Market Efficiency, Bounded Rationality, and Regulation of Supplemental Business Reporting Disclosures

J. Richard Dietrich[*]

Steven J. Kachelmeier[†]

Don N. Kleinmuntz[*]

Thomas J. Linsmeier[*]

Version 5, July 1998

[*] University of Illinois at Urbana-Champaign

[†] University of Texas at Austin

We gratefully acknowledge the financial support of the Coopers & Lybrand Foundation and the helpful comments and insights provided by professionals at Coopers & Lybrand LLP, particularly Bob Herz, Jim Harrington, Fred Elmy, Jeff Hoover, and Ray Wilson. We also thank Steve Buchheit and Kristina Zvinakis for research assistance. In addition, we acknowledge the helpful comments of Tim Cason, Peter Easton, Bud Fennema, Frank Hodge, Pat Hopkins, Ron King, Bill Kinney, Joan Luft, Laureen Maines, Jim McKeown, Jamie Pratt, Jerry Salamon, Nathan Stuart, Jim Wahlen, and David Wallin, as well as workshop participants at the University of Illinois, Indiana University, Michigan State University, the New England Behavioral Accounting Research Series, New York University, The Ohio State University, Pennsylvania State University, the University of Tennessee, Texas A&M University, the 1997 Annual Meeting of the Economic Science Association, the Eighth Annual Conference on Accounting and Financial Economics, the 1998 Midwest Regional Meeting of the American Accounting Association, and the 1998 Behavioral Decision Research in Management Conference.

Market Efficiency, Bounded Rationality, and Regulation of Supplemental Business Reporting Disclosures

1. Introduction

This study investigates two types of supplemental business reporting disclosures that can influence capital allocation decisions. First, supplemental disclosures can repackage or reorganize information already provided in financial statements. Often, this involves an explicit presentation of information that can be inferred from the primary financial statements (e.g., the estimated life of a productive asset). Second, supplemental disclosures can convey new information not contained in the traditional financial reporting model. A prominent example is information about uncertainty in future cash flows (e.g., disclosure of potential upside opportunities, downside risks, or both).

Both types of supplemental disclosures are consistent with current efforts to extend the financial reporting model to serve the changing needs of financial statement users. The American Institute of Certified Public Accountants' (AICPA) Special Committee on Financial Reporting (also known as the Jenkins Committee) recommends supplementing traditional financial reports with disclosures of "more information with a forward-looking perspective, including management's plans, opportunities, risks, and measurement uncertainties" (AICPA [1994, p. 5]).

Many firms already provide voluntary disclosures of the sort described by the Jenkins Committee. A controversial issue is whether such disclosures should be mandated. If investors are subject to judgment biases, one potential danger of a strictly voluntary system is that management may selectively disclose information in order to exploit those biases. For example,

investors may not expend the effort to infer information from traditional financial statements. If repackaged disclosure of this information facilitates greater reliance on its content, management may strategically choose to volunteer repackaged disclosures only when the information is favorable. Similarly, investors may overreact to one-sided disclosures of upside opportunity, neglecting downside risk that is implied but not explicitly presented.[1] Management, therefore, may disclose upside opportunity without disclosing corresponding downside risk in an attempt to influence investors. These strategic motives suggest a potential role for regulation: eliminating managerial discretion by mandating disclosure.

Financial reporting research traditionally has embraced the assumption that market prices are not influenced by individuals' judgment biases. For example, Gonedes and Dopuch [1974] argue that investors' judgment biases should be of no concern, because they presuppose that security markets are semi-strong efficient (i.e., market prices fully reflect all public information). Market efficiency implies that accounting standards setters only need to address the substance, rather than the form, of accounting disclosure (Beaver [1998, pp. 145-146]). Managerial discretion in selecting presentation format (e.g., repackaging, one-sided disclosure) is relatively unimportant because it is likely to have little influence on security prices. The primary goal of accounting regulation, therefore, is to bring investor-relevant information into the public domain (disclosure). Thus, under the premise of semi-strong efficient markets, accounting regulators need only limited involvement with presentation of voluntary supplemental disclosures because security prices will reflect fully all information that can be inferred from those disclosures.

In contrast, suppose that market prices behave, in the aggregate, as if investors are boundedly rational, violating semi-strong market efficiency. Information acquisition and processing imposes significant cognitive costs. As a result, investors may adopt decision

heuristics that compromise accuracy in order to conserve cognitive effort (Payne, Bettman, and Johnson [1993]). Biases, therefore, may be introduced into market prices due to incomplete processing of public information. Under this sort of market inefficiency, accounting standard setters need to consider the form as well as the substance of accounting disclosure. Specifically, regulations requiring particular forms of disclosure could improve investment allocation decisions, counteracting price biases caused by heuristic processing of voluntary disclosures.

In sum, the focus of regulatory intervention should depend on whether market reactions to supplemental business reporting disclosures are consistent with market efficiency or with price biases attributable to boundedly rational investors. In this study, we use a laboratory market to investigate whether explicit, "user-friendly" supplemental business reporting disclosures can make a difference in market pricing, even when redundant with information implicitly communicated through the primary financial statements. We also examine whether one-sided disclosures emphasizing favorable or unfavorable prospects bias market reactions in circumstances where it is generally understood that every upside opportunity implies an equivalent downside risk, and vice versa.

The oil extraction industry serves as the basis for our experimental setting because current oil reserve disclosures provide a practical example of these issues. Specifically, FASB Statement No. 69 (FASB [1982]) mandates the disclosure of proved reserves, a disclosure cited by the Jenkins Committee as a current example of useful supplementary performance information (AICPA [1994, p. 143]).[2] This disclosure is management's best estimate of oil reserves available for future production and sale, and is used in the calculation of depletion charges in the income statement and net book values of oil-producing properties on the balance sheet (Brock, Jennings, and Feiten [1996, p. 413]). Thus, supplemental disclosures of proved

reserves are redundant with information that can be inferred (albeit indirectly) from the primary financial statements. In addition, many firms in the industry voluntarily disclose "total reserves," a figure that communicates upside opportunity in future revenue realizations. A commensurate downside risk disclosure could be voluntarily disclosed in addition to (or in lieu of) the disclosure of upside opportunity. However, this is not observed in practice.

Our experiment employs laboratory markets, allowing us to vary these disclosures under *ceteris paribus* conditions. We present evidence from twenty market sessions; each comprised of eight traders. In each session, participants trade securities based on information from an income statement, a balance sheet, and one of five supplemental disclosure conditions: (1) nothing else (a control condition), (2) expected reserves, (3) expected reserves and a measure of upside opportunity, (4) expected reserves and a measure of downside risk, or (5) expected reserves, upside opportunity, and downside risk.

There are three primary findings. First, market prices better reflect expected future cash flows when expected reserves are explicitly disclosed, as opposed to when they only can be inferred from cumulative revenues and net book values in the financial statements. Second, a one-sided disclosure of upside opportunity biases prices upwards when firms experience bad news (i.e., *less* oil reserves than initially expected). In contrast, there is no downward bias associated with a one-sided disclosure of downside risk. Finally, a two-sided disclosure of upside opportunity *and* downside risk mitigates the bias induced by the disclosure of upside alone.

These findings are consistent with previous literature documenting judgment biases associated with bounded rationality. Investors overweight information that is presented explicitly relative to information that must be inferred. In addition, consistent with prospect theory,

investors weight losses disproportionately relative to gains of equal magnitude. Taken together, these findings are inconsistent with semi-strong market efficiency, suggesting that bounded rationality is relevant to an understanding of market reactions to supplemental business reporting disclosures.

Our results have important implications for managers and accounting regulators who are considering forward-looking disclosures of the type recommended by the Jenkins Committee. First, the form of disclosure matters, because it influences investors' acquisition and processing of information, which, in turn, influences security prices. Second, there is an opportunity for management to use selective voluntary disclosures of supplemental business reporting information to strategically influence security prices. This suggests a potential explanation for voluntary disclosure practice in the oil industry, where firms often provide one-sided disclosures of upside opportunity. Third, accounting regulators can counteract this management-induced bias by mandating balanced or more comprehensive disclosures (e.g., requiring reporting of downside risk whenever upside opportunity is presented, and vice versa).

Section 2 presents the theory and hypotheses to be tested. Section 3 outlines the experimental design and procedure. Section 4 presents results and section 5 comments on the implications of our results for standard setting, along with suggestions for future research.

2. Theoretical Perspectives and Research Hypotheses

If firms augment financial statements with additional disclosures, what market reactions should we expect? The answer to this question hinges on (1) whether market prices are consistent with semi-strong form efficiency or with deviations from efficiency induced by boundedly rational traders and (2) whether additional disclosures repackage existing financial statements or provide new information.

With respect to the first issue, the financial reporting literature has traditionally embraced the assumption of semi-strong efficiency, in which market prices reflect fully the economic implications of all publicly available information (see the review by Beaver [1998]). The efficient market hypothesis does not require rationality for all individual traders. Rather, the assumption is that prices are formed at the margin in a way that makes it impossible to earn abnormal returns from a trading strategy based on publicly available information. This view led Gonedes and Dopuch [1974] to question the value of earlier experimental demonstrations of individual biases in processing accounting information. Their article was quite influential, hastening the shift in financial reporting research from experimental studies of individual behavior to archival studies of aggregate market prices.

Recent research raises fundamental questions about the assumption of market efficiency. Evidence of sustained price anomalies in capital markets has been provided by Abarbanell and Bernard [1992], DeBondt and Thaler [1985; 1987; 1990], Hand [1990], and Porta et al. [1997], among others (see Thaler [1993]). Many of these studies explicitly link deviations from efficient prices to information processing biases of individual traders. While it is true that the marginal trader sets market prices, there is no guarantee that this trader is immune to information processing biases. More fundamentally, the question of whether information processing biases affect market prices is best resolved by empirical testing. In the words of Tversky and Kahneman [1986, p. S273], claims that competitive markets mitigate or eliminate cognitive biases should "be settled by observation, not supposition." In economics, a number of experimental studies have addressed this issue in relatively abstract (non-accounting) settings, including Camerer [1987; 1992], Grether [1992], and others reviewed by Smith [1994].

