Determinants of Accounting Change: an Industry Analysis of Depreciation Change

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This study examines whether the large number of depreciation-related accounting changes made by oil and gas drilling firms during the early eighties can be explained by changes in earnings prospects and related changes in agency cost variables. Empirical evidence, based on all thirty contract drilling firms for which data were available, shows that a model consisting of variables representing changes in sales, rig utilization rate and income before accounting change has significant explanatory and predictive power. Compared to a model consisting only of changes in sales, leverage or dividend constraint, models containing income change and rig usage change have better identification and prediction performance. The results imply that the dramatic declines in rig utilization during the early eighties, combined with related changes in income, led to the observed accounting changes in this industry.

1. Introduction

The oil and gas contract drilling industry consists of a large number of mostly small and private firms which typically drill on contract for others. During the early eighties, when energy prices collapsed, demand for contract drillers also declined sharply. Interestingly, a number of drilling firms switched during this period from the straight line (SL) method to the unit of production (UOP) method for depreciation of drilling rigs. Among the 30 publicly traded firms we could identify (with at least 50% of revenue from drilling), firms using UOP grew from 2 in 1981 to 10 in 1982 and 17 in 1983, with no subsequent increases.

In this paper, we examine whether some accounting changes in this industry could be explained by the industry's structural changes and the resulting changes in the firms' earnings prospects, together with related

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changes in agency cost model variables. For the drilling industry, changes in rig utilization rate and reported earnings (before accounting change) are used as proxies for the change in the drilling firms' production-investment environment. Changes in size, leverage, and dividend constraint are also tested as possible explanatory variables, as typically done in the agency cost literature.

This study differs from other accounting change studies in many respects. First, unlike past studies, the dependent variable here is defined as the accounting *change* decision (0–1 variable) rather than the accounting method used, and all explanatory variables are also defined as change variables.[1] As explained later in the paper, such an approach is a more appropriate research design for models of accounting change. Second, explanatory variables examined here include direct proxies for earnings and environment changes in addition to agency cost changes. Motivation for including these variables is provided in the next section. Except for some LIFO-change studies, accounting change studies generally have not included such external variables. Third, this paper uses improved methodology for model identification and evaluation compared to prior studies: the Akaike information criterion is used for model selection to minimize the chance of overfitting, and a probability-based criterion is used for model evaluation to control for the fact that the observations consist of unequal numbers of accounting change and nonchange firms.

The results show that the accounting change is best explained by a model consisting of both earnings change proxy variables and agency cost change proxy variables. This model has the best classification rate improvement based on naive or probabilistic prediction criteria. Results on the ability of the models to predict accounting changes in a hold-out group parallel the above results. These results imply that the big declines in rig utilization rates, together with the associated changes in earnings and agency costs, explain the sudden large-scale movement to UOP by the drilling firms. The results thus suggest that when structural changes in an industry's production-investment set occur, the firms in the industry may change to accounting methods that better reflect the changed economic reality.

In the next section, the hypothesized effects of earnings change and agency cost change variables on accounting change are described. Population selection and the definition of the dependent variable are discussed in section 3. Section 4 contains the empirical results on model identification and prediction. Conclusions are presented in section 5.

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1. In Lilien and Pastena [20], the dependent variable is the adjustment to retained earnings from an accounting change. We are, however, unaware of studies which use a 0–1 formulation for an accounting change itself as the dependent variable.

2. Explanatory Variables

Ball [6] first postulated that major changes in a firm's production-investment environment could lead to accounting changes since accounting can be viewed as "a function that maps from the environment into accounting reports" (p. 30). In this model, firms' expectations concerning environmental variables (such as selling price and demand) determine the selection of accounting techniques. Hence *changes* in such environmental variables would be explanatory factors in a model of accounting change. Foster [13, p. 135] describes a similar model of accounting changes in which economy factors, industry factors, and firm-specific factors are explanatory variables. Use of economy or industry factors as explanatory variables is common in most LIFO change studies, though not in other types of accounting changes examined. Hypothesized effects of such proxy variables on the depreciation accounting change of drilling firms are discussed below.

Accounting changes can additionally be caused by changes in agency costs between a firm and its managers, stockholders and bondholders. This agency cost model has been the basis of a number of accounting choice studies in recent years.[2] The model postulates that since contracts between stockholders, creditors, regulators, and management are often based on accounting numbers, changes in reported accounting numbers will have economic consequences to these agents. Thus an accounting change affecting earnings would be made by management if the changes in earnings would have favorable economic consequences to them and/or to the stockholders compared to the no-change alternative. Hypothesized effects of agency cost variables on depreciation accounting change are also discussed below.

Change in Rig Utilization Rate

Rig utilization rate (the ratio of the number of days a rig is used to the number of usable days in a year) plays an important role in computing depreciation expense for drilling rigs and hence is of interest as a variable to explain SL to UOP accounting change.[3] Under UOP, depreciation expense is based on the ratio of number of days the rig is used in a year to total estimated lifetime usage days. Under SL, depreciation expense is indepen-

2. The accounting issues studied include depreciation (Dhaliwal, Salamon and Smith [10]), lease (El-Gazzar, Lilien and Pastena [12]), foreign currency translation (Ayres [4]), oil exploration costs (Lilien and Pastena [20]), interest capitalization (Bowen, Noreen and Lacey [7]; Zimmer [25]), R & D (Daley and Vigeland [8]), and retail land sale (Hughes and Ricks [18]). See Holthausen and Leftwich [17] and Watts and Zimmerman [24] for summaries of this literature.

3. Depreciation for nondrilling equipment is generally computed using SL.

dent of ex-post usage, and depends only on the assumed life in years. The latter, of course, would be based on anticipated, or ex-ante, usage rates.

