spot price that will prevail in the future does not coincide with the current futures price of wheat, there will be both a hedge component and a speculative component to the farmer's derivatives trade. If the accounting process is silent about farmers' derivatives positions or if it reveals only the total derivatives trade of z_i, the hedge components and the speculative components cannot be disentangled. To see the potential for misinformation, suppose that the farmer is observed to have sold 60 units of wheat derivatives. A naive interpretation of this observation would suggest that the farmer is bearish on wheat and must expect a slump in the spot market. However, suppose that this farmer anticipates his wheat harvest at 100 units. Equation (6.4) indicates that the farmer has actually taken a speculative long position in the wheat futures market to the tune of 40 units, rather than a short position of 60 units, and is bullish rather than bearish on the price of wheat.

When farmers take short and long positions in the wheat futures market the equilibrium futures price aggregates and impounds the information possessed by individual farmers. To see this aggregation role more clearly, consider the market clearing condition for wheat futures: $\Sigma_i z_i = 0$. Inserting the expression for z_i derived in (6.4) yields the condition that the aggregate speculative demand for wheat must equal the anticipated wheat production, i.e.,

$$\sum_i \frac{E_i(\widetilde{p}) - p_f}{\rho \operatorname{var}_i(\widetilde{p})} = \sum_i q_i. \tag{6.5}$$

Solving for the equilibrium price p_f gives:

$$p_f = \frac{1}{\sum_i \frac{1}{\rho \operatorname{var}_i(\widetilde{p})}} \left(\sum_i \frac{E_i(\widetilde{p})}{\rho \operatorname{var}_i(\widetilde{p})} - \sum_i q_i \right).$$

Since the production decisions of farmers depends entirely on the currently observed futures price, if their private beliefs about the demand and supply conditions that will later prevail in the spot market is appropriately aggregated and reflected in the futures price, then the wheat production of *all* farmers is informed by the totality of information that individuals posess. In this case the futures price is informationally efficient and an ideal state of affairs is attained. For example, suppose there are N farmers in the market, $\text{var}_i(\widetilde{p}) = v, \forall i$ and denoting by Q the aggregate industry output of $\Sigma_i q_i$, the equilibrium futures price is:

$$p_f = \frac{1}{N} \sum_i E_i(\widetilde{p}) - \frac{\rho}{N} v Q. \tag{6.6}$$

Notice from (6.6) that the equilibrium futures price depends on the *average* belief of all farmers about the price that will prevail in the spot market. If aggregate industry output is common knowledge and the average belief about $\widetilde{p}$ is a sufficient statistic for all of the information possessed by individual farmers, then the futures price would be informationally efficient. However, if the equilibrium futures price fails to aggregate information appropriately the wheat production of the *entire* industry would be adversely affected. Thus, there could be enormous *real* consequences to the disclosures required of individual wheat farmers.

The confounding of farmers' hedge motivated trades with speculative trades will generally preclude an informationally efficient futures price and will thereby impact industry output. I now add specificity to the model to parsimonously illustrate and study these effects. Suppose the date 2 demand for wheat, $\widetilde{d}$ is described by:

$$\widetilde{d} = \widetilde{\eta} + \widetilde{\gamma} - p, \tag{6.7}$$

where $\widetilde{\eta}$ and $\widetilde{\gamma}$ are independent Normally distributed random shocks to demand with means $E(\widetilde{\eta}) = \mu > 0$, $E(\widetilde{\gamma}) = 0$, and variances σ_η^2 and σ_γ^2, respectively. There are $N + 1$ farmers indexed $0, 1, 2, \ldots, N$. Farmer 0 is an informed farmer while the other N farmers are uninformed in the sense described below. Farmer 0 has private information about the spot demand for wheat and his own production of wheat. I model