In accounting, Libby [1989], Berg, Dickhaut, and McCabe [1995], and Waller [1995] call for experimental research that directly addresses whether individual judgment biases can survive market discipline. Recent experimental studies have investigated the influence of financial reporting alternatives on individual price judgments, including debt-equity classification (Hopkins [1996]), and reporting of comprehensive income (Hirst and Hopkins [1998] and Maines and McDaniel [1998]). A limitation of these studies is that the influence of disclosure on individual price judgments may differ from the influence on market prices. Accordingly, laboratory market methods can add an important dimension, retaining experimental control over *ceteris paribus* conditions, while addressing directly Gonedes and Dopuch's [1974] concern regarding the implications of individual judgment biases for aggregate market behavior.[3]

To date, laboratory market studies in the accounting literature have investigated the efficiency of markets in the presence of incomplete information dissemination (Lundholm [1991] and Bloomfield and Libby [1996]), signaling of values known to management (King and Wallin [1991a; 1991b]), biases in probability judgment (Ganguly, Kagel, and Moser [1994]), and susceptibility to the sunk-cost fallacy (Kachelmeier [1996]). Each of these studies demonstrates circumstances leading to inefficient market pricing. However, the implications for financial reporting are limited, particularly because these studies have not provided information in a form similar to traditional financial reports (i.e., balance sheets, income statements, and footnote disclosures). By contrast, we measure market reactions to traditional financial statements and two types of supplemental disclosures: (1) explicit disclosures that repackage information in the primary financial statements and (2) disclosures of information not in the primary financial statements.

2.1 Repackaging Financial Statement Information

Management possesses forward-looking private information that is relevant to investors' assessments of the amount, timing, and uncertainty of future cash flows. Some of this information is not explicitly disclosed in traditional financial statements but, rather, is used in the preparation of financial statement amounts. Often, this information can be inferred from income statement and balance sheet data.

To illustrate with an example drawn from our experimental setting, consider a firm that owns a single producing oil well with an initial cost of $5,000, accumulated depletion of $1,610, and cumulative sales revenues to date of $4,000. In addition, suppose that the market price of oil is always $20 per barrel and the firm sells all oil produced each period (i.e., the amount of oil produced and sold to date is $4,000 ÷ $20 = 200 barrels). This information is sufficient to estimate management's expected remaining reserves, since the ratio of current net book value to accumulated depletion equals the ratio of expected remaining reserves to cumulative production/sales to date:

Net Book Value / Accumulated Depletion = Expected Reserves / Cumulative Production.

Thus, expected reserves are equal to [($5,000 - $1,610) ÷ $1,610] × 200 barrels = 421 barrels, which implies future revenues of $8,420 (421 × $20).

The calculations above are straightforward and based upon publicly available information. Thus, assuming market efficiency, this information should be fully reflected in market prices. On the other hand, these calculations require a nontrivial expenditure of cognitive effort. Bounded rationality suggests that individuals' selection of decision strategies involves a trade-off between minimizing cognitive effort and maximizing the probability of making an accurate choice (Payne, Bettman, and Johnson [1993]; also see Simon [1986]). Slovic [1972]

suggests that in order to reduce the cognitive strain of inferring information, "decision makers will tend to use only that information that is explicitly displayed and will use it only in the form in which it is displayed" (Payne, Bettman, and Johnson [1993, p. 48]).

In our example, suppose that investors initially believe that the well costing $5,000 will produce 500 barrels on average. Under this scenario, after 200 barrels of production, accumulated depletion would be $2,000 and 300 barrels would remain in reserves. Thus, a report of accumulated depletion of only $1,610 after 200 barrels of production would be good news, suggesting that management has estimated that there are more than 300 barrels remaining in reserves (with a corresponding increase in expected revenues).

However, instead of calculating management's estimate of remaining reserves, individuals may opt to "satisfice" by anchoring on their prior expectation (300 barrels) and adjusting in the general direction of the news revealed in the financial statements. An anchor-and-adjustment decision heuristic is commonly subject to bias, in that adjustments from anchors are typically in the appropriate direction but insufficient in magnitude (Tversky and Kahneman [1974]). Wright and Anderson [1989] show that this bias persists even in the presence of financial incentives.

One way to obviate this bias is to repackage information to make it easier for the decision maker to arrive at an accurate inference (Kleinmuntz and Schkade [1993]). In the oil industry, FASB Statement No. 69 requires explicit supplemental disclosure of management's best estimate of reserve quantities (i.e., proved reserves), which makes inferences about reserves from net book value unnecessary.[4] A bounded-rationality view suggests that supplemental reserve disclosures eliminate the cognitive cost of inferring reserve quantity estimates from financial statement information, facilitating more accurate individual pricing decisions and hence more

complete market reactions. Conversely, under semi-strong market efficiency, supplemental disclosures should have no incremental effect on market prices, because they are redundant with information inferable from financial statements. We contrast these views as two alternative forms of our first hypothesis:

H_{1A} (market efficiency):
> Supplemental reserve disclosures that explicitly present information inferable from the balance sheet and income statement will have no effect on market prices relative to prices observed when only balance sheet and income statement information is provided.

H_{1B} (bounded rationality):
> Supplemental reserve disclosures that explicitly present information inferable from the balance sheet and income statement will lead to more efficient market prices than the prices observed when only balance sheet and income statement information is provided.

2.2 Providing Information not Contained in Financial Statements

Many supplemental disclosures do more than just repackage financial statement information, in that traditional financial statements are not equipped to provide all of the forward-looking information that users demand (AICPA [1994]). A prime example is information on risks and opportunities. At best, the balance sheet and income statement provide point estimates of amounts that are predictive of future cash flow realizations. But like all point estimates, actual outcomes can vary from the estimate, either favorably (upside opportunity) or unfavorably (downside risk).

In the oil industry, reserve estimation is far from a precise science, and firms in the industry regularly experience production that either exceeds or falls short of initial proved reserve estimates. Moreover, management has knowledge of the degree of precision with which these estimates are formed. Financial statement amounts, however, are based only on the best estimate (proved reserves), and therefore do not communicate management's degree of certainty.

This limitation of traditional financial statements is a prime motivation for the broader disclosure of risks and opportunities called for in the Jenkins Committee Report.

As noted above, several firms in the oil industry voluntarily disclose "total reserves," an upper-bound estimate of production associated with a best-case scenario. For example, in its 1996 annual report, Exxon reports that its' total oil and gas resource base (i.e., its proved reserves plus all other discovered resources expected to ultimately be commercial) has grown by 14 percent over the past decade to 40 billion oil-equivalent barrels. By contrast, firms in the oil industry rarely if ever voluntarily disclose an estimated lower bound associated with a worst-case scenario (i.e., downside risk).

Why might firms opt for this type of one-sided disclosure? Intuition suggests a strategic motive, to sway the market by emphasizing upside opportunity (i.e., the potential for good news). However, this intuition conflicts with conventional views of market efficiency. In an efficient market, the market would act as if it extracted the complete information content of any disclosure. If the market has formed an estimate of expected reserves, a supplemental disclosure of upside opportunity (total reserves) would convey a sense of the uncertainty in the distribution around that expectation. For any upside opportunity, the market should be aware that there is a corresponding downside risk (and vice versa). In our experimental setting, there is public knowledge that the probability distribution of reserve quantities is symmetric.[5] Given symmetry, a one-sided disclosure of either downside risk or upside opportunity is sufficient to make an accurate inference about the other side of the distribution. Thus, in our experiment, the two forms of one-sided disclosure are informationally equivalent, and a semi-strong efficient market will treat them identically. This reasoning leads to the following hypothesis:

H_{2A} (market efficiency):

> Supplemental disclosures of expected reserves and upside opportunity in reserves will lead to the same market prices as supplemental disclosures of expected reserves and downside risk in reserves.

A bounded-rationality view, by contrast, would suggest a different perspective. Payne, Bettman, and Johnson [1993, pp. 50-52] characterize decision-makers' responses to incomplete information as one of resolving ambiguity by discounting elements of the decision context that are described incompletely. That is, explicit information is weighted more than information that must be inferred (see Slovic and MacPhillamy [1974] and Yates, Jagacinski, and Faber [1978], among others). In our example, the disclosure of an upper bound for reserves would lead market traders to focus more on the upside than on the downside, causing an upward revision in reserve estimates. Moreover, when a one-sided lower bound is disclosed, market traders would focus more on the downside than on the upside, causing a downward revision in reserve estimates. This reasoning leads to the following alternative hypothesis regarding the directional impact of one-sided disclosures on market prices:

H_{2B} (bounded rationality—direction of market reaction):

> Supplemental disclosures of both expected reserves and upside opportunity in reserves will cause an upward bias in market prices relative to the prices observed when only expected reserves are disclosed. Supplemental disclosures of both expected reserves and downside risk in reserves will cause a downward bias in market prices relative to the prices observed when only expected reserves are disclosed.

[INSERT FIGURE 1 ABOUT HERE]

Under bounded rationality, psychological findings on how individuals evaluate risky alternatives can provide further insight about the relative magnitude of market reactions to disclosures of upside opportunity and downside risk. Specifically, prospect theory incorporates a *value function* (analogous to a utility function, see Figure 1) that models three aspects of how

individuals perceive and *subjectively* value potential outcomes (Kahneman and Tversky [1979]; Tversky and Kahneman [1992]). First, individuals evaluate outcomes relative to a reference point, with outcomes above the reference point perceived as gains, and outcomes below the reference point perceived as losses. Second, the value function inflects at the reference point, implying risk aversion (concavity) for gains and risk seeking (convexity) for losses. This curvature in the value function implies diminishing marginal changes in perceived value as outcomes move farther from the reference point. Third, in the region around the reference point, the value function is steeper for losses than for gains. This last phenomenon, known as loss aversion, suggests that individuals are more sensitive to losses than gains.