When ex-post usage closely parallels the ex-ante assumed rate, the SL depreciation expense would be essentially the same as the UOP depreciation amount. If, instead, actual usage is significantly below (above) the ex-ante rate for extended periods of time, actual rig life would be longer (shorter) than expected life. However, since the SL method is based on ex-ante usage rate, it would continue to depreciate the rig over the older and inaccurate asset life. To correct this, a firm using the SL method can do one of two things. First, it could stay on SL and make a change in the estimated useful life assumption, that is, ex-ante usage rate, bringing it in line with the new level of anticipated usage rates. However, this option is only effective if the firm can correctly anticipate the future usage level, or else it could be forced to soon make another change in the estimated life. Such frequent changes are generally resisted by auditors. The second option is to make a one-time change in accounting method to UOP so that subsequent fluctuations in actual usage rates would be automatically reflected in the depreciation expense without the need for frequent accounting estimate changes.[4]

This analysis suggests the hypothesis that the incentive to change from SL to UOP would be proportionately greater if the year-to-year fractional reduction in rig usage is greater. It is important to note that change in rig utilization rate is suggested as an explanatory variable not only because it is a critical measure of drilling industry's environment but because of the conceptual link between this variable and depreciation expense in the SL and UOP methods.

Income Change

It is often suggested that accounting changes are motivated by a desire to improve the reported income numbers. For example, Archibald [3] tested whether "relative profit performance" of firms might explain depreciation accounting choice. Similarly, Holthausen [16] used a measure of shortfall in reported income numbers compared to previous years' income to explain depreciation accounting changes. Management's possible motivation to "manage" reported income numbers with accounting changes has also been the subject of the "functional fixation" hypothesis as well as the agency cost literature. Many anecdotal examples of accounting changes designed

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4. Since the accounting change would be audited, firms changing to UOP would also adopt a one-time change in estimated life to the expected value at the time of the accounting change as conventionally required by accountants.

toward improving reported earnings are also noted in the popular press.[5] Hence, the year-to-year change in reported income (before accounting change) is examined here as a possible explanatory variable. This is defined as $(E_t - E_{t-1})/E_{t-1}$, where E is the reported income before extraordinary items, discontinued operations, and accounting change.[6] The hypothesis is that firms with larger decreases in earnings are more likely to change to an income-increasing accounting method such as UOP.

Size Change

Firm size has been used as a proxy for political cost because of the argument that political visibility costs are higher for larger firms. Given the small sizes and low profitability of the firms studied here (average sales in 1982: $217 million), the political cost argument is irrelevant here. A more relevant argument for the drilling industry is that firm size proxies for a firm's ability to complete its drilling projects. Discussions with industry managers reveal that they believe smaller firms are perceived as less "credible" by clients and hence are less likely to win competitive drilling bids against larger firms. Their credibility (survival probability) is felt to improve if their size is larger. This argument suggests the hypothesis that when firms have larger reductions in size, they are more likely to change to UOP since UOP would increase reported assets (in addition to income).

Sales and total assets have been used previously as a proxy for size. In this study, both sales change and asset change were tried as size change variables and were found to have similar explanatory power. Hence, only the results with sales change are reported below. Sales change is defined as the change in annual sales deflated by previous year's sales.

Leverage Change

Lending agreements often place restrictions on assets. For example, 23 out of the 30 firms in this study mentioned restrictions on either debt or equity (net worth), or both, in their fiscal 1982 annual reports, though only

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5. For example, General Motors in 1987 extended asset lives for depreciation purposes and bolstered reported earnings by $2.55 a share, to $10.06 a share. Thus, 1987 income before accounting change was only $7.51 a share and hence, less than the 1986 earnings of $8.21 a share, but after-change earnings of 1987 were higher than 1986 earnings.

6. When the denominator is negative and the numerator is positive, income change variable is assigned an upper bound value of 2. When both the numerator and the denominator are negative, its value is the negative of the computed ratio. Truncation values of 3 and 5 were also tried, but the results are not sensitive to the value.

4 firms gave specific numerical data on the restrictions. Restrictions were common both for bank-held debt and publicly held debt.

In the agency cost model, it is hypothesized that, given the cost of renegotiating agreements, managers would prefer to reduce the current or expected likelihood of violating the loan covenants by changing to accounting methods such as UOP that increase reported earnings and assets (and hence reduce the leverage ratio). Thus *change* in debt-equity ratio is used as the proxy for the renegotiating costs and for the probability of potential violation of debt covenants.[7] This argument suggests the hypothesis that the propensity to change to UOP will be greater for firms whose leverage increases are greater.

Leverage is defined here as long-term liabilities to total assets. Since the effect of a change to UOP is to increase total assets, the total assets of firms that changed to UOP are restated to the prechange basis (by subtracting the current year effect and cumulative effect from total assets) to make the leverage ratios of UOP firms and SL firms comparable.

Change in Dividend Restriction

Restrictions on the payment of dividends are common in loan covenants. Almost all firms studied here mentioned such restrictions in their 1982 annual reports. Fourteen of the 30 firms paid dividends in 1982. Of the nonpaying firms, 6 reported debt covenants prohibiting dividends (i.e., unrestricted retained earnings of zero). Given the prevalence of dividend constraints, many studies have used this variable as a proxy for the contracting costs in lending agreements. A change to UOP would increase current earnings and hence retained earnings, and consequently reduce the dividend constraint, expressed as the ratio of dividend to unrestricted retained earnings (DIVURE). Hence, the hypothesis tested here is that firms changing to UOP are more likely to have larger increases in DIVURE.[8]

A similar hypothesis has been examined by Holthausen [16] who found that this variable was not significant in his study of depreciation switch-back decisions. Daley and Vigeland [8], however, found DIVURE to be significant in explaining R&D accounting method choice. Bowen et al. [7] also found DIVURE to be a significant variable for interest capitalization decisions.

