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The Effects of Asset Liquidity: Evidence from the Contract Drilling Industry*

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I use both the depth of the buyers' market and the trading volume to measure asset liquidity in the contract drilling industry and I find that drilling rigs are less liquid than oil wells. The results indicate that managers avoid selling illiquid assets unless they face high costs for alternative sources of funds. The evidence also suggests that managers follow a ''pecking order'' of asset sales, selling liquid assets before illiquid assets. Finally, I find evidence that the liquidity of a firm's asset portfolio increases its debt capacity. I conclude that asset liquidity is an important consideration in investment and capital structure decisions. *Journal of Economic Literature* Classification Numbers: G3, G31, G32, G33, L71.

1. INTRODUCTION

''Liquidity'' has different meanings in different economic contexts.[1] There has been a long-term debate in many different economic disciplines about the effects of liquidity on prices. In the asset pricing literature, for instance, many papers have investigated a possible ''liquidity premium'' in stock returns (e.g., Amihud and Mendelson, 1986). But intuition suggests that there may be greater differences in the liquidity of real assets than in the liquidity of financial assets. Pawn shops, for instance, are full of real assets whose owners have accepted a significant discount in price for instant cash, and these discounts vary greatly across assets.

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[1] ''Liquidity, like pornography, is easily recognized but not so easily defined . . .'' (O'Hara, 1995).

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The existence of pawn shops is an indication of capital market imperfection. According to Shleifer and Vishny (1992), capital market imperfection is a necessary condition for liquidity to affect asset prices. After all, a firm would not sell real assets at ''firesale'' prices that are below the intrinsic value of the asset to the seller, unless the firm's cost of capital market funding were higher than the loss in value from the asset sale. Pulvino (1998) tests this theory and finds evidence of firesale pricing in the market for airplanes.

Pulvino's paper is part of the literature that provides direct evidence on the interaction between debt capacity and asset liquidity. He finds that higher-debt airlines obtained lower firesale prices for airplanes, suggesting that the liquidity premium on an airplane is greater for more financially constrained airlines. Alderson and Betker (1995) find that the liquidity of a firm's assets is positively related to its debt capacity. Titman and Wessels (1988) find that tangible assets are more liquid than intangible assets and thus have higher debt capacity.

There is also evidence regarding the effects of industry conditions on asset liquidity. For instance, Pulvino (1998) finds that airplanes are sold to industry outsiders at lower prices than to insiders. Using data from the liquidation of an aerospace firm, Ramey and Shapiro (1996) report that assets that were sold to industry outsiders were sold at a greater discount than assets that remained in the industry. Stromberg (1997) finds that a higher percentage of distressed firms in the industry lowers the likelihood that the trustees of a bankrupt firm will choose to liquidate its assets.

The existing literature raises two important points. First, asset liquidity findings could be very industry-specific, so it may be useful to examine a variety of industries to determine whether the patterns in the data predicted by the theory exist across a broad spectrum of assets. Moreover, it would be interesting to study industries in which assets vary widely in liquidity, so that we can see how managerial behavior changes depending on asset liquidity. Second, there are numerous important questions to which either we have no answer or the answers we have could be entirely industry-specific. Some of the questions are:

1. Are there relatively high costs associated with selling illiquid assets?

2. Is there a ''pecking order,'' based on asset liquidity, that determines which assets are sold when a firm needs cash?

3. Do firms with liquid assets have higher debt capacities than those with illiquid assets?

My goal in this paper is to answer these questions. I choose the contract drilling industry for my data. Firms in this industry generally have two kinds

of assets: drilling rigs and oil fields. Anecdotal evidence suggests that rigs were sold at firesale prices from 1982 through 1988. Industry insiders report that drilling rigs were sold for ''10 cents on the dollar,'' or 10% of their original cost. In contrast, there was an active market in oil reserves during this period, because investors found that ''it has become cheaper to look for oil on the floor of the New York Stock Exchange than in the ground.'' The implied difference between the liquidity of drilling rigs and oil fields suggests that the contract drilling industry is a natural setting for this study.