In our experiment, this framework implies that the valuation of an oil property depends upon whether management's expected reserve disclosures reveal the property is worth more or less than initially expected (with the initial expectation defining a natural *ex ante* reference point). Consider a case where expected reserve information indicates a property with more oil than initially expected. Security holders would perceive this as a gain. In this gain domain, prospect theory predicts market prices below expected value (consistent with risk aversion). Furthermore, in the gain domain, the concavity of the value function (i.e., diminishing marginal changes in the value function as outcomes move farther from the reference point) implies that additional one-sided disclosures emphasizing downside risk will have greater effect on market prices than disclosures emphasizing upside opportunity.

In contrast, where expected reserve disclosures indicate a property with less oil than initially expected, security holders would perceive this as a loss. In this loss domain, prospect theory predicts market prices above expected value (consistent with risk seeking). Furthermore, in the loss domain, the convexity of the value function (i.e., diminishing marginal changes in the

value function as outcomes move farther from the reference point) implies that additional one-sided disclosures emphasizing upside opportunity will have greater impact than disclosures emphasizing downside risk. Thus, regardless of whether an investor is in the gain or loss domain, one-sided disclosures that emphasize potential outcomes nearer the reference point will have a larger impact on market prices.

Finally, when predicting the magnitude of market reactions to one-sided disclosures near the reference point, loss aversion (a steeper value function below the reference point than above, compare v(x) to v(-x) in Figure 1) implies the largest price effects will be for firms that disclose upside opportunity in the loss domain. These upside disclosures describe outcomes that fall in the steepest region of the value function. This suggests that traders will be especially sensitive to information indicating the possibility of recouping their losses. This reasoning leads to the following hypothesis regarding the relative magnitude of price reactions to one-sided disclosures:

> H_{2C} (bounded rationality—relative magnitude of market reaction):
>
> Consistent with prospect theory, the magnitude of market prices reactions to one-sided supplemental disclosures will differ across firms. To the extent that one-sided disclosures bias market prices, the largest bias will occur for firms that provide (a) supplemental disclosures of both expected reserves and upside opportunity in reserves and (b) have expected reserves lower than initially expected.

If one-sided disclosures bias market prices, then an obvious remedy would be to provide two-sided disclosures of both downside risk and upside opportunity. Our final pair of hypotheses explores the incremental influence of providing a two-sided disclosure as compared to providing only one-sided disclosures of either downside risk or upside opportunity. Similar to Hypothesis H_{2A}, assuming semi-strong efficient markets and given the implied symmetry of the reserve distribution, a one-sided disclosure of either downside risk or upside opportunity is

sufficient to describe the entire distribution. Thus, two-sided disclosures of both downside risk and upside opportunity will communicate no additional information beyond what can be inferred from a one-sided disclosure.

In contrast, as developed in the discussion of H_{2B}, under bounded rationality, individuals give more weight to information that is presented explicitly than information that is implied. If this bias exists, explicitly disclosing both downside risk and upside opportunity should correct the bias. These alternative views are presented below in a final pair of competing hypotheses:

H_{3A} (market efficiency):
> Supplemental disclosures of both upside opportunity and downside risk in reserve quantities will lead to the same market prices as supplemental reserve disclosures of only upside opportunity or downside risk.

H_{3B} (bounded rationality):
> Supplemental disclosure of both upside opportunity and downside risk will mitigate price biases induced by one-sided disclosures.

3. Experimental Design and Procedure

3.1 Participants

One hundred sixty upper division/graduate business students at the University of Texas at Austin voluntarily participated in twenty laboratory market sessions, with eight participants in each session. All participants had prior coursework in intermediate financial accounting sufficient to enable them to serve as informed users of basic financial statements. In addition, substantially all of the participants had some form of practical experience (e.g., a professional internship).

3.2 Task Instructions

All sessions took place in a research laboratory equipped with eight networked computers. After random assignment to computer stations, participants listened to an experimenter's verbal presentation of the instructions, while following along with their own copy (available from the authors upon request). These instructions described the process by which participants would trade in eight hypothetical oil firms, one at a time. Each firm was characterized as a highly simplified oil company, owning one producing well acquired at a known cost of $5,000. The well was financed through the sale of 1,000 shares of stock. Thus, at its inception, the firm had no other assets and no debt or other liabilities. Net proceeds from sales accumulate as cash.

The instructions provided participants with information on the best available estimate of the well's capacity immediately upon purchase and before revelation of any additional private information known to management. Each well was described as having 500 barrels of production capacity on average, with a five percent chance of the well containing less than 265 barrels and a five percent chance of the well containing more than 735 barrels. This description provided enough detail to construct a discrete approximation of the underlying probability distribution, following evidence in Keefer and Bodily [1983] that shows a three-point approximation based on 5th, 50th, and 95th percentiles affords reasonably accurate estimates of first and second moments of a distribution.

[INSERT FIGURE 2 ABOUT HERE]

The next section of the instructions described the financial statements and supplemental disclosures. Across treatment conditions and for each firm, all participants received the same periodic primary financial statements, in the form of an income statement and balance sheet (examples are shown in Figure 2). Revenues were determined by multiplying periodic

production (100 barrels) by a known price per barrel of $20. The simplifying assumptions of a fixed price per barrel, no inventory, and only one producing well made it easier for participants to infer expected values of reserves from cumulative revenues and net book values in the primary financial statements than would be the case for a real oil production firm. This works *against* the bounded-rationality hypotheses, because the cognitive demands of this task are reduced relative to a more realistic setting having multiple risk exposures.

The oil well's net book value in the balance sheet reflected management's best estimate of remaining reserves. The instructions communicated this fact explicitly, defining net book value as "the proportion of original reserves remaining to be sold in future periods." This information, along with income statement and balance sheet information suggesting the quantity of reserves sold to date, provided participants with the data necessary to infer expected reserve information from the base financial statements.

3.3 Disclosure Conditions

In addition to the base financial statements, the instructions described one of five supplemental disclosure conditions, constituting the experimental treatment factor. In the F/S-ONLY condition (a control condition), there were no disclosures to supplement the base financial statements. In the EXPECTED disclosure condition, the financial statements were accompanied by an explicit disclosure of management's best estimate of expected reserves, the same quantity used when computing depletion charges for the financial statements. The EXPECTED disclosure condition is an experimental analog to the proved reserve disclosures required under FASB Statement No. 69, affording a test of H_{1A} versus H_{1B}.

The other three disclosure conditions added new information about uncertainty in reserves to the information provided in the EXPECTED disclosure condition. The

EXPECTED+MAX disclosure condition also provided management's estimate of maximum reserves, defined as a likely upper bound such that there is only a 5% chance that more than this quantity remains to be produced. This disclosure condition is an experimental analog to the common industry practice of voluntarily disclosing total reserves to accompany proved reserves, although neither the term "proved" nor the term "total" were used in the experimental materials to avoid potential misunderstanding. The EXPECTED+MIN disclosure condition provided the obverse disclosure, minimum reserves, defined as management's estimate of a likely lower bound, such that there is only a 5% chance that less than this quantity remains to be produced. These two disclosure conditions allow tests of H_{2A} versus H_{2B} and H_{2C}. Finally, a fifth disclosure condition, EXPECTED+BOTH, provided supplemental financial statement disclosures of expected, maximum, and minimum reserves, affording a test of H_{3A} versus H_{3B}. The EXPECTED+BOTH condition's supplemental disclosures are shown at the bottom of Figure 2. The other disclosure conditions were constructed using subsets of this full-disclosure condition.

3.4 Firm Variations and Administration of Markets

Oil reserve distributions and outcomes for each of the eight firms were representative of the distribution presented to participants in the instructions. For each of the eight firms, Table 1 shows the expected values and standard deviations of the reserve distribution, as well as the actual outcomes that determine terminal dividend valuations. We preselected this information to ensure an equal number of firms with expected reserves above and below the *ex ante* expected value of 500 barrels.

We varied the eight firms across three within-session factors, arranged in a factorial design. The *information direction* factor defined whether management's private information reflected a positive or negative change in expected reserves. The *primary adjustment* factor

reflected either a large or a small change in both the first and second moments of the distribution of management's private information about oil reserves. Finally, the *secondary adjustment* factor made a small change in expected reserves, so that no two firms have identical expected values.

[INSERT TABLES 1 AND 2 ABOUT HERE]

Participants traded each of the eight firms for three periods. Period 0 occurred before any financial information was revealed. Period 1 occurred after distribution of financial statements and supplemental disclosures (if any) following the firm's first period of operations. Period 2 occurred after distribution of updated disclosures for the second period of operations. Table 2 shows the expected, maximum, and minimum reserve estimates for each firm in each period. Observe that the eight firms have identical expectations in period 0, followed by period 1 and period 2 revisions that are determined by the information direction, primary adjustment, and secondary adjustment factors described above. To control for potential learning effects, we created four order conditions that counterbalanced presentation order.

Following period 2, a terminal-value sheet was distributed to announce the firm's liquidating dividend. This announcement informed traders of the total number of production periods and the amount of oil produced before the well was exhausted. The number of production periods (averaging five) always exceeded the number of trading periods. Following the revelation of terminal value for one firm, trading in the next firm commenced.

At the beginning of trading for each firm, participants were given an endowment of three shares in the firm and a $50.00 loan (in experimental dollars) to provide working capital for trading purposes. During each of the three trading periods, participants were free both to buy

and sell shares using computerized double auction rules as implemented in trading software developed by Johnson, Lee, and Plott [1988] (and updated by Plott [1991]).[6]

Trading lasted four minutes per period for the first firm and three minutes per period for all subsequent firms. Upon completion of period 0, cash balances and security holdings transferred to period 1. This trading period began after participants reviewed financial statements and disclosures appropriate to the session's treatment condition. Participants had unlimited time to review this information. A similar process provided the transition from period 1 to period 2. At the end of period 2, final cash and security holdings determined each participant's profit for that firm. Each share held was worth 1/1,000 of the firm's terminal value.

Profit calculations were completed by multiplying the terminal share value by the number of shares held, adding the ending cash balance, and subtracting the $50.00 loan. Ending cash balances did not carry over to subsequent firms. For the entire session, participants earned actual cash equal to one-fifth of their aggregated profits in experimental dollars for all firms. Converted real cash profits for the 3 ½-hour session averaged $48 per participant, with a range from $30.50 to $68.50.