these assumptions in the following way. Farmer 0 observes the value of $\widetilde{\eta}$ at date 1 before committing resources to wheat production and before choosing his derivatives position. Additionally, the resources committed to production by farmer 0 determines his mean production of q_0 but his actual production is perturbed by a random quantity $\widetilde{\theta}$ that is Normally distributed with mean zero and variance σ_θ^2 and $\widetilde{\theta}$ is independent of $\widetilde{\eta}$ and $\widetilde{\gamma}$. Farmer 0 observes the value of $\widetilde{\theta}$ before he takes a position in the derivatives market. The production of all other farmers are known deterministic amounts q_i, where $q_i = kp_f$, $i = 0, 1, \ldots, N$. Let $Q \equiv (N + 1)kp_f$ be the expected industry output, while realized industry output is $Q + \theta$. Equilibrium in the spot market requires $\eta + \gamma - p = Q + \theta$, so that, as perceived at date 1,

$$\widetilde{p} = (\widetilde{\eta} - \widetilde{\theta}) + \widetilde{\gamma} - Q. \tag{6.8}$$

Since each farmer is a price taker, the aggregate expected industry output Q is viewed as a known constant which depends only upon the observed price in the futures market.

I turn, now, to the determination of the equilibrium futures price in a setting where there is no hedge accounting at all, so that the derivative positions taken by individual farmers are unobserved by other farmers. Given that the equilibrium futures price impounds the information of individual farmers, all farmers condition their beliefs about the spot price on the observed futures price. Thus, uninformed farmers assess $E(\widetilde{p}|p_f)$ and $\operatorname{var}(\widetilde{p}|p_f)$, while the informed farmer assess $E(\widetilde{p}|p_f, \eta, \theta)$ and $\operatorname{var}(\widetilde{p}|p_f, \eta, \theta)$. From (6.5) the market clearing condition determining the equilibrium futures price is:

$$N\left(\frac{E(\widetilde{p}|p_f) - p_f}{\rho\operatorname{var}(\widetilde{p}|p_f)}\right) + \frac{E(\widetilde{p}|p_f, \eta, \theta) - p_f}{\rho\operatorname{var}(\widetilde{p}|p_f, \eta, \theta)} = Q + \theta. \tag{6.9}$$

Calculation of the equilibrium futures price p_f requires a determination of its unknown information content. As in Grossman's (1978) artificial economy construction, I resolve this problem by making a conjecture about the information revealed by the futures price, calculating farmer's trades conditional on this conjecture, and then confirming that the equilibrium futures price does indeed reveal the conjectured information. Given the structure of $\widetilde{p}$ described in (6.8), and given that the

informed farmer already knows $(\widetilde{\eta} - \widetilde{\theta})$ and the value of Q, it is a safe conjecture that the futures price reveals no incremental information to him. Therefore, $E(\widetilde{p}|p_f, \eta, \theta) = (\eta - \theta) - Q$ and $\mathrm{var}(\widetilde{p}|p_f, \eta, \theta) = \sigma_\gamma^2$. Inserting these beliefs into the market clearing condition (6.9) and rearranging terms gives,

$$N\left(\frac{E(\widetilde{p}|p_f) - p_f}{\rho\,\mathrm{var}(\widetilde{p}|p_f)}\right) + \frac{(\eta - \theta) - Q - p_f}{\rho\sigma_\gamma^2} = Q + \theta. \tag{6.10}$$

Let the statistic $\widetilde{y} \equiv \widetilde{\eta} - \widetilde{\theta}(1 + \rho\sigma_\gamma^2)$, so that (6.10) can be expressed as

$$N\left(\frac{E(\widetilde{p}|p_f) - p_f}{\rho\,\mathrm{var}(\widetilde{p}|p_f)}\right) + \frac{y - Q - p_f}{\rho\sigma_\gamma^2} = Q. \tag{6.11}$$