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7. Dhaliwal [9] shows that the potential costs of renegotiation is a continuous function of the debt-equity ratio, and hence the contracting argument may be relevant to all firms rather than only to firms that are close to violating their covenants.

8. Data on unrestricted retained earnings was collected from COMPUSTAT and *Moody's Industrial Manual*, and in a few cases was calculated from details provided in the debt agreements.

Bonus Plan Change

Some accounting choice studies in the past have used bonus plan as an explanatory variable since the agency cost model suggests that the contracting costs between stockholders and managers are influenced by the presence of an income-based bonus plan. Given that a change to UOP can potentially increase reported earnings compared to SL, the hypothesized effect of bonus plan would be to provide an incentive to managers to change to UOP and increase (or minimize the decline in) their bonus payments. However, this argument, stated in terms of the presence of bonus plan rather than *change* in bonus-plan status, does not explain why a firm that had always had a bonus plan would want to change to UOP only in 1982 or 1983. In any case, even if there is conceptual support for a hypothesis that a change in bonus plan might explain accounting change to UOP, it should be noted that of the 9 firms that had a bonus plan in 1982, only 2 changed to bonus plan in 1982, and both of these were nonaccounting change firms. Given this small number, this variable is not considered in the empirical study described below.[9]

3. Population and the Dependent Variable

A list of publicly traded drilling firms was compiled by using COMPUSTAT's listing of drilling contractors (industry code 1381), drilling industry security price reports in *Drilling Contractor,* and a brokerage house listing of publicly held firms in the industry. To be included in the study, 10-K reports must be available, and more than 50 percent of total revenues must come from contract drilling in one of the years 1980–1983, which includes two good years and two bad years for the industry. This procedure resulted in 30 firms, representing all the firms in the industry meeting the above criteria.[10] The names of the population firms are listed in an appendix.

Data on accounting changes and estimate changes for the firms, including

9. The bonus plan hypothesis has other problems. It is based on the assumption that management bonus plans are not revised or renegotiated after accounting changes, which is hard to verify from annual report or proxy data. Moreover, to the extent that any manager's compensation (whether labeled bonus or not) ultimately depends on a firm's profitability, the likelihood of the hypothesis being supported empirically is low. Additionally, as Healy [15] noted, not all managers with profit-based bonus plans would prefer income-increasing accounting methods and that the accounting choice would depend on the plan's terms such as target earnings and upper bounds. Such plan details were not disclosed by five of the nine firms that had bonus plans.

10. A quick survey of recent published papers in accounting journals suggests that small sample sizes are not uncommon, e.g., Antle and Smith [2], 39 firms; Libby [19], 35 subjects; Hughes and Ricks [18], 31 firms; Haka et al. [14], 30 firms.

TABLE 1

Descriptive Data on Accounting Changes in 1982–83

Firm Name	Year of SL-UOP Change	Drilling Depr. Exp.	NI Before Ex. Items & Disc. Op.	SL to UOP Change: Current Yr. Effect	SL to UOP Change: Cumul. Effect
1. Anglo Energy	1983	$9.77	$−20.98	$5.50	$0
2. Blocker Energy	1982	12.88	−71.74	3.61	0.31
3. Brown (Tom)	1982	8.97	−15.99	2.70	0
4. Buttes Oil and Gas	1982	7.82	−4.35	7.21	0
5. Delta Drilling	1983	10.64	−24.83	8.35	1.55
6. Drillers, Inc.	1983	3.50	−10.89	2.06	1.56
7. Global Marine	1983	44.50	49.30	6.20	0
8. Kenai Corporation	1982	5.19	−3.48	0	0.611
9. Ratliff	1983	4.11	−3.14	0.96	0.46
10. Reading & Bates	1982	27.58	73.29	0	0
11. Sage Drilling	1983	0.55	−0.22	0.38	0
12. Sage Energy	1982	3.85	17.31	0	0
13. Transcontinental	1982	3.31	−7.06	3.06	−0.29
14. Unit Drilling	1982	5.33	−1.94	2.66	0
15. Verna Corporation	1983	6.78	−11.92	5.37	0.29

All dollars are in millions. Depreciation and income data are for the year of accounting change. Depreciation expense is as reported for drilling segment. Income effects described as "insignificant" are coded zero. Firms 1, 2, 3, 5, 6, and 7 reported a change in life estimates in addition to the accounting method change.

income effects of the changes, are given in Table 1. Six of the fifteen accounting changes were accompanied by a simultaneous increase in estimated useful life. In fact, all the firms that disclosed life estimate changes also changed to UOP simultaneously. In any case, as Table 1 shows, disclosure of useful life data for rigs (and changes in useful life) is often missing, and there is no assurance that firms that did not report a change in useful life did not have one. Hence, in this study, the dependent variable of interest is defined as the depreciation accounting method change and no distinction is made between firms that only changed the accounting method and those that changed both the method and the estimated useful life.

Given the large number of changes in 1982 and 1983, the data are pooled for the two years for the purposes of estimation. This requires careful definition of the dependent variable. If a firm starts out a year with SL and stays with SL during that year, the dependent variable is assigned 0 for that year. If the firm changes to UOP during the year, the variable is assigned 1. Note that if a firm starts out a year with UOP, its dependent variable (the decision to change to UOP) is undefined for that year. Thus, if a firm changed to UOP in 1982, its 1983 dependent variable is undefined and hence it is only included once in the pooled 1983 sample.