3.5 Other Experimental Instruments

Two other instruments facilitated our research objectives. First, to ensure that participants understood both the task and the accounting information provided, subjects completed a pre-experimental questionnaire. Response errors (which were rare) were reviewed to the participants' satisfaction before the commencement of trading. This questionnaire reinforced participants' knowledge of (1) the *ex ante* distribution of reserve quantities prior to period 0, (2) the computation of profits, and (3) the calculations required to infer reserve

quantities from the financial statements. The latter item provides support for the assumption that participants were able to comprehend the primary financial statements in this setting.

A second instrument allowed us to compare *market* prices to *individual predictions* of those prices. Before the opening of computer trading each period, participants completed a half-page form asking them, "At which share price do you believe the firm's stock is most likely to trade this period?" These responses permit supplementary analyses comparing market prices to individual predictions of those prices. In addition, trading did not begin until all participants had completed this instrument, ensuring that they had sufficient opportunity to review the accounting information and were ready to begin trading.

4. Results

The primary measure for assessing market reactions to the disclosure conditions is *average trading price*, the average of all successful trades recorded during each trading period.[7] For parsimony, we often refer to this measure as price. Table 3 reports prices for each disclosure condition. Each entry in the table shows the mean of prices across four replicate market sessions, sorted by disclosure condition, trading period, and firm. As a benchmark for comparison, the table also shows the expected value per share conditional on management's information.

[INSERT TABLE 3 AND FIGURE 3 ABOUT HERE]

Figure 3 shows prices averaged across disclosure conditions and replicate market sessions. A statistical analysis (not shown) indicates that period 0 prices never differ significantly from $10.00, the expected value before revelation of any financial statement information specific to the firm. Thus, for these stakes, this setting, and these participants, risk neutrality is a reasonable first approximation of aggregate market risk preferences across the 20

market sessions. Still, risk preferences may vary idiosyncratically across market sessions. To control for this possibility, we treat period 0 prices as a covariate in all statistical analyses.

It is evident from Figure 3 that after period 0, prices respond in the direction of expected values. Specifically, for the good-news firms (i.e., firms with reserve quantities exceeding the *ex ante* expectation of 500 barrels, depicted as gray lines in Figure 3), prices rise in periods 1 and 2. For bad-news firms (i.e., firms where reserve information falls short of the *ex ante* expectation of 500 barrels, black lines in Figure 3), prices fall towards expected values. These observations provide evidence that participants were able to respond meaningfully to the economic setting and market incentives.

[INSERT TABLE 4 ABOUT HERE]

While this basic fan-shaped pattern holds for all disclosure conditions, the direction and magnitude of price revisions vary systematically by disclosure condition. Table 4 presents a repeated-measures analysis of variance for trading periods 1 and 2. The dependent variable is the difference between price and the firm's corresponding expected value. This measure isolates the effects of disclosure condition on price after controlling for variations arising from firm-specific differences. Independent variables include the disclosure condition as well as four within-session factors: trading period, information direction, primary adjustment, and secondary adjustment. Table 4 shows *p* values less than or equal to 0.10.

The first conclusion we draw from Table 4 is that the effects of disclosure conditions are consistent across periods 1 and 2, in that there are no significant interactions involving both the disclosure condition and trading period. This means there is no need to analyze periods 1 and 2 separately in subsequent hypothesis tests, simplifying the analysis. Second, there are two statistically significant four-factor interactions. The first, involving all four within-session factors

(information direction, primary adjustment, secondary adjustment, and trading period; $F_{1,12}$ = 4.99, p = 0.05), suggests that trading prices in periods 1 and 2 are jointly influenced by all these manipulations. The second significant interaction involves disclosure condition and the three firm-related factors (information direction, primary adjustment, and secondary adjustment; $F_{1,12}$ = 4.77, p = 0.02). This interaction indicates that the supplemental disclosures do indeed influence trading prices, but that the nature of this influence depends upon firm characteristics. Thus, in order to test our hypotheses, we evaluate whether this interaction is significant for specific pairs of disclosure conditions.[8]

4.1 Hypotheses H_{1A} and H_{1B}

Our first pair of competing hypotheses requires comparison of prices in the F/S-ONLY and EXPECTED disclosure conditions. This interaction contrast is statistically significant ($F_{1,12}$ = 7.77, p = 0.02), indicating that prices differed across these two disclosure conditions for some of the firms. Thus, traders did not view disclosures in the F/S-ONLY and EXPECTED disclosure conditions as informationally equivalent, hence rejecting market efficiency (H_{1A}).

[INSERT FIGURE 4 ABOUT HERE]

Is this rejection of market efficiency consistent with the form of bounded rationality outlined in H_{1B}? This hypothesis is supported if prices are closer to expected values in the EXPECTED disclosure condition when compared to the F/S-ONLY condition. For these two disclosure conditions, Panel A of Figure 4 shows the average of period 1 and 2 prices minus expected values (with good-news firms depicted in gray and bad-news firms depicted in black).

Prices in the F/S-ONLY condition are consistent with traders failing to fully infer management's expected reserve estimates from financial statements. The figure shows that an explicit disclosure of expected reserves facilitates more complete price reactions, supporting

H_{1B}. This finding is consistent with the notion that information presentation format affects decision making by influencing the ease with which information is acquired and processed (Kleinmuntz and Schkade [1993]). The supplemental disclosure improved decision making by making it easier for traders to acquire and use the relevant information.

A competing explanation is that participants were not capable of processing traditional financial statements. However, the pre-experimental questionnaire suggests otherwise. Recall that the questionnaire explicitly reviewed the calculations necessary to infer reserve estimates from the income statement and balance sheet, giving us evidence that market participants were *capable* of drawing appropriate inferences. Furthermore, in the F/S-ONLY condition, price movements (from period 0 to periods 1 and 2) are in the direction of revealed news, so at least some participants appear to be using the financial statement information (see Table 3).[9] However, the magnitude of these price movements is insufficient (not reaching expected values), as predicted by the anchoring and adjustment decision process described in section 2.1.

4.2 Hypotheses H_{2A}, H_{2B}, and H_{2C}

To test H_{2A} (market efficiency), we examine the interaction contrast for the EXPECTED+MAX and EXPECTED+MIN disclosure conditions. This contrast shows that prices are different in these two conditions for some of the firms ($F_{1,12} = 11.22$, $p = 0.01$). This implies that traders did not view these two disclosure conditions as informationally equivalent, thereby again rejecting market efficiency (H_{2A}).

Hypothesis H_{2B} provides a specific prediction of the direction of market reaction to these one-sided disclosures under bounded rationality. The interaction contrast for the EXPECTED+MAX and EXPECTED disclosure conditions is significant, suggesting that prices differ across these two conditions for some of the firms ($F_{1,12} = 8.84$, $p = 0.01$). Examination of

Panel B of Figure 4 reveals that for those firms where there was a price difference, prices were higher for the EXPECTED+MAX condition, as hypothesized. In contrast, prices in the EXPECTED+MIN condition are not lower than prices in the EXPECTED condition (see Panel C of Figure 4). In fact, the interaction contrast for the EXPECTED and EXPECTED+MIN conditions suggests that prices did not differ across firms for these two conditions ($F_{1,12}$ = 0.14, not significant). These results partially support H_{2B}. For some firms, upside disclosures bias prices upwards, but downside disclosures do not bias prices downwards.

Hypothesis H_{2C} posits that the magnitude of market price bias will differ across firms. We focus only on the EXPECTED+MAX disclosure condition, where there is evidence of an upward price bias. The largest effect from upside disclosures occurs for bad-news firms (denoted by black lines in Panel B of Figure 4). The average price increase between the EXPECTED and EXPECTED+MAX disclosure conditions for these four firms is \$0.74, which is statistically significant ($F_{1,12}$ = 5.22, p = .04). By contrast, the firms experiencing good news (positive revisions in expected reserves) are unaffected by the upside disclosure (average difference of \$0.12; $F_{1,12}$ = 0.05, not significant). These results support H_{2C}. The largest market reaction to upside disclosures occurs for firms with outcomes in the steepest portion of the prospect theory value function (i.e., loss firms with upside disclosure amounts nearer the reference point).

The fact that we observe no significant price changes in the EXPECTED+MIN condition appears to be inconsistent with H_{2B}. However, the prospect theory rationale for H_{2C} provides a plausible explanation. For bad-news firms, the downside risk disclosures lead to outcomes in the region of the value function farthest below the reference point (see Figure 1). In this region, there are diminishing marginal changes in value, which could attenuate any bias due to overweighting of explicitly presented downside risk. For good-news firms, the downside disclosures lead to

outcomes that fall close to the reference point. The rationale underlying H_{2C} suggests that risk aversion would amplify this bias, because the value curve is relatively steep in the region around the reference point. However, if participants are only mildly risk averse in the gain domain (relative to the degree of risk seeking and loss aversion near the reference point in the loss domain, see Figure 1), this bias could be too small to detect reliably in our experimental design.

In sum, the evidence from market reactions to one-sided disclosures leads to a rejection of the efficient market hypothesis (H_{2A}). Support is provided for both types of bounded rationality (H_{2B} and H_{2C}). Market reactions to one-sided disclosures of upside opportunity are consistent with both overweighting of explicitly presented information and with differential reactions to gains and losses judged relative to a reference point. Recall that in practice, oil and gas firms often voluntarily disclose upside opportunity but not downside risk. If firms are doing this in order to increase security prices, it is interesting to note that our findings suggest that this strategy is most effective in dampening negative market reactions to disclosures of bad news.