Because liquidity is generally unobservable, I begin by establishing an empirical measure for asset liquidity. Specifically, two independent proxies are used to compare the relative liquidity of different types of assets. The first proxy measures the frequency with which assets are sold; the second proxy measures the depth of the buyer's market. The measures are used to compare the liquidity of assets in the contract drilling industry. Using these measures, I find that oil fields were more liquid than drilling rigs.

I use the liquidity difference results to address the three separate questions regarding asset liquidity listed earlier. The results provide strong evidence that there are relatively high costs associated with selling illiquid assets (liquidity costs hypothesis). The data also suggest that firms tend to sell their more liquid assets before selling their illiquid assets (pecking order hypothesis). Finally, I find that firms that hold a relatively liquid portfolio of assets have higher debt capacities than firms with more illiquid assets (debt capacity hypothesis). Taken together, the results imply that asset liquidity is a significant factor affecting firms' investment decisions as well as capital structure.

The paper proceeds as follows. Section 2 describes the contract drilling industry and presents the data sets used in the empirical tests. The liquidity proxies are defined in Section 3, and the relative liquidity of certain classes of assets is established. Section 4 gives the results of several tests regarding the effect of asset liquidity on managers' decisions. Section 5 discusses alternative explanations for the results, and Section 6 concludes.

2. INDUSTRY BACKGROUND AND DATA

2.1. *The Contract Drilling Industry*

The contract drilling industry is unusually well suited to studying the effects of asset liquidity on managers' decisions. Because of the sudden crash in oil prices from 1982 through 1986, many of the firms in the sample were seriously cash-constrained (for instance, see the interest coverage ratios in Table 1). The industry also has several of the other necessary characteristics for asset illiquidity, as described in Shleifer and Vishny (1992). For instance, most contract drillers hold no assets outside of the

TABLE 1
Description of Contract Drilling Firms during Industry Distress (1982–1988)

Variable	Mean	Median	SE
Panel A: All firms (N = 481 firm-years)			
Total assets ($MM)	1,680	198	236
Debt ratio	0.37	0.34	0.01
Interest coverage ratio	5.01	3.24	0.28
Percentage of assets in contract drilling or well service	33%	25%	2%
Percentage of assets in oil production	32%	22%	2%
Panel B: Firms that sold well service assets (N = 8 firm-years)			
Total assets ($MM)	1,623	589	638
Debt ratio	0.29	0.21	0.07
Interest coverage ratio	2.07	2.25	0.50
Percent of assets in contract drilling or well service	44%	40%	12%
Percent of assets in oil production	8%	1%	4%
Percent of assets sold	13%	3%	10%
Panel C: Firms that sold drilling assets (N = 6 firm-years)			
Total assets ($MM)	1,718	1,805	604
Debt ratio	0.27	0.24	0.05
Interest coverage ratio	3.00	4.24	0.96
Percent of assets in contract drilling or well service	21%	7%	12%
Percent of assets in oil production	36%	25%	13%
Percent of assets sold	6%	2%	4%
Panel D: Firms that sold oil production assets (N = 17 firm-years)			
Total assets ($MM)	6,678	814	3,054
Debt ratio	0.35	0.31	0.05
Interest coverage ratio	5.75	3.67	1.85
Percent of assets in contract drilling or well service	21%	7%	7%
Percent of assets in oil production	54%	58%	8%
Percent of assets sold	9%	4%	3%
Panel E: Firms that sold refining or other oil industry assets (N = 14 firm-years)			
Total assets ($MM)	13,842	3,429	4,511
Debt ratio	0.34	0.30	0.05
Interest coverage ratio	4.68	3.49	0.86
Percent of assets in contract drilling or well service	9%	2%	4%
Percent of assets in oil production	34%	34%	8%
Percent of assets sold	11%	11%	3%

