and lowest observations of each data item. The regression coefficients, coefficient standard errors and the r-squared statistics differed across these techniques.

References

Alciatore, M., C. Dee, P. Easton, and N. Spear. 1999. Asset write-downs: A decade of research, Journal of Accounting Literature (Forthcoming).

Ayres, F., and J. Rayburn. 1991. Selectivity bias and the association between unexpected returns, earnings and supplementary reserve disclosures in the petroleum industry. Working Paper, University of Oklahoma.

Boone, J., 1995. The use of finding costs in investment analysis. Petroleum Accounting and Financial Management Journal (Fall/Winter): 47-59.

Coe, T., 1995. A review of finding cost studies. Petroleum Accounting and Financial Management Journal (Fall/Winter): 37-46.

Easton, P., T Harris and J. Ohlson. 1992. Accounting Earnings Can Explain Most of Security Returns. Journal of Accounting and Economics: 119-142.

Spear, N., 1996. The differential stock market reaction to the cash and accrual components of earnings of oil and gas producers. Journal of Energy Finance and Development: 99-111.

Warfield, T., and J. Wild. 1992. Accounting recognition lag and the relevance of earnings as an explanatory variable for returns. The Accounting Review: 821-842.

reserves assuming continuation of yearend economic and operating conditions.

* The annual changes in the value-based information along the following categories:
  (1) Prices and costs
  (2) Quantities
  (3) Income taxes
  (4) Others
* A number of independent organizations (such as Newport Associates, Arthur Andersen, John Herold, Goldman Sachs, etc.) assist the investment community by calculating and publishing estimates of the "Finding Costs" of oil and gas producers.
* That is because costs incurred leading to reserve additions are usually made over several years preceding the drilling of a discovery well.

3. A number of independent organizations (such as Newport Associates, Arthur Andersen, John Herold, Goldman Sachs, etc.) assist the investment community by calculating and publishing estimates of the "Finding Costs" of oil and gas producers.
4. That is because costs incurred leading to reserve additions are usually made over several years preceding the drilling of a discovery well.
5. Natural gas is converted to equivalent barrels based on BTU content (i.e., 6 MCF = 1 barrel).
6. All of these measures were extracted from the Finding Costs Guidelines' working paper released by COPAS (see footnote 1).
7. Industry membership was identified in accordance with the industry classification adopted by Arthur Andersen's oil and gas reserve database.
8. These regressions were repeated with several outlier removal techniques including (1) all observations included, (2) removal of observations based on the size of the regression residual, (3) removal of observations based on influence on the regression coefficients, (4) removal based on influence on r These regressions were repeated with several outlier removal techniques including (1) all observations included, (2) removal of observations based on the size of the regression residual, (3) removal of observations based on influence on the regression coefficients, (4) removal based on influence on r-squared, and (5) removal of the highest

about the reserve finding activities of O&G producers are adequate and that there does not appear to be any justification for any alteration to the current rules as outlined in SFAS No. 69. The finding of this paper should also be helpful to the International Accounting Standards Committee which is currently developing a new international standard for the extractive industries.

Footnotes

1. This problem is not limited to measures generated by the investment community; rather, it is a problem that is still debated among the oil and gas producers for internally generated measures. This disagreement led the Council of Petroleum Accountants Societies (COPAS) to issue a working paper aiming to provide guidelines for use in determining "Finding Costs". In addition, the Financial Accounting Standards Board's SEC Committee is working jointly with COPAS on these guidelines.
2. SFAS 69 requires O&G producing firms to disclose, on an annual basis, the following items:
   * Net quantities of a firm's interests in proved reserves and proved developed reserves of crude oil and natural gas as of the beginning and end of each year.
   * Changes in a firm's net quantities of proved O&G reserves along the following categories:
     (1) Revisions of previous estimates
     (2) Improved recovery
     (3) Purchases of reserves in-place
     (4) Extensions and discoveries
     (5) Production
     (6) Sales of reserves in-place
   * A firm's aggregate capitalized costs relating to O&G producing activities and the related accumulated depreciation, depletion, amortization, and valuation allowances.
   * The costs incurred in property acquisition, exploration, and development activities.
   * The historical results of operations for O&G producing activities.
   * Value-based information about a firm's proved O&G reserves based on estimates of future cash flows from production of proved