This paper differs from previous papers in this literature in the use of an accounting *change* variable as the dependent variable. Papers examining accounting choice typically define the dependent variable based on an accounting method (or level). For example, Bowen et al. [7] assign a 0 to interest capitalizers and 1 to noncapitalizers. This is also true with Zimmer [25]. Such a definition is not always undesirable—it is in fact more suited for examining cross-sectional differences between firms using one method versus another (e.g., Ayres [4] in which the differences between early adopters and late adopters of FASB Statement 52 are examined). However, since alternative models of accounting changes are compared here, the dependent variable is defined here as accounting change.[11]

Table 1 also provides data on sales, income, drilling-related depreciation, and the effect of accounting change on depreciation for firms that changed to UOP. In some cases, the current year income effect of accounting change has the same magnitude as the reported depreciation expenses, that is, the change to UOP halved the reported depreciation expense for these firms. On the average, the current year effect of the accounting change reduced the before-change depreciation expense by 27.2 percent. Thus the accounting change has had a substantial effect on the depreciation expense.

While the current year effect has been large, the cumulative effect of accounting change is mostly negligible, as seen in Table 1. This means that the actual rig usage rate in the years prior to the accounting change was approximately in line with the assumed normal usage rate. By contrast, the large current year effect of accounting change indicates that the actual usage rate in the year of accounting change departed substantially from the prior years' assumed usage rate. This suggests that rig utilization rate change is a relevant explanatory variable for the decision to change to UOP.

Table 2 shows the correlations between the variables studied using 1982 data.[12] Significant correlation is present among many of the independent variables, as is common among variables examined in prior studies on accounting choice. (See, for example, Bowen et al. [7], Table 5; Daley and Vigeland [8], Table 3; Holthausen [16], Table 5). In particular, sales change, rig utilization change, and income change are highly correlated with each other and with accounting change. By contrast, there is very little correlation between leverage change and the dependent variable, and in addition this

11. In Zmijewski and Hagerman [27], the dependent variable represents a firm's "income strategy," i.e., choice from a portfolio of accounting methods. In our group of firms, apart from SL to UOP, only one other type of change was observed during 1982–83; two firms changed from successful effort to full cost method in 1982, of which one firm also changed to UOP. Hence, the income strategy approach is not applicable here.

12. Data are similar when pooled 1982–83 data are used.

TABLE 2

Correlation Matrix for Model Variables Based on 1982 Data

	Depr. Change	*Sales*	*Leverage*	*DIVURE*	*Rig Utilization*
Depr. Change	1.000	−0.189	0.432	0.136	−0.412
Sales	−0.189	1.000	−0.277	−0.455	0.522
Leverage	0.432	−0.277	1.000	0.449	−0.377
DIVURE	0.136	−0.455	0.449	1.000	−0.436
Rig Utilization	−0.412	0.522	−0.377	−0.436	1.000
Sales Change	−0.502	0.190	−0.378	−0.488	0.577
Leverage Change	−0.028	−0.218	0.039	0.174	−0.097
DIVURE Change	0.032	−0.189	−0.106	0.457	−0.306
Rig Util. Change	−0.396	0.517	−0.344	−0.438	0.990
Income Change	−0.287	0.508	−0.535	−0.627	0.683

	Sales Change	*Lever. Change*	*DIVURE Change*	*Rig Util. Change*	*Income Change*
Depr. Change	−0.502	−0.028	0.032	−0.396	−0.287
Sales	0.190	−0.218	−0.189	0.517	0.508
Leverage	−0.378	0.039	−0.106	−0.344	−0.535
DIVURE	−0.488	0.174	0.457	−0.438	−0.627
Rig Utilization	0.577	−0.097	−0.306	0.990	0.683
Sales Change	1.000	−0.156	−0.391	0.576	0.635
Leverage Change	−0.156	1.000	0.159	−0.082	−0.126
DIVURE Change	−0.391	0.159	1.000	−0.324	−0.329
Rig Util. Change	0.576	−0.082	−0.324	1.000	0.659
Income Change	0.635	−0.126	−0.329	0.659	1.000

DIVURE is dividends to unrestricted retained earnings. "Change" values represent year-to-year changes from 1981 to 1982. Correlations are based on 28 observations for pairs involving depreciation change and 30 for other pairs.

correlation is negative. In other words, decreases in leverage are associated with the adoption of UOP, which is the opposite of the hypothesized effect. Of course, this negative total derivative (correlation between leverage and the dependent variable) does not entirely rule out a positive coefficient of leverage (partial derivative) in a multivariate model. As a final note, the correlation between agency cost variables (leverage or dividend constraint) and income change or rig utilization change variables is generally small, suggesting that the earnings change proxy variables are not merely proxies themselves of the agency cost contracting variables.

In line with prior studies, a univariate t-test of mean comparison of the variables for the accounting change and nonchange groups is presented in Table 3. In addition, since the parametric assumptions for using the t-test are not usually met by ratio variables such as leverage, results from the

TABLE 3

Descriptive Data and Univariate Tests of Differences Between Accounting Change and No-Change Firms