Note. The sample contains 481 firm-years of data in the 1982 to 1988 period. Total assets is measured at book value. The debt ratio is the ratio of total debt (long term plus current debt) to total assets. The interest coverage ratio is calculated as EBITDA/interest expense. Percentage of assets in each industry is defined as the book value of assets in each line of business, divided by the total book value of the firm's assets. Percentage of assets sold is measured by the market value of the assets sold, divided by the sum of the market value of the firm's equity and the book value of debt.

contract drilling and oil production industries. Also, drilling rigs and oil fields have very little value outside of their respective industries, except as scrap metal and cow pasture. Finally, there is anecdotal evidence that firms in the contract drilling industry faced highly imperfect capital markets, especially after the Penn Square Bank was closed in 1984. According to one source, ''Any banks still willing or able to lend to energy companies rewrote their guidelines so restrictively that getting an oil or gas loan was now not much easier than passing through the proverbial eye of the needle.'' (Yergin, 1992)

Together, these factors suggest that asset liquidity would be expected to affect asset prices in the contract drilling industry during the sample period. If liquidity is a factor which is driving the prices of asset sales in the industry, any profit-maximizing manager would be forced to react to the potentially large liquidity differences in this industry.

2.2. *Data*

The sample contains all publicly traded U.S. oil drilling firms (SIC code 1381) from 1978 to 1990. There were 55 firms in the industry in 1978. I was able to obtain data from Compustat and CRSP data for 41 of those 55 firms. The sample period begins in 1978 because in that year changes in accounting regulations required that firms disclose segment data and the amount of their proved reserves. Segment data were collected from annual reports.

Asset sales and purchases are identified from press releases, using the Petroleum/Energy Business News Index and the Lexis/Nexis database, and from annual reports. If an entire firm was sold or purchased, as a merger or acquisition, the transaction was not included in the database. Because of the different implications for the manager's employment prospects, mergers and acquisitions are assumed to be different types of transactions from asset sales which involve only a fraction of the firm.

Most of the assets held, bought, and sold by contract drilling firms fall into four industry categories. Some of the firms have lines of business outside of the oil industry, but those assets are too diverse to be categorized.

SIC code	Industry	Types of assets
1381	Contract drilling	Drilling rigs • Rotary rigs (land-based) • Offshore rigs
1389	Well service	Supplies for drilling wells: drill bits, drilling mud, well casing and tubing
1311	Oil production	Oil fields
5541, 4612, 2911	Oil pipelines, refineries, and marketing	Pipelines, refineries, service stations

Summary statistics for the industry distress period are reported in Table 1. There are 106 firms in the industry during the sample period. The database captures 151 asset sales and 190 asset purchases. The average firm in the sample has roughly one-third of its assets in the contract drilling industry, one-third of its assets in oil transportation or refining, and one-third of its assets outside of the oil industry. Of the firms in the sample, 10% are specialists in contract drilling. Most of the firms are small (the sample median book value of total assets is \$198MM) but there are a few very large firms (the mean book value of total assets for firms in the sample is \$1,680MM).

There is no minimum size restriction on asset sales in this sample. Sales of individual assets are less likely to be motivated by a change in strategic focus for the firm than the sale of a division. The average asset sale in this sample constitutes 6.9% of the book value of the firm, with a median statistic of 3.2%. In contrast, Brown, James, and Mooradian (1994) report that their average transaction price is 14% of book value, and John and Ofek (1995) have an average transaction price that is 40% of book value.

3. RESULTS: PROXIES FOR ASSET LIQUIDITY

3.1. *Asset Turnover*

The first proxy for asset liquidity is asset turnover. Asset turnover is equal to trading volume, normalized by the amount of assets available for sale. I calculate the turnover ratio by taking the dollar volume of a particular type of assets sold divided by the book value of assets held in the previous year. Segment data are used to obtain the book value of a firm's holdings of a particular asset type. Unfortunately, most of the firms in the sample do not disaggregate their segment data at the four-digit SIC code level which would allow four separate categories. As a result, the drilling assets are combined with well service assets, and pipelines, refineries, and service stations are grouped with the oil fields.