gest that there are differential market implications for these measures depending on the industry membership. That is, the correlation between returns and each of the measures for the Independents is significant at the 0.01 level. On the other hand, for all other industry groups, the correlation statistics are not significant at conventional levels. One caveat regarding these industry membership tests is that the coefficients for each industry group are estimated using a much smaller number of observations, which can decrease the power to detect relationships. The correlation statistics for the accounting method subsamples suggest that the alternative measures are value relevant regardless of the accounting method choice. Interestingly, the correlation statistics for the full cost firms are significantly higher than those for the successful efforts firms.

G- Conclusion

All of the above efficiency measures were extracted using publicly available data as required by SFAS No. 69 and therefore suffer from a number of problems relating to mismatch, and data deficiency. As a result of the sharp oil decline of 1986, and the recent oil price drop, members of the investments community argued that, in order to properly assess the reserve finding activities of O&G producers, these firms should disclose detailed internal "Finding Costs" measures. While a handful of firms voluntarily disclose detailed internal "Findings Costs" measures, the rest of the firms in the industry refuse to do so arguing that the costs of disclosing the internal measures (such as a loss of competitive market position) would outweigh the benefits.

In effect, on numerous occasions, O&G firms have argued that current disclosures, as required by SFAS No. 69, while not detailed, provide a good overall summary of their reserve finding activities. The results of this paper appear to support the argument made by the O&G producers in that the current disclosure requirements provide adequate information about their reserve finding activities. It is obvious from the finding of this study that Exploration Cost Per EBO of Discoveries is the best efficiency measure, in terms of its ability to explain variations in security returns. That is, it provides a good summary of some of the information which affected security prices over the sample period. One explanation for this is that this measure provides the most direct evidence about the exploration efficiency of the firm. While the other three measures were value relevant as well, their incremental effect seems to be minimal.

The findings of this study show that the current disclosure requirements

Ayres and Rayburn (1991) and Spear (1996)), these studies have examined the association between returns and earnings over shorter time intervals. Increasing the return interval and aggregating earnings over longer periods should reduce the impact induced by the differences inherent in the two accounting methods.

For the entire sample, the correlation between returns and exploration cost per EBO of discoveries (i.e., Measure 1), after controlling for earnings, is -0.35 and significant at the 0.01 level. This finding is consistent with the view that this measure is value relevant, in the sense that it provides a summary of some of the information that the marked used in setting security prices. This finding is also consistent with the view that the disclosure requirements of SFAS 69 are value relevant. The correlation statistics also suggest that all other measures are value relevant. However, it appears that Measure 1 dominates all other measures. Formal statistical tests show that, after controlling for the effect of Measure 1, the incremental explanatory power of each of the three other measures is hardly significant at 0.10 level.

Table 6: Rank Correlation Between Security Returns and Alternative Efficiency Measures

	Rjt,Ejt	Rjt,M1jt | Ejt	Rjt,M2jt | Ejt	Rjt,M3jt | Ejt	Rjt,M4jt | Ejt
All Firms	0.77 ***	-0.35 ***	-0.38 ***	-0.39 ***	-0.41 ***
Majors	0.75 ***	-0.17	-0.21	-0.24	-0.26
Independents	0.82 ***	-0.41 ***	-0.44 ***	-0.45 ***	-0.48 ***
Diversified	0.64 ***	-0.16	-0.16	-0.15	-0.17
Pipelines/Utilities	0.59 ***	-0.11	-0.12	-0.13	-0.13
Full Cost	0.74 ***	-0.42 ***	-0.45 ***	-0.47 ***	-0.49 ***
Successful Efforts	0.77 ***	-0.26 **	-0.28 **	-0.29 **	-0.31 ***