4.3 Hypotheses H_{3A} and H_{3B}

Given that the one-sided disclosure of upside opportunity induces an upward price bias, would a balanced disclosure of both upside opportunity and downside risk mitigate this bias? Panel D of Figure 4 shows that with one-sided upside disclosures, bad-news firms (in black) are priced above expected value, but with two-sided disclosures, prices are much closer to expected value. The interaction contrast for the EXPECTED+MAX and EXPECTED+BOTH conditions is marginally significant, suggesting that for some firms, the two conditions are not informationally equivalent ($F_{1,12} = 3.48$, $p = 0.09$). Furthermore, the interaction contrast for EXPECTED and EXPECTED+BOTH conditions indicates that the price reactions to these two disclosures do not differ across firms ($F_{1,12} = 1.23$, not significant). Taken together, these results

suggest that any upward price bias induced by the one-sided disclosure is mitigated by two-sided risk disclosures, supporting bounded rationality (H_{3B}) over market efficiency (H_{3A}).[10]

We do not reach a similar conclusion when examining the interaction contrast for the two-sided disclosure condition, EXPECTED+BOTH and the one-sided disclosure condition EXPECTED+MIN ($F_{1,12} = 2.21$, not significant). This is not surprising, given the absence of a measurable bias for the EXPECTED+MIN disclosure condition in the earlier comparison of H_{2A} versus H_{2B}.

4.4 Individual Price Predictions

As supplemental evidence, we performed an analysis of price predictions collected from individual participants before each trading period. This provides an opportunity to assess whether our primary conclusions hold in an individual judgment context. The form of our analysis was identical to the analysis reported above. In this section, we report only a summary of the results.[11]

In comparison to the market prices reported in Table 3, individual price predictions are systematically lower. In trading period 0, before any firm-specific information is released, individual price predictions average $9.48, which is $0.48 lower than average trading price of $9.96. This difference persists in trading periods 1 and 2, where the average difference between actual and predicted prices is $0.41. Furthermore, this prediction error does not change significantly from the first to the eighth traded firm. Thus, although our experimental setting is an iterated market where participants have the opportunity to observe and learn from each other's actions, traders systematically underpredict market prices for each of the eight traded firms.

Most of the inferences regarding the effect of disclosure conditions on prices hold when individual price predictions are used in place of market prices. For example, when comparing F/S-ONLY and EXPECTED disclosure conditions, inferences do not change when individual price predictions are used in lieu of market prices. Similarly, no biases are associated with the EXPECTED+MIN disclosure condition. However, inferences about the effects of the EXPECTED+MAX disclosure condition are quite different. Recall that for market prices, a supplemental disclosure of upside opportunity biased the prices of bad-news firms above expected value. This effect is absent when individual price predictions are used as the dependent variable instead of market prices.

This result contradicts the prevailing view that markets either mitigate or eliminate individual biases, not vice versa (e.g., Libby [1989] and Ganguly, Kagel, and Moser [1994]). Instead, this result suggests that, in certain circumstances, markets can exacerbate individual biases.[12] This is possible if the marginal traders who set market prices are boundedly rational, even if the average trader is not. Thus, a laboratory market setting can identify phenomena that might be difficult to detect in an individual judgment experiment.

5. Conclusions and Implications

In this section we will briefly summarize the results, then comment on the implications of this research both for accounting standard setting and for research on business reporting disclosures. Our findings reveal three primary conclusions about supplemental business reporting disclosures. First, a disclosure that provides explicit information relevant to estimating expected future cash flows leads to more complete market reactions, even if the same information can be inferred from the primary financial statements. This finding is consistent with the view that market traders are cognitive misers, and that easier-to-use disclosure is better

disclosure. Second, a one-sided disclosure of upside opportunity leads to an upward bias in prices for firms disseminating *unfavorable* economic news (i.e., less reserves than initially expected). A likely explanation is that the unfavorable position led traders to adopt risk-seeking preferences, heightening their sensitivity to disclosures indicating the possibility of recouping their losses. Third, simultaneous disclosure of both upside opportunity and downside risk removes the bias.

5.1 *Implications for Standard Setting*

While disclosures in our experiment were manipulated exogenously, rather than endogenously selected by management, we view our study as a useful contribution towards the ultimate goals of understanding why firms disclose what they do and why there may be a role for regulation. In an efficient capital market, management cannot "fool" the public through accounting choices that offer no incremental economic information content. From this perspective, the primary role of accounting regulation is to bring new information into the public domain (Beaver [1998, Chapter 5]). However, recent archival and laboratory research, including this study, provides evidence that is inconsistent with market efficiency. This leads to a different view of strategic disclosure and accounting regulation.

Consider first our findings in support of H_{1B} over H_{1A}. In the United States, the disclosure of proved reserves is required under FASB Statement No. 69. In theory, this same information can be inferred from the primary financial statements. So why was this requirement deemed necessary? Our results suggest a possible explanation in situations where management has an incentive to increase the stock price, perhaps because of the way in which management compensation is structured. Without a requirement to explicitly disclose this information, management might elect to make explicit disclosure only when news is good, but not when news

is bad. If explicit disclosure leads to more complete price adjustments, as our findings suggest, this strategy would be to management's advantage.

Of course, the market might learn to interpret the signal implied by nondisclosure. King and Wallin [1991b] generally found evidence supporting efficient market reactions to strategic nondisclosure. However, they also found deviations from efficient prices when disclosures were ambiguous. Since, in our study, financial statements provide ambiguous disclosures about the productive life of an asset, this suggests it may be difficult for traders to interpret strategic nondisclosure signals in our setting. Similarly, Lev and Penman's [1990] archival study of market reactions to management forecasts found no evidence of the market penalizing nondisclosing firms. In any event, regulations like FASB Statement 69 render the signaling issue moot, ensuring a level playing field by removing managerial discretion about when to explicitly disclose expected reserves.

Next consider the case of disclosure of upside opportunity and downside risk. Here the disclosure is discretionary, with management permitted but not required to provide this information. Our results suggest that management stands to gain from voluntarily disclosing upside opportunity (total or maximum reserves), since this disclosure can produce higher market valuations. Further, our findings suggest that a mandated balanced disclosure of both maximum and minimum reserves can remove this distortion. This finding is consistent with the Jenkins Committee's assertion that financial statement users "prefer more balanced reporting that discusses both positive and negative developments" (AICPA [1994, p. 29]).

Even if balanced reporting were to be mandated, there is still the possibility of management opportunism, in the form of deceptive representations. In our experiment, we avoided this issue by instructing participants to assume that all disclosures were credible and

unbiased. In practice, management's estimated reserve quantities are difficult to verify. Nevertheless, checks and balances in the financial reporting process (e.g., internal controls, auditing) and concerns over long-term reputation effects (e.g., see King [1996]) reduce opportunities for misrepresentation. More generally, our findings suggest that discretionary disclosures provide management with opportunities to selectively exploit investor biases without the need for actual misrepresentation. In an efficient market, such a strategy would fool no one, as pricing would behave as if the market made rational inferences regarding both the implicit content of financial reports and the signals implied by selective nondisclosure. Evidence of systematic deviations from market efficiency implies the possibility of managerial exploitation of investor biases even if all disclosures are credible.

5.2 *Implications for Business Reporting Research*

Naturally, our conclusions depend on the extent to which our experimental markets have characteristics that parallel real-world securities markets. An important advantage of the laboratory is that we can construct alternative disclosure regimes in an incentive-driven market setting under *ceteris paribus* conditions. However, some significant abstractions are a necessary consequence of this control. For example, we prohibited traders from short selling, which might have limited their ability to arbitrage away any overpricing attributable to the disclosure regimes. However, even in the presence of short selling in real world markets, there is evidence of both under-and overreactions to accounting information (for one example, see the literature on post-earnings-announcement drift, reviewed in Beaver [1998]). Thus, systematic mispricing is more than just a laboratory artifact.

Further, some arguably unrealistic features of our laboratory market might lead to *more* competitive discipline than occurs in real-world markets. Most prominently, firms in our

experimental setting liquidate shortly after trading. Firms in the real world generally do not terminate so predictably. This difference causes the information reported in our experimental setting to have greater relevance in estimating the liquidation value of the firm. In the real world, by contrast, some forms of inconsistency between accounting reports and economic reality can persist indefinitely (e.g., see Easton, Harris, and Ohlson [1992]). Put differently, the arbitrage discipline that promotes market efficiency assumes that economic truth is eventually revealed, but this assumption is actually more valid in our experiment than in real markets.

As a final concern, our use of student subjects warrants comment. Although the student participants in this study were at a relatively advanced stage of education, we hesitate to claim that our results would generalize to professional traders or financial analysts. At the same time, it should not be taken for granted that professionals would necessarily make more accurate or more efficient inferences than students. Burns [1985], for example, conducted a laboratory market analog to the Australian wool market, in which students significantly outperformed professional wool traders. More recently, Camerer [1997, Table 5] reported an experimental test of a strategic setting where a group of highly-paid CEOs serving on the California Institute of Technology Board of Trustees showed larger deviations from rationality than a group of high-school students from the Los Angeles area.

Furthermore, recent studies of professional analysts' individual stock-price judgments have reached conclusions similar to ours about the importance of presentation format (e.g., Hopkins [1996] and Hirst and Hopkins [1998]). A primary benefit of these studies is their use of professionals, whereas a primary benefit of our study is the use of market prices in lieu of individual price judgments. We see a role for both of these experimental approaches, in concert

with archival studies of real-world market data, to triangulate towards a more complete understanding of the role of accounting disclosures in capital markets.

There is clearly much more that needs to be learned about the effects of risk-based accounting disclosures, particularly in relationship to the use of financial instruments to manage market risk (e.g., see Linsmeier and Pearson [1997]). In our study, the capacity of firms' productive resources was varied, but prices were kept constant. Our ongoing research includes investigations of recently mandated disclosures regarding exposure to price risk and instruments used to manage that risk.

More generally, the strategic aspects of disclosure in settings where markets deviate from efficient prices warrant further study. To our knowledge, ours is the first laboratory market study to incorporate supplemental disclosures along with traditional income statements and balance sheets. Other disclosure experiments have examined the interplay between management's strategic disclosure choices and market reactions (e.g., King and Wallin [1991a; 1991b]), but have abstracted away from standard-setting issues specific to the presentation of traditional financial statements. Future research that merges these perspectives can provide a rich environment for exploring strategic disclosure choices in the context of contemporary standard-setting issues.