The turnover measures are reported in Table 2. The average turnover ratio for well drilling assets is 2%, which is significantly lower than the 3% turnover ratio for oil fields, pipelines, refineries, and service stations. The null hypothesis that the turnover ratios are equal is rejected at the 0.10 level of significance. During industry distress, differences between the asset types in industry turnover are more extreme, and the null hypothesis is rejected at the 0.01 level.[2]

[2] An alternative explanation for the turnover results is that the market to book ratio for drilling assets was much lower than the market to book ratio for oil fields, refineries, pipelines, and service stations. I test this alternative hypothesis by constructing an artificial market value for the assets in each sector. The artificial market value of the assets in a line of business is equal to the market value of the firm's equity plus the book value of the firm's debt, multiplied by the percentage of the firm's assets in that line of business. The results are essentially unchanged by this correction.

TABLE 2
Asset Turnover Ratios

Panel A: Comparison between subindustries

Time period	Well drilling assets	Oil production assets	Difference	*t* statistic
1978–1990	0.022	0.033	0.011	1.80*
Predistress: 1978–1982	0.026	0.023	−0.003	−0.08
Distress: 1982–1988	0.011	0.033	0.022	3.19***
Postdistress: 1988–1990	0.030	0.053	0.023	1.29

Panel B: Comparison across time periods

Asset type	Predistress 1978–1982	Distress 1982–1988	Difference	*t* statistic
Drilling assets	0.026	0.011	−0.015	−1.95**
Production assets	0.023	0.033	0.010	1.20

Asset type	Distress 1982–1988	Postdistress 1988–1990	Difference	*t* statistic
Drilling assets	0.011	0.028	0.017	1.61*
Production assets	0.033	0.051	0.018	1.22

Note. The principal of this table compares the average turnover ratio for contract drilling and well service assets (''well drilling assets'') with the ratio for oil fields, refineries, and pipelines (''oil production assets'') between 1978 and 1990. The turnover ratio is defined as the market value of assets sold divided by the book value of assets held in the previous year. The book value of a given type of assets is collected from segment data. The second panel tests the significance of the change in the ratios between different time periods. The turnover ratio is truncated at 1 to reduce the influence of outliers. Note that * indicates that the difference is statistically significantly different from zero at the 0.1 level of significance, ** indicates that the difference is significant at the 0.05 level, and *** indicates that the difference is significant at the 0.01 level.

3.2. *Depth of the Buyer's Market*

The depth of the buyer's market is a second proxy for the liquidity of assets. I use three different measures for the size of the buyer's market. The first measure is the number of potential buyers. I use a probit model to identify factors that affect the likelihood of asset purchases (see Table 3A) and find that firms with higher interest coverage ratios are more likely to purchase assets. Consequently, I define potential buyers as industry insiders that are not financially constrained.[3] The second measure of the

[3] Industry insiders are the set of firms identified by Standard & Poor's Directory of Corporations as active in the 4-digit SIC code industry for that type of asset (e.g., well drilling is the industry for drilling rigs). A firm is not financially constrained if its interest coverage ratio is at least as high as the interest coverage ratio for the average buyer in my sample (9.23). The results are basically unchanged if the median or a different quartile is used rather than the mean.