I conjecture that the equilibrium futures price reveals the value of the statistic y. This conjecture implies that $E(\widetilde{p}|p_f) = E(\widetilde{p}|y) = E(\widetilde{\eta} - \widetilde{\theta}|y) - Q$ and $\mathrm{var}(\widetilde{p}|p_f) = \mathrm{var}(\widetilde{\eta} - \widetilde{\theta}|y) + \sigma_\gamma^2$. Since both $\widetilde{y}$ and $(\widetilde{\eta} - \widetilde{\theta})$ are distributed Normal with $E(\widetilde{y}) = E(\widetilde{\eta} - \widetilde{\theta}) = \mu$, $\mathrm{cov}((\widetilde{\eta} - \widetilde{\theta}), \widetilde{y}) = \sigma_\eta^2 + (1 + \rho\sigma_\gamma^2)\sigma_\theta^2$ and $\mathrm{var}(\widetilde{y}) = \sigma_\eta^2 + (1 + \rho\sigma_\gamma^2)^2\sigma_\theta^2$, standard Bayesian updating for Normally distributed random variables gives,

$$E(\widetilde{p}|y) = \alpha y + (1 - \alpha)\mu - Q,$$

where

$$\alpha = \frac{\sigma_\eta^2 + (1 + \rho\sigma_\gamma^2)\sigma_\theta^2}{\sigma_\eta^2 + (1 + \rho\sigma_\gamma^2)^2\sigma_\theta^2}.$$

Also,

$$\begin{aligned}\mathrm{var}(\widetilde{p}|y) &= \mathrm{var}(\widetilde{\eta} - \widetilde{\theta}|y) + \sigma_\gamma^2 \\ &= (1 - \alpha)(\sigma_\eta^2 + \sigma_\theta^2) - \alpha\rho\sigma_\gamma^2\sigma_\theta^2 + \sigma_\gamma^2 \equiv v + \sigma_\gamma^2.\end{aligned}$$

Inserting these assessments into (6.11), and using $Q = (N + 1)kp_f$, the market clearing condition can be expressed as

$$N\left(\frac{\alpha y + (1 - \alpha)\mu - (N + 1)kp_f - p_f}{\rho(v + \sigma_\gamma^2)}\right) + \frac{y - Q - p_f}{\rho\sigma_\gamma^2} = (N + 1)kp_f. \tag{6.12}$$

Solving for p_f yields:

Proposition 6.2. In the economy with no disclosure of derivative positions the equilibrium futures price is strictly increasing in $y \equiv \eta - \theta(1 + \rho\sigma_\gamma^2)$, and is characterized by,

$$A^0 p_f^0 = \left(\frac{v + \sigma_\gamma^2(1 + \alpha N)}{v + \sigma_\gamma^2(1 + N)}\right)y + \left(1 - \frac{v + \sigma_\gamma^2(1 + \alpha N)}{v + \sigma_\gamma^2(1 + N)}\right)\mu, \quad (6.13)$$

where

$$A^0 \equiv 1 + (N+1)k + \left(\frac{v + \sigma_\gamma^2}{v + \sigma_\gamma^2(1 + N)}\right)\rho\sigma_\gamma^2(N+1)k. \quad (6.14)$$

Proposition 6.2 indicates that the futures price is informationally inefficient when farmers derivative positions are not disclosed. The information that is relevant to industry production is $(\eta - \theta)$. When this quantity is high the spot price will also be high and industry production should respond to this increased demand. However, guided by the futures price, industry production responds to variations in $\eta - \theta(1 + \rho\sigma_\gamma^2)$ thus being overly sensitive to variations in the θ shock. In order to understand the source of this inefficiency examine (6.10). The confounding of $(\eta - \theta)$ with θ is due to the presence of θ on the right-hand side which, in turn, is due to the unknown hedging need of farmer 0. This informed farmer's knowledge of the spot price, $(\eta - \theta)$, is reflected in his speculative trade while his knowledge of the pure production shock θ is reflected in his hedge motivated trade. Given the lack of adequate disclosure the market cannot disentangle the farmer's hedge motivated trade from his speculative trade and this is what causes the futures price to become informationally inefficient.

The result that the futures price fails to appropriately inform production decisions when producers' hedging needs are confounded with speculative trades has been derived in a very simple model where this confounding exists for only one producer. The same qualitative result will hold when many, or all, producers have private information about their hedging and speculative trades in the futures market, though the algebra is much more messy. My analysis also indicates that revelation of producers' aggregate derivative position z_i will generally be inade-

quate to break this confounding.[2] The key additional disclosure needed is disclosure of a producer's *inherent risk*, since such disclosure would reveal the producer's hedging needs and therefore allow the speculative component of his derivative trade to be inferred. This implies that fair value adjustments to a firm's derivative position alone is insufficient, but fair value adjustments of both the derivative position as well as the inherent risk that is being hedged (comprehensive fair value accounting) would fully inform the market.