Variable	*Overall Mean*	*Group 1 (No acc. chg.) Mean*	*Group 1 (No acc. chg.) Std.Dev.*	*Group 2 (Acc. chg.) Mean*	*Group 2 (Acc. chg.) Std.Dev.*	*t-ratio (Signif.)*	*Mann-Whitney Z (Signif.)*
			1982 Values				
Sales ($m)	216.8	245.1	266.4	146.0	154.8	1.225 (0.117)	0.025 (0.490)
Assets ($m)	426.2	463.6	496.6	332.7	342.5	0.796 (0.436)	0.076 (0.469)
Leverage	0.384	0.327	0.190	0.526	0.207	2.356 (0.018)	1.907 (0.028)
DIVURE	0.438	0.398	0.458	0.540	0.501	0.673 (0.257)	0.448 (0.327)
Rig Utilization	68.57	74.05	19.31	54.88	21.39	2.202 (0.024)	1.984 (0.024)
			1981–82 year-to-year change				
Sales	0.042	0.131	0.234	−0.179	0.288	2.708 (0.011)	2.467 (0.007)
Assets	0.133	0.170	0.168	0.039	0.122	2.285 (0.017)	1.958 (0.025)
Leverage	0.176	0.188	0.749	0.148	0.323	0.199 (0.422)	0.585 (0.280)
DIVURE	0.532	0.508	1.097	0.591	1.513	0.141 (0.445)	0.242 (0.404)
Rig utilization	−0.283	−0.231	0.188	−0.413	0.224	2.036 (0.033)	1.933 (0.027)
Income (before acc. change)	−0.400	−0.268	0.788	−0.732	0.520	1.823 (0.042)	1.742 (0.041)

The data are for 20 firms in group 1 which were on straight line method in 1982, and 8 firms in group 2 which changed to UOP in 1982. Two firms which were on UOP prior to 1982 are excluded. The t-tests are based on unequal variances. The Z value is the normal approximation to Mann-Whitney U value. Significance levels are for one-tailed test.

nonparametric Mann-Whitney U test are also reported. For significance testing, the computed U can be transformed to a normal variate for observations larger than ten (Roscoe [23]). Table 3 reports the Z values from this approximation. Inferences on mean differences for all variables are similar under both parametric t and the nonparametric U test.

As described in section 2, it is the *change* variables, that is, changes in sales, rig utilization, and so on, that are of interest in explaining the UOP accounting change. The bottom panel of Table 3 contains data for these variables. (In addition, for comparison, data for level variables based on

1982 values are given in the top panel of the table.) The differences between group mean values are significant at the 0.05 level for change in sales, rig utilization, and income. While leverage level variable is significant, change in leverage is not, again suggesting that it is not likely to be a good explanatory variable.

The mean differences are not significant for dividend constraint, either for change or for level variable. A possible reason for the poor performance of this variable is that only half the firms paid dividends during 1982–83 and there was little cross-sectional variation in dividend payment between the two groups of firms.

4. Multivariate Test Results

Studies involving a categorical dependent variable use either probit or logit procedures for model estimation.[13] Probit assumes that the residual term is normally distributed, while logit assumes a logistic distribution. Probit is used in this study.

Given that pooled 1982–83 data are used for estimation, an estimation methodology called "bivariate probit with selection" is potentially applicable here.[14] In this methodology, the bivariate dependent variable for a given company would be its 1982 accounting change decision and its 1983 decision. For example, assume that y_1 is the 1982 decision and y_2 is the 1983 decision. For a firm that did not adopt UOP in either year, the dependent variable value would be {0,0}. Similarly, a firm that adopted UOP in 1983 would have a dependent variable of {0,1}. Note, however, that the value of y_2 is observed (and defined) only if y_1 is 0. For firms which adopted UOP in 1982, y_2 is undefined. This is called partial observability or sample selection. For our population of firms the bivariate dependent variable definition results in a sample size of 28 observations.

Bivariate probit with sequential selection is analyzed in Poirier [22]. Estimation of such a model is made simple by the availability of software such as William H. Greene's LIMDEP (tm). It is known, however, that bivariate probit estimation is sensitive to starting values of the estimates, and convergence is not common with a small number of observations. Not surprisingly, with 28 observations, we encountered far too many cases of nonconvergence. For example, of the 6 models reported in Table 5 and

13. Daley and Vigeland [8] used the jackknife procedure, but concluded that the added cost of the procedure compared to probit "is not justified."

14. We thank the reviewer for suggesting this methodology which is potentially applicable in many other accounting contexts involving sequential events.

discussed below, only 1 (model 1B with just one independent variable) converged. Hence, in the rest of the paper, we present the results only for the univariate probit estimations based on the pooled 1982–83 sample.

As described in section 3, our selective pooling approach can be viewed as a second-best strategy designed to mimic the bivariate probit with selection model in a univariate probit context. Possible cross-sectional correlation in residuals due to pooling is minimized through appropriate definition of the dependent variable. Recall that the dependent variable is the accounting change (0 if an SL firm remains on SL and 1 if an SL firm changes to UOP). As a result, firms that changed to UOP in 1982 have an undefined dependent variable in 1983 (since they are not candidates for change in 1983). Hence, such firms are excluded from the 1983 data being pooled. The pooled data include the 28 firms using SL at the beginning of 1982 and the 20 firms using SL at the beginning of 1983, for a total of 48 firms.[15]

In addition to examining the significance of coefficients, different model identification criteria have been used in prior studies for choosing a model from among alternative combinations of independent variables. With categorical dependent variables, both estimated R^2 and classification accuracy (CA) have been used for model comparison and selection. Additionally, overall model fit can be evaluated using the log likelihood ratio test (–2 times log likelihood ratio), which is distributed as chi-square with degrees of freedom equal to the number of variables used. However, all these measures can be arbitrarily improved by adding additional explanatory variables. Thus the tendency is toward selecting large models that may result in overfitting.

One solution to controlling for overfitting is the use of the Akaike [1] information criterion (AIC) for model identification.[16] AIC is given by –2 times log of maximum likelihood function +2 times the number of independent variables used, and the model selection procedure is to select the model with the *smallest* AIC value, subject to other usual diagnostic tests. AIC thus balances model fit with the number of variables used. This study uses mainly AIC model identification though chi-square statistics are also reported.

Models are then evaluated based on their ability to predict accounting changes during a hold-out period. This is usually done using classification accuracy (percentage correctly classified). If, however, the composition of

15. Models were also estimated using only the 1982 data. Inferences from these estimations (reported in an earlier version) were similar to those reported here.