Legends:

Rjt is the return on shares of firm j over the period t (i.e.,1985-1994)

Ejt is the accounting earnings per share of firm j for the period t

Mi,jt is the efficiency measure i (i = 1, 2, 3, or 4) for firm j for the period t

* Significantly different from zero at the 10% level

** Significantly different from zero at the 5% level

*** Significantly different from zero at the 1% level

The correlation statistics for the industry membership subsamples sug-

ration activities, they succeeded in attaining higher exploration efficiency levels than their Successful Efforts counterpart (see Measures 1 and 2). However, there was no significant difference between the two groups' all-inclusive efficiency levels (see Measure 4).

Table 5: Descriptives Statistics for the Efficiency Measures-by Accounting Method

		Mean	Std. Deviation	Median	Percentile 25	Percentile 75
Successful Efforts	Measure1	2.87	4.06	2.2	1.21	3.42
	Measure2	2.15	1.97	1.91	1.09	2.55
	Measure3	7.96	4.33	7.2	4.83	8.42
	Measure4	5.54	1.87	5.55	4.51	6.64
Full Cost	Measure1	2.04	1.51	1.71	0.85	2.63
	Measure2	1.87	1.69	1.54	1.01	1.99
	Measure3	6.86	3.76	5.96	4.05	7.8
	Measure4	5.42	2.24	5.49	3.73	6.22

F- Tests Results

Due to the presence of a significant number of outliers, the empirical testing was performed using ranks rather than absolute values of each data item. Accordingly, Spearman rank correlations were used in lieu of regression r-square statistics and partial Spearman rank correlations were used to test for the incremental explanatory power of the alternative efficiency measures[8].

Table 6 summarizes the results for the analyses of the contemporaneous Spearman correlations between returns, earnings, and the alternative efficiency measures. These correlations capture the ideas implicit in regressions (1), and (2). For the entire sample, the correlation between returns and earnings was 0.77 and significant at the 0.01 level. There is a similarly high correlation between returns and earnings for every subsample. The high correlation is consistent with the results in Easton, Harris and Ohlson (1992) and Warfield and Wild (1992) who suggested that the explanatory power of earnings for returns would increase as the return interval increases.

As can be seen in Table 6, the correlation between returns and earnings of successful efforts firms was not significantly different from and that of full cost firms. While previous studies have consistently reported a differential market implication for the earnings of the two groups (see for example,

As noted earlier, Measure 3 and Measure 4 do not measure exploration efficiency per se; rather they measure the overall finding cost of proved reserves. Measure 3 differs from Measure 2 in that it includes development costs as well as the costs associated with the acquisition of unproved properties. The median value for this measure is $6.57, which is significantly higher than those of Measure 1 and Measure 2. It is worth noting here that most of this increase was induced by development costs. As can be seen in Table 3, the Majors have outperformed all other groups followed closely by the Independents.

TABLE 3: Descriptive for Measure 3- Total Cost (Less Proved Acqustions) Per EBOof Discoveries and Revisions

	Mean	Std. Deviation	Median	Percentile 25	Percentile 75
Majors	5.65	1.75	5.40	3.93	7.18
Independents	7.36	4.74	6.24	4.09	8.10
Diversified	8.07	3.04	7.94	6.03	9.05
Pipelines/Utilities	9.00	4.77	7.53	5.85	10.69

Measure 4 differs from Measure 3 in that it takes into consideration the costs associated with the acquisition of proved properties and the reserves added as a result of reserve purchase in-place. Thus, it is an all-inclusive measure of efficiency. The median value for this measure is $5.53, which is significantly lower than that of Measure 3. As can be seen in Table 4, the Independents have outperformed all industry groups. Interestingly, the Majors were the only firms that did not report any significant improvement in this measure relative to Measure 3.