Additional insights into the inefficiency caused by the lack of adequate hedge disclosures is obtained by studying the futures price that would obtain if the inherent risk of the informed producer $(q_0 + \theta)$ as well as his total derivatives trade z_0 is disclosed. I refer to such a regime as a regime with comprehensive hedge disclosures. Since Proposition 6.1 indicates that $z_0 = (q_0 + \theta) + \frac{E(\widetilde{p}|p_f, \eta, \theta) - p_f}{\rho \, var(\widetilde{p}|p_f, \eta, \theta)}$, these disclosures reveal $E(\widetilde{p}|p_f, \eta, \theta)$ and therefore reveal the value of $(\eta - \theta)$. Thus, the key information that was hidden in the regime without hedge disclosures can be readily inferred without even inverting the equilibrium futures price. It can be shown that even if the aggregate derivatives position z_0 of the informed producer is not disclosed but only his inherent risk exposure is disclosed, the same perfect inference of $(\eta - \theta)$ can be made from the equilibrium futures price. Given this inference, all producers have the same information the market clearing condition becomes:

$$(N + 1) \left(\frac{\eta - \theta - Q^* - p_f^*}{\rho \sigma_\gamma^2} \right) = Q^* + \theta,$$

where Q^* and p_f^* denote the equilibrium expected industry production and the equilibrium futures price in this fully informed setting. Inserting $Q^* = (N + 1)k p_f^*$ and solving for p_f^* yields:

Proposition 6.3. In the economy with comprehensive hedge disclosures the equilibrium futures price is characterized by

$$A^* p_f^* = \eta - \theta - \frac{1}{N + 1} \rho \sigma_\gamma^2 \theta, \tag{6.15}$$

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[2] The information conveyed by a firm's aggregate derivatives position when its inherent risk is unknown to outsiders is analyzed by Gigler et al. (2007). They show that such partial information could lead to rather perverse inferences.

where

$$A^* \equiv 1 + (N+1)k + \left(\frac{1}{N+1}\right)\rho\sigma_\gamma^2(N+1)k. \qquad (6.16)$$

Having characterized the equilibrium futures price in settings with and without hedge disclosures, we can now examine how the lack of hedge disclosures impacts industry output. Since in each regime industry output is the same multiple of the equilibrium futures price, we need only examine how the equilibrium futures price differs across the two regimes. As one would expect, the equilibrium futures price is sometimes higher and sometimes lower in one regime versus the other depending on the realizations of η and θ. But, we show that the lack of hedge disclosures results in a downwards bias to the equilibrium futures price and, therefore, in a downwards bias to aggregate industry output.

Proposition 6.4. On average, the equilibrium futures price and the aggregate industry output is strictly lower in the regime without hedge disclosures than in the regime with comprehensive hedge disclosures.

Proof. The average equilibrium futures price in the regime without hedge disclosures is obtained by taking the expectation over η and θ in Equation (6.13). Recall that $E(y) = E(\eta - \theta(1 + \rho\sigma_\gamma^2)) = \mu$, so

$$E(p_f^0) = \frac{\mu}{A^0}.$$

Also, from (6.15),

$$E(p_f^*) = \frac{\mu}{A^*}$$

so that $E(p_f^*) > E(p_f^0)$ iff $A^* < A^0$. Using the expressions for A^* and A^0 given in (6.16) and (6.14) this inequality holds iff $N + 1 > \frac{v + \sigma_\gamma^2(N+1)}{v + \sigma_\gamma^2}$, which is true for all parameter values. $\qquad\square$

KMSV (2000) show that this downward bias in the futures price is caused by distortions in risk sharing which, in turn, is caused by the information asymmetry that exists in equilibrium between informed and uninformed producers. The result described here is very similar to the Easley

and O'Hara (2004) result on how the presence of informed and uninformed traders in the capital market drives up a firm's cost of capital.