Appendix: History of Standard Setting and Prior Research on Oil and Gas Reporting Issues

The Financial Accounting Standards Board (FASB) and the Securities and Exchange Commission (SEC) have issued several standards that address accounting and disclosure for oil and gas production activities. In 1977, the FASB issued Statement No. 19, which required (1) accounting in financial statements at historical cost using the successful efforts rather than the full cost method and (2) disclosure of proved reserve quantities, capitalized costs relating to production activities, and costs incurred in production activities (FASB [1977]). In 1978, the SEC concluded that neither successful efforts nor full cost financial statements were sufficiently informative, primarily because historical costs incurred in the discovery of reserves are not relevant indicators of value received. Accordingly, the SEC concluded that a new reserve recognition accounting (RRA) method should be developed. This method would require current rather than historical valuations of proved reserves in the *primary* financial statements. During the development of this method, SEC registrants were (1) required to disclose RRA amounts supplementally and (2) permitted to use either the full cost or successful efforts method in the financial statements, as discussed in Accounting Series Release (ASR) Nos. 253 and 269 (SEC [1978] and SEC [1979], respectively). As a consequence, the FASB issued Statement No. 25 (FASB [1979]), which suspended the effective date of Statement No. 19 as to the historical cost accounting method used in financial statements but not as to the disclosure requirements.

In 1981, the SEC issued ASR No. 289 (SEC [1981]), which states that because of inherent uncertainties relating to the pricing, quantity, and timing of proved reserve sales, it no longer viewed RRA as a viable alternative to historical cost-based methods in the *primary*

financial statements. ASR No. 289 also asserted the SEC's commitment to *supplemental* value-based disclosures of oil and gas reserves and urged the FASB to require such disclosure. In 1982, the FASB responded with Statement No. 69 that requires disclosure of two new types of supplementary information: (1) results of operations for producing activities and (2) a standardized measure of discounted future net cash flows relating to proved reserve quantities that roughly approximates the RRA measure previously required by the SEC.

Prior research on oil and gas reporting issues has examined (1) the economic consequences of switching from the full costs to successful efforts method (e.g., Dyckman and Smith [1979]; Collins and Dent [1979]; Lev [1979]) and (2) the valuation relevance of historical cost versus RRA measures of oil and gas reserves (e.g., Harris and Ohlson [1987]; Doran, Collins, and Dhaliwal [1988]). In general, this research has found significant economic effects of switching from full cost to successful efforts and valuation relevance for both historical cost and RRA-based measures. These studies neither examine repackaging of explicit proved reserve quantity information nor disclosures of new information about reserve uncertainty not inferable from financial statements.

REFERENCES

ABARBANELL, J. S., AND V. L. BERNARD. "Tests of Analysts' Overreaction/Underreaction to Earnings Information as an Explanation for Anomalous Stock Price Behavior." *Journal of Finance* (July 1992): 1181-207.

AMERICAN INSTITUTE OF CERTIFIED PUBLIC ACCOUNTANTS. *Improving Business Reporting—A Customer Focus: Comprehensive Report of the Special Committee on Financial Reporting*. Jersey City, NJ: AICPA, 1994.

BEAVER, W. H. *Financial Reporting: An Accounting Revolution*, 3d Ed. Upper Saddle River, NJ: Prentice-Hall, 1998.

BERG, J.; J. DICKHAUT; AND K. MCCABE. "The Individual versus the Aggregate." In *Judgment and Decision-Making Research in Accounting and Auditing*, edited by R. H. Ashton and A. H. Ashton, pp. 102-134. New York: Cambridge University Press, 1995.

BLOOMFIELD, R., AND R. LIBBY. "Market Reactions to Differentially Available Information in the Laboratory." *Journal of Accounting Research* (Autumn 1996): 183-207.

BROCK, H. R.; D. R. JENNINGS; AND J. B. FEITEN. *Petroleum Accounting: Principles, Procedures, & Issues*, 4th Ed. Denton, TX: Professional Development Institute, 1996.

BURNS, P. "Experience and Decision Making: A Comparison of Students and Businessmen in a Simulated Progressive Auction." In *Research in Experimental Economics*, vol. 3, edited by V. L. Smith, pp. 139-57. Greenwich, CN: JAI Press, 1985.

CAMERER, C. F. "Do Biases in Probability Judgment Matter in Markets? Experimental Evidence." *The American Economic Review* (December 1987): 981-97.

_____. "The Rationality of Prices and Volumes in Experimental Markets." *Organizational Behavior and Human Decision Processes* (March 1992): 237-72.

_____. "Progress in Behavioral Game Theory." *Journal of Economic Perspectives* (Fall 1997): 167-88.

COLLINS, D. W., AND W. T. DENT. "The Proposed Elimination of Full Cost Accounting in the Extractive Petroleum Industry: An Empirical Assessment of the Market Consequences." *Journal of Accounting and Economics* (March 1979): 3-44.

DAVIS, D. D., AND C. A. HOLT. *Experimental Economics*. Princeton, NJ: Princeton University Press, 1993.

DEBONDT, W. F. M., AND R. H. THALER. "Does the Stock Market Overreact?" *Journal of Finance* (July 1985): 793-807.

_____. "Further Evidence on Investor Overreaction and Stock Market Seasonality." *Journal of Finance* (July 1987): 557-81.

_____. "Do Security Analysts Overreact?" *The American Economic Review* (May 1990): 52-7.

DEJONG, D. V.; R. FORSYTHE; AND W. C. UECKER. "The Methodology of Laboratory Markets and Its Implications for Agency Research in Accounting and Auditing." *Journal of Accounting Research* (Autumn 1985): 753-93.

DORAN, M.D.; D.W. COLLINS; AND D.S. DHALIWAL. "The Information of Historical Cost Earnings Relative to Supplemental Reserve-Based Accounting Data in the Extractive Petroleum Industry." *Accounting Review* (July 1998): 389-413.

DYCKMAN, T. R., AND A. J. SMITH. "Financial Accounting and Reporting by Oil and Gas Producing Companies: A Study of Information Effects." *Journal of Accounting and Economics* (March 1979): 45-75.

EASTON, P. D.; T. S. HARRIS; AND J. A. OHLSON. "Aggregate Accounting Earnings Can Explain Most of Security Returns: The Case of Long Return Intervals." *Journal of Accounting and Economics* (June/Sept. 1992): 119-142.

FINANCIAL ACCOUNTING STANDARDS BOARD. *Statement of Financial Accounting Standards No. 19: Financial Accounting and Reporting by Oil and Gas Producing Companies.* Stamford, CT: FASB, 1977.

_____. *Statement of Financial Accounting Standards No. 25: Suspension of Certain Accounting Requirements for Oil and Gas Producing Companies*. Stamford, CT: FASB, 1979.

_____. *Statement of Financial Accounting Standards No. 69: Disclosures about Oil and Gas Producing Activities*. Stamford, CT: FASB, 1982.

FRIEDMAN, D., AND S. SUNDER. *Experimental Methods: A Primer for Economists*. New York: Cambridge University Press, 1994.

GANGULY, A. R.; J. H. KAGEL; AND D. V. MOSER. "The Effects of Biases in Probability Judgments on Market Prices." *Accounting, Organizations and Society* (November 1994): 675-700.

GONEDES, N., AND N. DOPUCH. "Capital Market Equilibrium, Information Production, and Selecting Accounting Techniques: Theoretical Framework and Review of Empirical Work." *Journal of Accounting Research* (Supplement 1974): 48-129.

GRETHER, D. M. "Testing Bayes Rule and the Representativeness Heuristic: Some Experimental Evidence." *Journal of Economic Behavior and Organization* (January 1992): 31-57.

HAND, J. R. M. "A Test of the Extended Functional Fixation Hypothesis." *The Accounting Review* (October 1990): 740-63.

HARRIS, T.S., AND J.A. OHLSON. " Accounting Disclosures and the Market's Valuation of Oil and Gas Properties." *The Accounting Review* (October 1987): 651-670.

HIRST, D. E., AND P. E. HOPKINS. "Comprehensive Income Reporting and Analysts' Valuation Judgments." *Journal of Accounting Research* (Supplement 1998): forthcoming.

HOPKINS, P. E. "The Effect of Financial Statement Classification of Hybrid Financial Instruments on Financial Analysts' Stock Price Judgments." *Journal of Accounting Research* (Supplement 1996): 33-50.

JOHNSON, A.; H. Y. LEE; AND C. R. PLOTT. "Multiple Unit Double Auction User's Manual." Social Science Working Paper 676, California Institute of Technology, 1988.

KACHELMEIER, S. J. "Do Cosmetic Reporting Variations Affect Market Behavior? A Laboratory Study of the Accounting Emphasis on Unavoidable Costs." *Review of Accounting Studies* 1, no. 2 (1996): 115-40.

KAGEL, J. H., AND A. E. ROTH, EDS. *The Handbook of Experimental Economics*. Princeton, NJ: Princeton University Press, 1995.

KAHNEMAN, D., AND A. TVERSKY. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* (March 1979): 263-91.

KEEFER, D. L., AND S. E. BODILY. "Three-Point Approximations for Continuous Random Variables." *Management Science* (1983): 595-609.

KING, R. R. "Using Experimental Economics in Auditing Research." In *Auditing: Advances in Behavioral Research*, edited by L. A. Ponemon and D. R. L. Gabhart, pp. 93-112. New York: Springer-Verlag, 1991.

_____. "Reputation Formation for Reliable Reporting: An Experimental Investigation." *The Accounting Review* (July 1996): 375-96.

KING, R. R., AND D. E. WALLIN. "Disclosures when Seller's Level of Information is Unknown." *Journal of Accounting Research* (Spring 1991a): 96-108.

_____. "Market-Induced Information Disclosures: An Experimental Markets Investigation." *Contemporary Accounting Research* (Fall 1991b): 170-97.

KLEINMUNTZ, D. N., AND D. A. SCHKADE. "Information Displays and Decision Processes." *Psychological Science* (July 1993): 221-27.

LEV, B. " The Impact of Accounting Regulation on the Stock Market: The Case of Oil and Gas Companies." *The Accounting Review* (July 1979): 485-503.