TABLE 4: Descriptive Statistics for Measure 4-Total Cost Per EBD of total Reserve Additions

	Mean	Std. Deviation	Median	Percentile 25	Percentile 75
Majors	5.38	1.38	5.47	4.07	6.63
Independents	5.09	2.26	4.80	3.34	5.78
Diversified	6.14	1.20	5.99	5.57	7.01
Pipelines/Utilities	6.48	2.23	5.92	5.40	7.53

Table 5 presents descriptive statistics for the alternative efficiency measures grouped by the accounting method. It is interesting to find that while Full Cost firms are known for being very aggressive in their explo-

vides two measures of central tendency (mean and median) as well as measures of dispersion. The median value for exploration cost per EBO of Discoveries for the entire sample is $1.97. As can be seen in Table 1, the median value for this measure for the *Independents* is $1.57, which is significantly lower than that of the other groups. On the other hand, surprisingly, the *Majors* incurred the highest exploration costs per EBO of discoveries.

TABLE 1: Descriptive Statistics for Measure 1-Exploration Cost Per EBO of Discoveries

	Mean	Std. Deviation	Median	Percentile 25	Percentile 75
Majors	2.83	0.89	2.59	2.21	3.47
Independents	2.51	4.15	1.57	0.88	2.79
Diversified	2.38	1.45	2.37	1.15	3.53
Pipelines/Utilities	2.40	1.35	2.50	1.43	3.09

The median value for exploration cost per EBO of discoveries as well as revisions is $ 1.70, which is lower than that for Measure 1. This suggests that oil and gas firms have, on average, underestimated their proved oil and gas reserves. As can be seen in Table 2, all of the industry groups have attained lower median values for this measure than those of measure 1. While the independents still outperformed the other groups, it is clear that the majors have reported, by far, the best improvement in this measure over that of measure 1. This finding suggests that the Majors are very conservative when it comes to reporting their proved oil and gas reserves. This should not be surprising especially since all of the majors also adopt the most conservative accounting method (that is the successful efforts method) to account for their oil and gas exploration activities.

TABLE 2: Descriptive Statistics for Measure 2-Exploration Cost Per EBD of Discoveries & Revisions

	Mean	Std. Deviation	Median	Percentile 25	Percentile 75
Majors	1.81	0.54	1.71	1.43	2.10
Independents	1.99	2.33	1.50	0.78	2.26
Diversified	2.11	1.35	1.88	1.34	2.80
Pipelines/Utilities	2.34	1.60	2.04	1.26	2.27

Mi,jt is the efficiency measure i (i = 1, 2, 3, or 4) for firm j for the period t, and Pjt-1 is the price per share of firm j at the beginning of the period t.

A formal comparison of the r-squared statistic from regression (1) with the r-squared from regression (2) may be used as an indication of the value relevance of the alternative efficiency measures. A higher r-squared in regression (2) suggests that the efficiency measure is value relevant in the sense that it provides a summary of some of the information used by investors in setting security prices.

D. Data Sources and Sample Selection Procedures

The initial sample was prepared after combining the 1990 and the 1995 Arthur Andersen Oil and Gas Reserve Databases. The 1990 Database included the reserve data of 239 oil and gas firms for the 1985-1989 sample period, while the 1995 Database included the reserve data of 216 oil and gas firms for the 1990-1994 sample period. Firms that did not have a complete ten-year data series were eliminated. None U.S firms were also excluded. Availability of the required earnings information and security returns data (comprised of year-end prices and quarterly dividends) on the combined annual Compustat files at the University of Chicago reduced the sample size to 109 firms. Below is a breakdown of the sample by accounting method and industry membership.[7]

Industry Membership	Accounting Method		TOTAL
	Successful Efforts	Full Cost	
Majors	12		12
Independent	33	31	64
Diversified	12	11	23
Pipelines/Utilities	5	5	10
Total	62	47	109

E. Descriptive Statistics

Tables 1-4 present descriptive statistics for the four "Finding Costs" measures summarized according to the industry membership. Due to the presence of a significant number of outliers, each table pro-

between the "Finding Costs" measures and returns calculated over a longer interval, such as a fiscal year or multiple fiscal years. This approach provides an answer to the research question: Do "Finding Costs" measures provide a summary of some of the information that investors have used in setting security prices over the period? Accordingly, this approach addresses the role of accounting to provide a summary of the events that have affected the firm over the accounting period. To address this question, association studies examine the relation between returns (measured over a period) and accounting data, such as "Finding Costs", for the same period.