In the regime without hedge disclosures, the futures price confounds fluctuations in $(\eta - \theta)$ with fluctuations in θ. The industry is then induced to take a "middle of the road" production strategy, under-reacting to one shock and overreacting to the other. It is useful to think of $(\eta - \theta)$ and θ as two distinct random variables, where fluctuations in $(\eta - \theta)$ is equivalent to fluctuations in spot demand and fluctuations in θ alone represents shocks to the inherent risk of the informed producer. Therefore insensitivity of industry output to fluctuations in $(\eta - \theta)$ will have an impact on the volatility of spot prices. If demand is booming, but industry output does not respond adequately to this booming demand, the equilibrium spot price will be higher than would be the case if the futures market was fully informed. Conversely when demand is low and industry output does not adjust downwards in an appropriate manner, equilibrium spot prices will fall disproportionately. The next result proves that is indeed true.

Proposition 6.5. In the regime without hedge disclosures, industry output is relatively insensitive to fluctuations in spot market demand and overly sensitive to fluctuations in hedge motivated futures trades.

Proof. From (6.13) the equilibrium futures price in the regime without hedge disclosures can be expressed as

$$p_f^0 = \frac{1}{A^0}\left(\frac{v + \sigma_\gamma^2(1 + \alpha N)}{v + \sigma_\gamma^2(1 + N)}\right)(\eta - \theta - \rho\sigma_\gamma^2\theta)$$

$$+ \frac{1}{A^0}\left(1 - \frac{v + \sigma_\gamma^2(1 + \alpha N)}{v + \sigma_\gamma^2(1 + N)}\right)\mu$$

and, from (6.15), the equilibrium futures price in the regime with comprehensive hedge disclosures is,

$$p_f^* = \frac{1}{A^*}(\eta - \theta) - \frac{1}{A^*}\frac{1}{N + 1}\rho\sigma_\gamma^2\theta.$$

Since $A^0 > A^*$, as established in Proposition 6.4, and $\left(\frac{v+\sigma_\gamma^2(1+\alpha N)}{v+\sigma_\gamma^2(1+N)}\right) < 1$ because $\alpha < 1$, it follows that the coefficient on $(\eta - \theta)$ is strictly smaller in the regime without hedge disclosures than in the regime with comprehensive hedge disclosures, which establishes the first part of the proposition. The second part of the proposition is established by comparing the coefficients on θ across the two regimes. The claim we need to establish is that $\frac{1}{A^0}\left(\frac{v+\sigma_\gamma^2(1+\alpha N)}{v+\sigma_\gamma^2(1+N)}\right)\rho\sigma_\gamma^2 > \frac{1}{A^*}\frac{1}{N+1}\rho\sigma_\gamma^2$, or equivalently,

$$A^*\left(\frac{v + \sigma_\gamma^2(1 + \alpha N)}{v + \sigma_\gamma^2(1 + N)}\right) - \frac{A^0}{N + 1} > 0.$$

Substituting the values of A^* and A^0 from (6.16) and (6.14), the claim is equivalent to,

$$\frac{A^*\alpha N\sigma_\gamma^2}{v+\sigma_\gamma^2(1+N)} + \frac{(v + \sigma_\gamma^2)[(1 + (N + 1)k) + \rho\sigma_\gamma^2 k]}{v + \sigma_\gamma^2(1 + N)}$$
$$-\frac{1 + (N + 1)k + \left(\frac{v+\sigma_\gamma^2}{v+\sigma_\gamma^2(1+N)}\right)\rho\sigma_\gamma^2(N + 1)k}{N + 1} > 0,$$

which is equivalent to

$$\frac{A^*\alpha N\sigma_\gamma^2}{v + \sigma_\gamma^2(1 + N)} + [1 + (N + 1)k]\left(\frac{v + \sigma_\gamma^2}{v + \sigma_\gamma^2(1 + N)} - \frac{1}{N + 1}\right) > 0,$$

which is true since each term on the left-hand side is strictly positive. This completes the proof. $\square$