16. See Dharan [11] for the theory behind AIC and for related references and also for an accounting application of AIC. Lindahl [21] uses AIC in an inventory accounting change study.

the values of the dependent variable differ for different models, this criterion could be misleading (Zmijewski [26]). A superior comparison criterion is the relative improvement of a model over a naive model that classifies all observation as belonging to the category with the highest ex-ante probability. If the ex-ante probability of a firm belonging to category i is p_i, the probability of a guess being right in this model is $\max(p_i)$. An alternative is the probabilistic guess model in which the probability of classifying an observation as category i is p_i. Hence the probability of a guess being right is Σp_i^2. In this study both naive and probabilistic criteria are used for evaluating predictive ability over a hold-out sample.

Estimation results are presented in Tables 4 and 5. Given the 5 independent variables (changes in sales, leverage, dividend constraint, rig usage, and income) a total of 31 models can be potentially estimated.[17] Table 4 contains a summary of the estimated AIC values and their ranks for all these models. Table 5 contains details of coefficient estimates, and so forth, for a selection of the 31 models. Model 1 in Table 5 consists of only the contracting variables used in prior studies, and models 1A and 1B are based on subsets of these variables. Model 2 includes only the 2 earnings change proxy variables. Model 3 is a parsimonious model selected based on AIC minimization (among the 31 possible models) as well as significance of coefficients. For comparison, a model with all variables is also included in the table, labeled Model 4.

Model 1, with only the contracting variables, has chi-square value significant at 5 percent, and is ranked eleventh lowest in its AIC value among the 31 models (sequence number 7 in Table 4). Only the coefficient of sales change is significant and has the expected sign. The coefficients of leverage change and dividend constraint change are insignificant. In addition, as in the case of univariate results, the coefficient of leverage change is negative, meaning that decreases in leverage (rather than increases) lead to UOP accounting change. This model, among the ones reported in Table 5, has the worst estimation period classification rate.

In model 1A the dividend variable is dropped, and in model 1B leverage change is dropped as well. The AIC of model 1A is the second lowest, but the negative coefficient for leverage change makes this model unappealing as an explanatory model of accounting change. Model 1B, with sales change as the only independent variable, has the lowest AIC among the 31-model set. Its chi-square is significant at the 1 percent level, and all coefficients

17. These are 1 model with all 5 variables, 5 models with 4 variables, 10 models each with 3 and 2 variables, and 5 models with only 1 variable.

TABLE 4

Summary of Estimation Results for all Models

#	Variables					AIC	AIC Rank
1	S	L	D	R	I	58.23	21
2	S	L	D	R		57.56	18
3	S	L	D		I	57.16	15
4	S	L		R	I	56.35	9
5	S		D	R	I	58.37	22
6		L	D	R	I	59.26	27
7	S	L	D			56.61	11
8	S	L		R		55.56	6
9	S		D	R		57.17	16
10		L	D	R		60.36	29
11	S	L			I	55.18	4
12	S		D		I	56.82	13
13		L	D		I	59.03	25
14	S			R	I	56.43	10
15		L		R	I	57.29	17
16			D	R	I	58.63	24
17	S	L				54.70	2
18	S		D			55.78	8
19	S			R		55.45	5
20	S				I	54.92	3
21		L	D			62.16	31
22		L		R		58.61	23
23		L			I	57.04	14
24			D	R		59.09	26
25			D		I	57.81	20
26				R	I	56.72	12
27	S					54.17	1
28		L				61.31	30
29			D			60.29	28
30				R		57.71	19
31					I	55.96	7

Estimation is based on pooled 1982–83 data. AIC is the Akaike information criterion. The change variables are sales (S), leverage (L), dividend constraint (D), rig utilization (R), and income (I).

of the model are significant. Not surprisingly, estimation period classification rate is also the best for this model.

Model 2 in Table 5 contains the two additional variables identified in section 3 as related to accounting change. This model also has excellent fit. Its coefficients have the expected signs. For income change, the coefficient is significant as well. The lack of significance of rig utilization rate change variable may be due to the high correlation between the two variables (Table 2). For example, rig usage change is significant in a model in which it is

TABLE 5

Probit Estimation Using Pooled 1982–83 Data

#	*Constant*	*Change in Sales*	*Change in Leverage*	*Change in DIVURE*	*Change in Rig Util.*	*Change in Income*	*AIC Test*	*% Correct Classified*	*% Improvement Over Naive Prob.*	
1	−0.771 (−3.072)	−1.902 (−2.492)	−0.565 (−0.986)	0.057 (0.299)			56.61	68.75	0.00	20.55
1A	−0.752 (−3.099)	−1.964 (−2.659)	−0.616 (−1.114)				54.70	70.83	3.03	24.20
1B	−0.776 (−3.266)	−1.680 (−2.584)					54.17	75.00	9.09	31.51
2	−1.325 (−2.954)				−1.241 (−1.109)	−0.753 (−1.642)	56.72	72.92	6.06	27.85
3	−1.022 (−2.947)	−1.246 (−1.681)				−0.539 (−1.092)	54.92	72.92	6.06	27.85
4	−1.370 (−2.641)	−1.346 (−1.658)	−0.872 (−1.375)	−0.071 (−0.335)	−1.176 (−0.953)	−0.659 (−1.106)	58.23	77.08	12.12	35.16

1. All models are estimated with 48 observations. Asymptotic t-ratios are given in parentheses below the coefficient estimates. Chi-square values are significant at the 0.05 level for all models and at the 0.01 level for model 1B.