_____ AND S. H. PENMAN. "Voluntary Forecast Disclosure, Nondisclosure, and Stock Prices." *Journal of Accounting Research* (Spring 1990): 49-76.

LIBBY, R. "Experimental Research and the Distinctive Features of Accounting Settings." In *The State of Accounting Research as We Enter the 1990s*, edited by T. J. Frecka, pp. 126-47. Urbana, IL: University of Illinois, 1989.

LINSMEIER, T. J., AND N. D. PEARSON. "Quantitative Disclosures of Market Risk in the SEC Release." *Accounting Horizons* (March 1997): 92-106.

LOPES, L. L. "Psychology and Economics: Perspectives on Risk, Cooperation, and the Marketplace." *Annual Review of Psychology* 45 (1994): 197-227.

LUNDHOLM, R. J. "What Affects the Efficiency of a Market? Some Answers from the Laboratory." *The Accounting Review* (July 1991): 486-515.

MAINES, L. A., AND L. S. MCDANIEL. "Implications of Comprehensive Income Volatility and Presentation Format for Investors' Judgments." Working paper, Indiana University, 1998.

PAYNE, J. W.; J. R. BETTMAN; AND E. J. JOHNSON. *The Adaptive Decision Maker*. New York: Cambridge University Press 1993.

PLOTT, C. R. "A Computerized Laboratory Market System and Research Support Systems for the Multiple Unit Double Auction." Social Science Working Paper 783, California Institute of Technology, 1991.

PORTA, R. L.; J. LAKONISHOK; A. SHLEIFER; AND R. VISHNY. "Good News for Value Stocks: Further Evidence on Market Efficiency." *Journal of Finance* (June 1997): 859-74.

SECURITIES AND EXCHANGE COMMISSION. *Accounting Series Release No. 253: Adoption of Requirements for Financial Accounting and Reporting Practices for Oil and Gas Producing Activities.* Washington, D.C.: SEC, 1978.

_____. *Accounting Series Release No. 269: Oil and Gas Producers - Supplemental Disclosures on the Basis of Reserve Recognition Accounting.* Washington, D.C.: SEC, 1979.

_____. *Accounting Series Release No. 289: Financial Reporting by Oil and Gas Producers.* Washington, D.C.: SEC, 1981.

SIMON, H. A. "Rationality in Psychology and Economics." *Journal of Business* (October 1986): S209-24.

SLOVIC, P. "From Shakespeare to Simon: Speculation—and some evidence—about man's ability to process information." *Oregon Research Institute Bulletin*, 12 (1972).

SLOVIC, P., AND D. MACPHILLAMY. "Dimensional Commensurablility and Cue Utilization in Comparative Judgment." *Organizational Behavior and Human Performance* (1974): 174-94.

SMITH, V. L. "Economics in the Laboratory." *Journal of Economic Perspectives* (Winter 1994): 113-31.

STERMAN, J. D. "Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment." *Management Science*, 35 (1989): 321-39.

THALER, R. H., ED. *Advances in Behavioral Finance.* New York: Russell Sage Foundation, 1993.

TVERSKY, A., AND D. KAHNEMAN. "Judgment under Uncertainty: Heuristics and Biases." *Science* (1974), 1124-31.

_____. "Rational Choice and the Framing of Decisions." *Journal of Business* (October 1986): S251-78.

_____. "Advances in Prospect Theory: Cumulative Representation of Uncertainty." *Journal of Risk and Uncertainty* (October 1992): 297-323.

WALLER, W. S. "Decision-Making Research in Managerial Accounting: Return to Behavioral-Economics Foundations." In *Judgment and Decision-Making Research in Accounting and Auditing*, edited by R. H. Ashton and A. H. Ashton, pp. 29-54. New York: Cambridge University Press, 1995.

WRIGHT, W. F., AND U. ANDERSON. "Effects of Situation Familiarity and Financial Incentives on Use of the Anchoring and Adjustment Heuristic for Probability Assessment." *Organizational Behavior and Human Decision Processes* (August 1989): 68-82.

YATES, J. F.; C. M. JAGACINSKI; AND M. D. FABER. "Evaluation of Partially Described Multiattribute Options." *Organizational Behavior and Human Performance* (1978): 240-51.

Notes

[1] To be consistent with AICPA [1994], we use the terms “upside opportunity” (“downside risk”) to refer to outcomes in an uncertain distribution that are better (worse) than expected outcomes.

[2] See the appendix for a summary of the history of standard setting and prior research on oil and gas reporting issues.

[3] There are several reviews of laboratory markets and experimental economics, including an article by Smith [1994], books by Davis and Holt [1993] and Kagel and Roth [1995], and a methodological primer by Friedman and Sunder [1994]. Lopes [1994] contrasts the experimental perspectives of economics against those of psychology. In accounting, DeJong, Forsythe, and Uecker’s [1985] introduction of the methodology was followed by several other studies, many of which have dealt with strategic models of auditing (reviewed by King [1991]).

[4] The term “proved reserves” is potentially confusing. In the oil and gas industry, proved reserves is management’s best estimate of quantities of oil available with reasonable certainty, not the minimum amount available with complete certainty (Brock, Jennings, and Feiten [1996, pp. 394-397]). To avoid any misunderstanding in our experimental materials, we refer to management’s best estimate as “expected reserves” (not proved reserves).

[5] At acquisition of each oil well, the instructions describe a 90% confidence bound that is evenly spaced around expected reserves. Further, after acquisition, traders received information and experienced outcomes consistent with a symmetric distribution.

[6] Using this software, participants proposed a buying price (bid) or selling price (ask). The computer display showed the current high bid and low ask. A trade consummated when a participant accepted either the outstanding bid or the outstanding ask. Cash and security balances

were updated automatically. Short selling was not permitted in our market because it would have added appreciably to the complexity of an already complex experiment.

[7] We also examined a number of similar measures, including median trading price, trimmed means of trading prices, and trading prices at the end of each period. These measures led to the same conclusions as those reported for average trading prices. Furthermore, we examined several other measures, including the volatility of prices within each trading period (standard deviation) and trading volumes, and found no systematic differences across disclosure conditions.

[8] In Table 4, all remaining significant interactions and main effects are subsumed within the higher order interactions discussed in this section.

[9] In the F/S-ONLY condition, the correlation between period 2 trading prices and the expected terminal value of the firm based on management's private information is 0.76 ($p < 0.01$).

[10] Dual-sided disclosures also could make risk more prominent. Risk-averse investors might then lower prices because they are paying more attention to risk. For good-news firms (shown in light gray in Panel D of Figure 4), prices are particularly low in the EXPECTED+BOTH disclosure condition. While this pattern is consistent with a risk prominence effect, it is not statistically significant.

[11] Tables, graphs, and statistical tests similar to those reported for market prices are available from the authors upon request.

[12] See Sterman [1989] for another example where aggregate behavior amplifies individual biases.

Table 1: Management Knowledge of Oil Reserve Quantities (in Barrels)

	Prior to Acquisition		**Subsequent to Acquisition**		**Revealed on Termination**	
Firm	Expected Value	Standard Deviation	Expected Value	Standard Deviation	Actual Quantity	Dividend Paid (per Share)
1	500	144	355	64	283	$ 5.66
2	500	144	379	64	451	$ 9.02
3	500	144	428	128	549	$ 10.98
4	500	144	440	128	319	$ 6.38
5	500	144	560	128	415	$ 8.30
6	500	144	572	128	717	$ 14.34
7	500	144	621	64	681	$ 13.62
8	500	144	645	64	585	$ 11.70

Table 2: Reserve Quantity Disclosures

Firm	Trading Period 0			Trading Period 1			Trading Period 2		
	Expected Reserves	Max. Reserves	Min. Reserves	Expected Reserves	Max. Reserves	Min. Reserves	Expected Reserves	Max. Reserves	Min. Reserves
Information Direction Negative Primary Adjustment Large Secondary Adjustment Low									
1	500	735	265	255	360	150	156	260	54
Secondary Adjustment High									
2	500	735	265	279	384	174	179	284	75
Primary Adjustment Small Secondary Adjustment Low									
3	500	735	265	330	539	123	239	441	53
Secondary Adjustment High									
4	500	735	265	341	551	134	249	452	59
Information Direction Positive Primary Adjustment Small Secondary Adjustment Low									
5	500	735	265	460	670	250	361	571	152
Secondary Adjustment High									
6	500	735	265	472	682	262	373	582	164
Primary Adjustment Large Secondary Adjustment Low									
7	500	735	265	521	626	416	421	526	316
Secondary Adjustment High									
8	500	735	265	545	650	440	445	550	340

Table 3: Average Trading Price by Trading Period, Information Condition, and Firm

	Information Direction							
	Negative				Positive			
	Primary Adjustment							
	Large		Small		Small		Large	
	Secondary Adjustment							
	Low	High	Low	High	Low	High	Low	High
Trading Period 0								
Expected Value	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Disclosure Condition								
FIN. STATEMENTS ONLY	9.83	9.76	9.70	9.87	9.71	9.13	9.62	9.94
EXPECTED	10.25	10.23	10.25	10.09	10.02	10.22	9.72	10.18
EXPECTED + MAX.	9.93	10.77	10.37	10.60	10.02	9.69	10.17	10.06
EXPECTED + MIN.	10.25	10.28	10.14	10.23	10.14	10.26	10.09	9.75
EXPECTED + BOTH	9.80	10.00	9.80	9.63	9.74	9.62	9.54	9.31
Trading Period 1								
Expected Value	7.10	7.58	8.59	8.83	11.20	11.44	12.42	12.90
Disclosure Condition								
FIN. STATEMENTS ONLY	8.57	8.80	8.94	9.74	10.56	10.09	10.41	10.66
EXPECTED	7.49	7.63	8.75	8.56	11.20	11.36	11.96	12.19
EXPECTED + MAX.	8.49	8.33	9.42	10.02	11.49	11.25	12.03	12.09
EXPECTED + MIN.	8.01	8.11	8.61	8.98	10.96	11.24	12.11	11.72
EXPECTED + BOTH	8.22	7.75	8.84	8.97	10.62	10.81	10.94	10.69
Trading Period 2								
Expected Value	7.12	7.59	8.78	8.98	11.22	11.45	12.42	12.90
Disclosure Condition								
FIN. STATEMENTS ONLY	7.81	8.00	9.19	9.61	11.17	10.67	10.14	11.37
EXPECTED	7.37	7.74	8.86	9.01	11.23	11.38	12.15	12.71
EXPECTED + MAX.	8.68	7.71	8.95	9.75	11.98	11.55	12.26	12.47
EXPECTED + MIN.	7.71	7.74	8.70	8.72	11.09	11.40	12.22	12.42
EXPECTED + BOTH	7.48	7.31	8.14	8.86	11.10	11.12	11.26	11.50