This study advocates the association approach. The classical information content approach is not advocated here for two reasons. First, the aim of the study is to investigate the extent to which SFAS 69 disclosures, which include the components of the Findings Costs measures, provide a reasonable summary of the information used by investors in setting security prices. Security Price Changes (raw returns) do capture the change in the information set used by investors over the return period. Second, the information content approach requires a measure of the expected amount of the "Finding Costs". Determining this expected amount is problematic for many reasons, some of which include the mismatching issues discussed above. In order to overcome the variations associated with mismatching the period the reserve additions with the period in which the firm incurred the costs that led to the reserve additions, all of the "Finding Costs" measures, earnings data, and the price changes were computed using aggregated data for the entire sample period (i.e., 1985-1994).

Adapting the theoretical model in Easton, Harris and Ohlson [1992], the empirical testing may be formalized in a regression framework:

$$Rjt = 0 + 1[Ejt/Pjt\text{-}1] + ejt \qquad (1)$$

$$Rjt = 0 + 1[Ejt/Pjt\text{-}1] + 2[Mi,jt/Pjt\text{-}1] + ejt \qquad (2)$$

where

Rjt is the return on shares of firm j over the period t (i.e.,1985-1994),

Ejt is the accounting earnings per share of firm j for the period t,

prior quantity estimates. The rationale for including the "revisions" component is that it represents revisions to prior discoveries.

Measure 3 - Total Costs (Less Proved Acquisition) Per EBO of Discoveries and Revisions:

This calculation represents an aggregate measure of the total costs incurred in adding reserves through discoveries and revisions. Costs included are those associated with exploration, development, and acquisition of unproved properties.

Measure 4 - Total Costs Per EBO of Total Reserve Additions:

This calculation includes all proved reserves added during the year together with those added through purchases. Costs included are those associated with exploration, development, and acquisition of unproved and proved properties.

C. Research Design

The value relevance of the "Finding Costs" measures can be investigated using one of two approaches: information content approach or association approach. Alciatore et al. (1999) maintain that it is important to recognize that each of these two approaches addresses a different set of questions and that the choice of question to be addressed leads to the determination of which method to employ.

The information content approach focuses on the relation between the "Finding Costs" measures and returns measured over a relatively short interval (e.g., a few days window surrounding their release date). This approach provides an answer to the research question: Do "Finding Costs" measures convey information to investors at the time of their release? Accordingly, this approach addresses the role of accounting of providing timely information that may be used by investors in setting security prices. To address this question, it is appropriate to examine returns over a short period. As noted by Alciatore et al. (1999), using a short window: (1) should increase the likelihood that any observed market reaction is related to the event (as opposed to other factors), and (2) may capture the effects of the market's viewing the announcement as a signal of management's future actions.

The association approach, on the other hand, examines the association

cost incurred[2], it does not require these firms to match costs incurred and reserve additions at the well/ property/ field level. As a result, it is left up to the investment community to generate aggregated "Finding Costs" measures, relying solely on the disclosed information as required in SFAS No. 69.[3] Accordingly, each aggregated measure is likely to suffer from mismatch between costs incurred and reserves added in a common time period, which would introduce an undue variation to the time-series property of the measure.[4] In order to overcome the variations associated with mismatching the period of the reserve additions with the period in which the firm incurred the costs that led to the reserve additions, one has to calculate multiple year weighted average "Finding Costs" measures. Although the "Finding Costs" measures generated by the investment community may not reflect the true underlying efficiency level of oil and gas producers, they are useful for comparing the performance of one oil and gas producer to another over an extended period of time.