2. The AIC ranks for the models (from Table 4) are:

Model 1: 7   Model 1A: 2   Model 1B: 1

Model 2: 12   Model 3: 3   Model 4: 21

used alone, suggesting that potential earnings consequences of falling rig usage rates motivated income-increasing accounting changes. An alternative form of the rig usage variable, defined as the rig usage level rather than the change, yielded somewhat weaker results, suggesting that the changes in the environment leading to low rig usage rates, rather than low usage rate per se, were the explanatory factors. Model 2's estimation period classification rate, based either on the naive criterion or on the probabilistic criterion, is one of the highest (except for model 1B). These results indicate that the variables proxying for the effect of production-investment environment do indeed provide some explanation for the UOP accounting change in this industry setting.

Model 3 in Table 5 may be viewed as a combination of models 1 and 2, with the best variables retained. This model also has the third lowest AIC value, and as will be seen in the prediction test below, has better predictive ability than either model 1 or 2. By comparison, the all-inclusive model 4 has much larger AIC value, with a rank of 21 among all models, and has no better prediction period performance than model 3.

To test the models' classification performance on a hold-out group, all models were reestimated with a randomly selected half of the pooled 1982–83 data, and the classification accuracy was assessed using the hold-out half of the data. Each of the two subgroups contained the same proportion of change and nonchange firms.

Table 6 contains the prediction results for the hold-out group. The prediction performances of all models are generally weak, and few beat a naive forecasting strategy in terms of overall classification rate. However, this is misleading since a naive model would predict none of the accounting change firms correctly while all the models predict at least some of the change firms correctly. For the models reported in Table 5, model 1B (which has the lowest AIC) has only a 66.67 percent classification rate but it classifies 4 out of the 7 accounting change firms correctly. Model 1's performance is similar. Model 2, which has the rig usage and income change variables, classifies 5 out of the 7 accounting changes correctly, which is the best classification in this category among all 31 models. However, it only classifies 12 out of 17 nonchange firms correctly, lowering its overall classification rate somewhat. By contrast, model 3, which has the best variables from both models 1 and 2, classifies nonchange firms much more accurately while identifying only 4 out of 7 accounting change firms. Its overall percentage improvement (over a naive or probabilistic criterion) is the best among the 31 models. When all the other variables are added to model 3 (giving rise to model 4), the prediction performance remains the same. Overall, the prediction results show that the earnings change proxy

TABLE 6

Model Prediction Performance

Model	*Variables*	*Prediction Performance*	*% Predicted Correctly*	*% Improvement Over Naive*	*% Improvement Over Prob. Guess*
1	Sales change, Leverage change, DIVURE change	Actual Acc. Change (No / Yes): Predicted Acc. Chg. No: 14, 4; Yes: 3, 3	70.83	0.00	20.71

Note: The prediction performance is identical to the above for the model with Sales change and Leverage change (Model 1A), and the model with Sales change and DIVURE change variables.

Model	*Variables*	*Prediction Performance*	*% Predicted Correctly*	*% Improvement Over Naive*	*% Improvement Over Prob. Guess*
1B	Sales change	Actual Acc. Change (No / Yes): Predicted Acc. Chg. No: 13, 4; Yes: 4, 3	66.67	−5.88	13.61
2	Rig. util. change, Income change	Actual Acc. Change (No / Yes): Predicted Acc. Chg. No: 12, 2; Yes: 5, 5	70.83	0.00	20.71
3	Sales change, Income change	Actual Acc. Change (No / Yes): Predicted Acc. Chg. No: 15, 3; Yes: 2, 4	79.17	11.76	34.91
4	All Variables	(Identical to Model 3)			

Models were estimated with 24 observations from a random half of the pooled 1982–83 data. The other 24 observations were used as the hold-out group.

variables, combined with sales change variable, are very useful in improving prediction performance.

5. Conclusion

The estimation and prediction results in Tables 5 and 6, as well as the univariate test results, indicate that the earnings change proxy variables have significant explanatory power in an accounting choice model for contract drillers. Except for sales change, the agency cost variables (in change form) do not have either significant coefficients in model estimations or significant prediction power. The results support the notion that changes in environmental factors can motivate managers to consider an accounting change to improve earnings (or to adhere to an accounting model of mapping environment to accounting reports). Thus accounting change studies may benefit from a detailed modeling of changes in firms' production-investment environment.

APPENDIX

Population Firms

1. Anglo Energy
2. Astro Drilling
3. Atwood Oceanics
4. Blocker Energy
5. Brown (Tom)
6. Buttes Oil and Gas
7. Delta Drilling
8. Drillers, Inc.
9. Global Marine
10. Helmerich and Payne
11. Kenai Corporation
12. MGF Oil
13. Midland Southwest
14. Moran Energy
15. Nicklos Oil and Gas
16. Noble Affiliates
17. ODECO
18. Parker Drilling
19. Ratliff Drilling
20. Reading and Bates
21. Rowan Companies
22. Sage Drilling
23. Sage Energy
24. SEDCO
25. South Texas Drilling & Exploration
26. Transcontinental Energy
27. Tucker Drilling
28. Unit Drilling

Determinants of Accounting Change: an Industry Analysis of Depreciation Change

Professional Adaptation

Why do corporations sometimes adopt changes in the accounting methods they use to report earnings? This question has interested accounting researchers for over two decades. A currently popular model of accounting changes, known as the agency theory, states that a company's accounting changes are a result of changes in the costs of ''agency'' relationships between the company's managers, regulators, stockholders, and debtholders. A related model, which we focus on, is that accounting changes are a response by corporations to changes occurring in their competitive environment, such as changes in prices or product demand. In this study, we examine this question in the context of a specific industry's accounting practices.