Table 4: Summary of Repeated Measures Analysis for the Difference between Average Trading Price and Expected Value for Trading Periods 1 & 2

Main Effects and Interactions	*Degrees of Freedom*	*F Statistic*	*p Value*[*]
Disclosure Condition (DC)	4,12	1.92	
Direction (DIR)	1,12	33.70	< 0.01
Primary Adjustment (PA)	1,12	3.60	0.08
Secondary Adjustment (SA)	1,12	5.00	0.05
Trading Period (TP)	1,12	0.10	
DC x DIR	4,12	2.96	0.07
DC x PA	4,12	0.94	
DC x SA	4,12	0.22	
DC x TP	4,12	0.42	
DIR x PA	1,12	20.46	< 0.01
DIR x SA	1,12	0.49	
DIR x TP	1,12	37.53	< 0.01
PA x SA	1,12	4.67	0.05
PA x TP	1,12	< 0.01	
SA x TP	1,12	1.27	
DC x DIR x PA	4,12	0.72	
DC x DIR x SA	4,12	0.27	
DC x DIR x TP	4,12	2.20	
DC x PA x SA	4,12	1.48	
DC x PA x TP	4,12	2.22	
DC x SA x TP	4,12	0.80	
DIR x PA x SA	1,12	18.43	< 0.01
DIR x PA x TP	1,12	5.49	0.04
DIR x SA x TP	1,12	0.68	
PA x SA x TP	1,12	2.04	
DC x DIR x PA x SA	4,12	4.77	0.02
DC x DIR x PA x TP	4,12	2.02	
DC x DIR x SA x TP	4,12	1.15	
DC x PA x SA x TP	4,12	0.97	
DIR x PA x SA x TP	1,12	4.99	0.05
DC x DIR x PA x SA x TP	4,12	0.24	

[*] Values above 0.10 are not shown.

Figure 1: The Prospect Theory Value Function

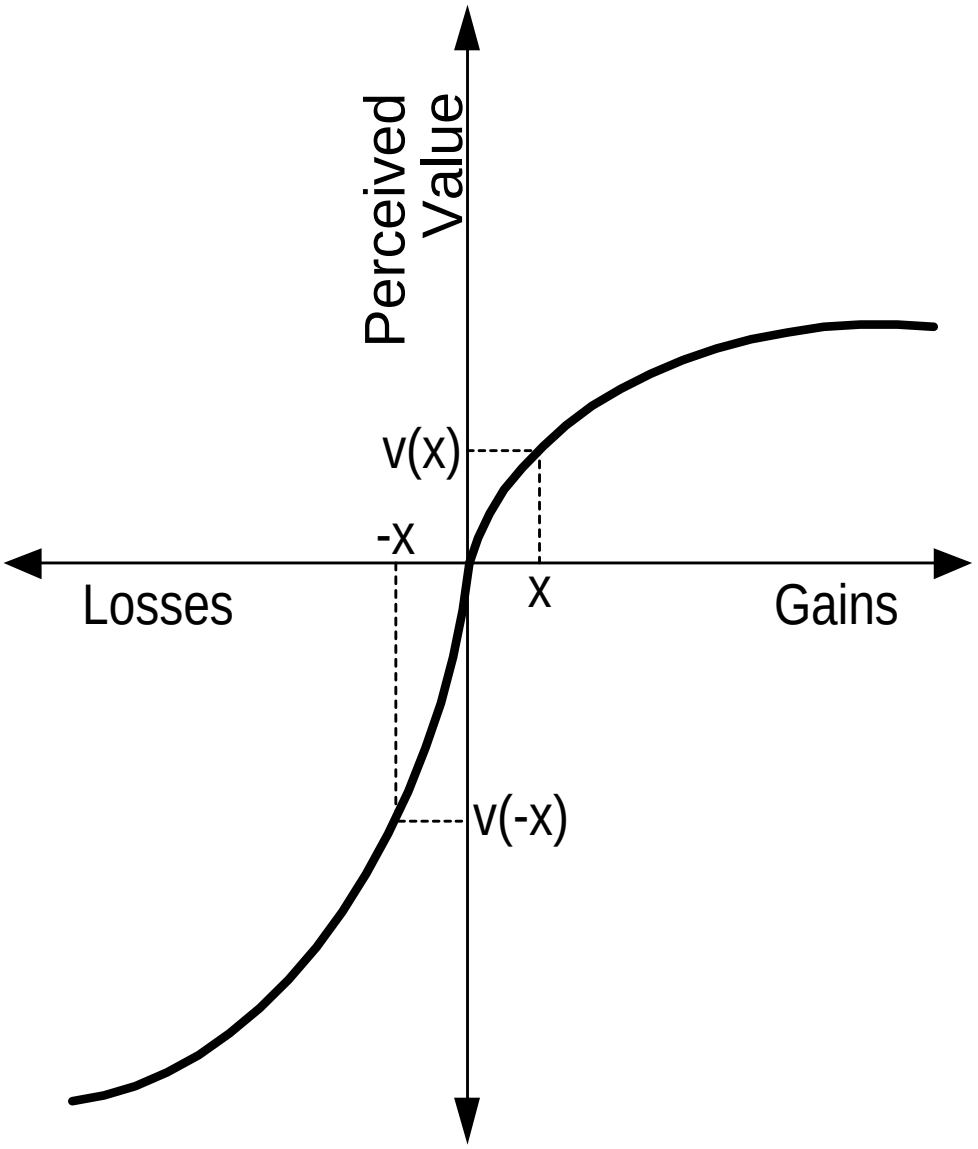

Figure 2: Sample Financial Report

Firm C, Period 2

Income Statement for Period 2

Sales = 100 barrels x $20	$2,000
Less Cost of Sales (depletion of well)	(805)
= Net income	$1,195

Balance Sheet as of the End of Period 2

Cash		$4,000
Oil Well, at cost	$5,000	
Less Accumulated Depletion	(1,610)	
= Net Book Value of Well		$3,390
Total Assets		$7,390
Capital Stock		$5,000
Retained Earnings		2,390
Total Equity		$7,390

Supplemental Disclosures:

Estimate of Expected Reserves	
Management's best estimate of the amount of oil remaining to be produced in future periods (in barrels)	421
Value of this quantity if sold at $20 per barrel	$8,420
Estimate of Maximum Reserves Possible	
As a likely upper bound, management estimates only a 5% chance of more than this quantity of oil remaining to be produced (in barrels)	526
Value of this quantity if sold at $20 per barrel	$10,520
Estimate of Minimum Reserves Possible	
As a likely lower bound, management estimates only a 5% chance that there is less than this quantity of oil remaining to be produced (in barrels)	316
Value of this quantity if sold at $20 per barrel	$6,320

Figure 3: Average Trading Price by Trading Period and by Firm

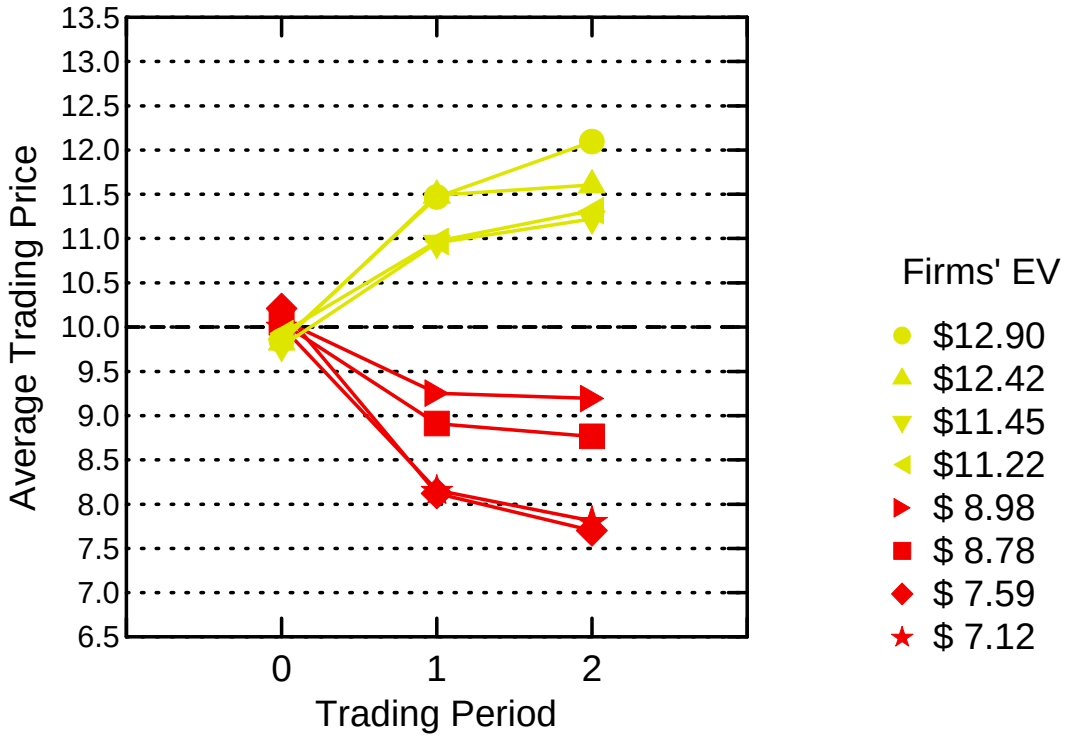

Figure 4: Comparisons of Difference between Average Trading Price and Expected Value by Information Condition and by Firm (Trading Periods 1 and 2)