The key result that the absence of hedge disclosures depresses the aggregate output of the industry is missing from the public debate surrounding SFAS 133. This is not surprising since one would expect individual firms to be concerned only with their own individual payoffs and not with aggregate phenomena. Our result identifies a very important *externality* induced by comprehensive hedge disclosure, that may actually hurt some individual informed producers, but which should be the proper concern of regulators who choose disclosure standards to maximize the welfare of the entire community of producers and consumers. It would be enormously useful to obtain some empirical estimates of the magnitude of the loss in industry output caused by the

lack of appropriate hedge disclosures and the sensitivity of this loss to key parameters. Data on magnitudes would require the kind of careful calibration studies used in macro-economics (see Kydland and Prescott (1982)), which is beyond the scope of this paper. However, some preliminary insights can be obtained regarding the relative importance of various parameters that affect the loss we have identified. The expected loss in industry output is

$$L \equiv E(Q^*) - E(Q^0) = (N + 1)k[E(p_f^*) - E(p_f^0)]$$
$$= (N + 1)k\mu \left(\frac{1}{A^*} - \frac{1}{A^0} \right).$$

Dividing through by $E(Q^*)$ gives the percentage loss in expected industry output,

$$L_r = \frac{A^0 - A^*}{A^0},$$

where A^0 and A^* are given by (6.14) and (6.16). The parameters that affect the value of L_r are σ_η^2, σ_θ^2, σ_γ^2, ρ, and k. The variance parameters σ_η^2 and σ_θ^2 describe the *a priori* extent of information asymmetry between the informed and uninformed producers, the parameters σ_γ^2 and ρ affect the size of the risk premium embedded in the futures price, and the parameter k describes the sensitivity of industry production to the futures price. The expression for L_r in terms of the primitive parameters is complex, but numerical analysis (see KMSV (2000)) reveals that L_r is strictly increasing and most sensitive to $v \equiv \mathrm{var}(\eta - \theta | y)$ which describes the equilibrium *ex post* information asymmetry between the informed and uninformed producers and which, in turn, is strictly increasing in each of the parameters σ_η^2, σ_θ^2, σ_γ^2, and ρ. It is precisely this information asymmetry that is dispelled by appropriate hedge disclosures.

7

Conclusion

In his survey of the disclosure literature, Verrecchia (2001) calls for a "comprehensive theory of disclosure," and suggests that such a comprehensive theory should focus on understanding how a firm's cost of capital is decreased by disclosure that reduces information asymmetry among traders in the capital market. The real effects perspective, that I have illustrated, suggests that the key information asymmetry that affects resource allocation in the economy is the information asymmetry between the firm's managers and the capital market as a whole, rather than asymmetries among individual traders in the capital market. The information asymmetry among individual traders does matter, but this effect is at most a small second-order effect. Given that firms are, or should be, focused on value maximization and given that valuation in the capital market depends critically on what the capital market as a whole knows, I have shown that the information asymmetry between managers and the capital market could have *devastating* consequences for all stakeholders, informed and uninformed. The consequences of such information asymmetry are masked when disclosure is framed in Verrecchia's models of pure exchange because the decisions made by firms are simply absent from the analysis. But they come to life in more

general equilibrium analysis. It is also obvious that public disclosure by firms will decrease the kind of information asymmetry I have been discussing as a first-order effect and will reduce information asymmetries among individual traders only as a second-order effect.

A real effects perspective suggests that attempts to formulate a *comprehensive* theory of disclosure would, like a search for the "Holy Grail," be either futile or sterile. Much more insight can be obtained by focusing on very specific issues faced by standard setters, such as the measurement and reporting of derivatives, intangible investments, fair values of assets and liabilities, executive stock options, revenue recognition criteria, etc. Each of these issues is concerned with informing the capital market as a whole rather than reducing information asymmetry among individual traders in the capital market. As demonstrated by the research surveyed here, each of these issues requires the formulation of its own abstraction (model) that is tightly focused on *specific* managerial decisions and each such model requires its own analytical methodology and associated empirical analysis. It is unlikely that any general model, that is also analytically tractable, will suffice.

Acknowledgments

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