The industry we use as an example is the oil and gas drilling industry. During the early 1980s, a large number of drilling firms made a change in the way they reported the depreciation of drilling rigs. The usual procedure is to compute annual depreciation based on the straight line (SL) method, by dividing the cost of the rig by the assumed rig life, regardless of current usage levels. However, the drilling firms started switching during this period to a less common depreciation procedure called the unit of production (UOP) method, in which the depreciation is higher if usage is higher and vice versa. Among the 30 drillers we examined, those using the UOP method grew from two in 1981 to 10 in 1982 and 17 in 1983, with no subsequent increases.

We know, of course, that energy prices collapsed during the early 1980s, triggering a sharp decline in the demand for contract drilling. In this study, we examine whether the large-scale accounting change to UOP among drillers could be explained by the industry's vast structural changes and the resulting changes in the firms' earnings prospects, together with related changes in agency cost model variables.

Although focused on a single industry, the procedures, or methodology, used in our study are more widely applicable, and are themselves expected to be of much interest to other academics. For example, unlike many previous accounting researchers, we define the dependent variable in our model of accounting change as the accounting *change* decision rather than the accounting *method* used. In other words, our methodology offers a way to directly examine the question of why companies adopt accounting changes, and not why companies use a given accounting method. We also define all our explanatory variables as ''change'' variables for the same reason. Second, ours is one of the first studies to combine the two alternative models of accounting changes described earlier (agency costs and environmental changes) into a single model. Third, we use an objective methodology called the Akaike information criterion for selecting our estimation models, which minimizes the chance of overfitting the models to data on hand.

Our basic hypothesis, that environmental variables could affect accounting changes, is similar to a view suggested by some researchers such as Ray Ball and George Foster. In Ball's model, corporate expectations concerning environmental variables (such as selling price and demand) determine the selection of accounting techniques. Hence, changes in such environmental variables would be explanatory factors in a model of accounting change. Foster describes a similar model of accounting changes in which economy factors, industry factors, and firm-specific factors are explanatory variables.

To represent the environmental changes, we study two variables. The first is a drilling firm's annual rig utilization rate, which is the ratio of the number of days a rig is used to the number of usable days in a year. This critical performance measure of a drilling firm plays an important role in computing depreciation expense for drilling rigs and is of interest as a variable to explain the SL to UOP accounting change. For example, when actual rig usage falls significantly below planned rates for extended periods of time, actual rig life would be longer than the life assumed for the SL method. To correct this, a firm can be expected to make a change in the depreciation accounting method to UOP so that subsequent fluctuations in actual usage rates would be automatically reflected in the depreciation expense. Hence, we hypothesize that the incentive to change to SL from UOP would be proportionately greater if the year-to-year fractional reduction in rig usage is greater.

Our second environmental change proxy is the change in earnings itself. It is often suggested that accounting changes are motivated by managers' desires to improve the reported income numbers. Managers' possible motivation to ''manage'' reported income numbers with accounting changes has been the subject of many accounting studies. Many anecdotal examples of accounting changes designed toward improving reported earnings are also noted in the popular press. Hence, the year-to-year change in reported income (before accounting change) is examined here as a possible explanatory variable. The hypothesis is that firms with larger decreases in earnings are more likely to change to an income-increasing accounting method such as UOP.

As noted, accounting changes can additionally be caused by changes in agency costs between a firm and its managers, stockholders and bondholders. Known as the agency cost model, this theory suggests that accounting changes affecting earnings would be made by management if the changes in earnings would have favorable economic consequences to them and/or to the stockholders compared to the no-change alternative.

To represent agency cost changes, researchers generally ''round up the usual suspects'': a size variable such as sales (because it governs political costs), a debt variable such as leverage (because it measures the agency costs between stockholders and debtholders), and a dividend variable such as the ratio of dividends to unrestricted retained earnings (also because of the above agency costs). Some studies have also examined executive bonus plans because they affect the agency relationship between stockholders and managers. In this paper, we consider these usual agency cost variables, with one important change: all variables are defined in the change form, that is, change from previous year's level. Also, bonus plans are not included in the results because of data problems caused by our small sample size.

For the empirical tests, we included all 30 publicly traded drilling firms for which we had accounting data. Our first test was a comparison of the mean values of the variables for the accounting change and nonchange groups. The results from this ''univariate'' test show that the differences between group mean values are statistically significant for change in sales, rig utilization, and income, but not for change in leverage or dividend constraint. A possible reason for the poor performance of the latter variable is that only half the firms paid dividends during 1982–83 and there was little variation in dividend pattern between the two groups of firms.

Our second test examined the performance of groups of variables using a procedure known as probit. Similar to regression, probit is designed to handle cases where the dependent variable is nominal (0, 1, etc.) rather than continuous. Given the five different independent variables in this study (changes in sales, leverage, dividend constraint, rig usage, and income), and given that any combination of these (just one variable, any two, any three, etc.) can be used, a total of 31 probit models can be potentially estimated. We estimated all these models. The results from this ''multivariate'' test show that the models consisting of only the agency cost variables used in prior studies ranked extremely poorly based on an information measure known as AIC, and based on how well they successfully classify companies into the change and nonchange groups. Further, only the coefficient of sales change is significant and has the expected sign. By contrast, a model consisting of the two environmental variables, rig usage change and earnings change, shows an excellent fit and has one of the highest successful classification rates. Classification results based on a "hold-out" group of firms are similar to the above estimation results.

Overall, these results indicate that the variables representing the effect of production-investment environment do, indeed, provide some explanation for the UOP accounting change in this industry setting. By contrast, the agency cost variables by themselves do not appear to have either significant explanatory power. The results support the notion that changes in environmental factors can motivate managers to consider an accounting change to improve earnings. Thus, accounting change studies may benefit from a detailed modeling of changes in firms' production-investment environments.