B. Finding Costs Measures

All of the "Finding Costs" measures compute the average cost per equivalent barrel of oil (EBO) added.[5] There are many variations in the way "Finding Costs" measures can be calculated, depending on the elements of the costs incurred, or the components of the reserves added. This section provides a discussion of four alternative measures[6], none of which rely on internally generated data. The first two measures provide a gauge of the relative exploration efficiency of O&G producers and the last two measures provide a gauge of the overall reserve finding efficiency.

Measure 1 - Exploration Cost Per EBO of Discoveries:

This calculation includes proved reserves added as a result of new discoveries but does not include reserves added as a result of revisions to prior quantity estimates. All costs associated with exploration activities are included, regardless of their success.

Measure 2 - Exploration Cost Per EBO of Discoveries and Revisions:

This calculation is similar to the one used in generating Measure 1, except for the inclusion of reserves added as a result of revisions to

INTRODUCTION

The recent oil price collapse led many oil and gas (O&G) producing firms to re-evaluate the efficiency of their oil and gas reserve finding activities. Efficiency, in this context, refers to the cost of finding new proved oil and gas reserves on a per-barrel basis (thereafter, Finding Costs). From the investment community's point of view, evaluating the efficiency of the reserve finding activities of O&G producing firms is extremely problematic (see Boone, 1995). The difficulty relates to the deficiencies associated with the publicly disclosed data and the lack of agreement over a standard definition for a "Finding Costs" measure and over the elements included in its calculation.

The purpose of this study is to examine the value relevance of alternative publicly-available "Finding Costs" measures by investigating the contemporaneous association between "raw" security returns and the alternative measures over the sample period, after controlling for the association between security returns and earnings. That is, security returns would be used as a benchmark against which to measure the value relevance of the alternative measures. High contemporaneous association between a given "Finding Costs" measure and security returns would suggest that the measure is useful for security valuation purposes. While prior studies have simply focused on discussing the appropriateness of alternative approaches to measuring "Finding Costs" [see Coe (1995) for a review of these studies], this study provides the first empirical evidence on the value relevance of the alternative measures.

A. Background

In order to properly assess the reserve finding activities of O&G producers, one needs to access, track, and match costs incurred and reserve additions at the well/property/field level in a common time period. These details are available for internal reporting purposes but not to the external users. While Statement of Financial Accounting Standards No. 69 requires oil and gas firms to disclose information about their interests in oil and gas reserve quantities and the annual

The Arab Journal of Accounting
Vol. 3, No. 1
May1999
PP. 117-130

The Efficiency of the Reserve Finding Activities of Oil and Gas Producers

Nasser A. Spear
King-Fahd University of Petroleum and Minerals

Abstract

In light of the recent decline in oil and gas prices, many oil and gas producers found it extremely difficult to survive and had to restructure their petroleum activities. In such an environment, efficiency became a concept of paramount importance. In the united state, oil and gas producers are not required to disclose measures about the efficiency of their oil and gas operations. Rather, under SFAS No. 69, these companies are only required to disclose aggregated costs date and to proved information about the efficiency of reserve quantum and reserve value and annual changes therein. Thus it is left up to the investment community to utilize the above publicly available disclosures to extract aggregated efficiency measures. Although these measures suffer from mismatch between cost incurred and reserve added in a common time period, they are used by investors to compare the performance of oil and gas producer over extended periods.

This paper examines the value relevance of alternative publicly-available efficiency measures of 109 U.S producers by investigating the contemporaneous association between "raw" security returns and the alternative measures over the 1985-1994 sample period. That is, adapting the theoretical framework of Easton, Harries and Ohlson [1992], security return would be used as a benchmark against which to measure the value relevance of the alternative measures. The empirical results show that, after controlling for earning, these measures provide a good summary of the information which affected security price over the sample period. That is to say, these measure provide a good indication about the efficiency of the reserve finding activities of oil and gas producers in spote of the problem associated whit their calculation.