TABLE 3A
The Effects of Asset Composition on the Likelihood of Asset Purchases

	Probit results	
	Coefficient	*t* statistic
Constant	−1.02	
Interest coverage	0.11	3.52
ROA	0.27	0.92
Firm size (book value)	0.00	4.95
Interest coverage squared	−0.01	−4.36
Distressed period dummy	−0.45	−4.18
Number of observations	905	
Pseudo-R^2	0.27	
Cases correct: Model	742	
Number of asset purchases	190	
Cases correct: Null	715	

	Description of variables		
	Mean	SE	Num. obs
Asset purchases dummy var.	0.14	0.34	1378
Interest coverage	5.98	6.40	973
ROA	0.01	0.29	953
Firm size (book value)	1525.11	4779.02	1008
Int. cov. squared	76.71	153.97	973
Distressed period dummy	0.44	0.50	1378

Note. The following model is estimated using maximum likelihood methods and pooled cross-section and time series data: Pr(asset purchase$_t$) = $b1$ + $b2$*(Interest coverage$_{t-1}$) + $b3$*(ROA$_{t-1}$) + $b4$*(Firm size$_{t-1}$) + $b5$*(Interest coverage squared$_{t-1}$) + $b7$*(Distressed period dummy). All values of explanatory variables are lagged 1 year with respect to the dependent variable. The dependent variable equals 1 when the firm buys an asset in that year. The sample is defined as the set of firms that were active in the drilling industry as of 1982 and goes from 1982 to 1990. The independent variables control for the effects of financial constraints, firm profitability, firm size, and the industry distress period (1982–1988). The square of the interest coverage ratio is included to account for nonlinearities (diminishing marginal effects) of increasing the interest coverage ratio. The interest coverage ratio is also truncated at 0 and 25, to avoid nonlinearities and infinite values. To assess the model's fit, the pseudo-R^2 is included (as calculated by Greene, 1993). Also to check goodness of fit, the number of times the model is correct is compared with the null hypothesis that no assets are purchased. Variable definitions are given in Table 5B.

depth of the buyer's market is the average level of free cash flows in the hands of unconstrained insiders, since free cash flows are a measure of the firms' ability to purchase. The third measure is the free cash flows in the hands of potential buyers relative to the amount of assets available for purchase.

TABLE 3B
The Depth of the Buyer's Market

	Number of potential buyers			
	Well service	Drilling rigs	Oil fields	Refineries
Sum over years	78	143	1030	194
Average per year	5	10	69	13
SEM	1	2	6	3

	Free cash flows to potential buyers			
	Well service	Drilling rigs	Oil fields	Refineries
Sum over years	$38,117	$43,162	$295,834	$365,395
Average per year	$2,545	$2,877	$19,722	$24,360
SEM	$554	$891	$4,505	$6,028

	Free cash flows to potential buyers/book value of asset base	
	Well service, drilling assets	Oil fields, refineries
Ratio of sums	0.67	3.68
Average of ratios	0.61	1.67
SEM	0.27	0.58

	Free cash flows to all insiders/book value of asset base	
	Well service, drilling assets	Oil fields, refineries
Ratio of sums	1.34	11.76
Average of ratios	1.85	15.93
SEM	0.41	2.82

Note. The depth of the buyer's market is assessed by the number of potential buyers, and the free cash flows to potential buyers. The set of potential buyers is restricted to the set of industry insiders for each asset type. Industry insiders are identified by Standard & Poor's Directory of Corporations. Any insider that has interest coverage >9.23 (which is the average interest coverage ratio for buyers) is identified as a potential buyer. Interest coverage is defined as (pretax earnings + depreciation + interest expense) divided by interest expense. Free cash flows are defined as pretax earnings + depreciation.

The buyer's market results are reported in Table 3B. The first panel reports the total number of potential buyers for each asset type and the average number of actual buyers per year. The numbers indicate that the market for drilling assets is nearly twice the size of the market for service assets, and the market for oil fields is over 10 times the size of the market for well service assets. The differences in the averages are statistically significant.

The second panel in Table 3B reports the free cash flows to potential buyers for each asset type. The free cash flow statistics give the same basic results as the first measure, except that the market for pipelines, refineries, and service stations is more liquid than the market for oil fields. Again, the differences between categories are statistically significant.

The third panel in Table 3B reports the free cash flows to potential

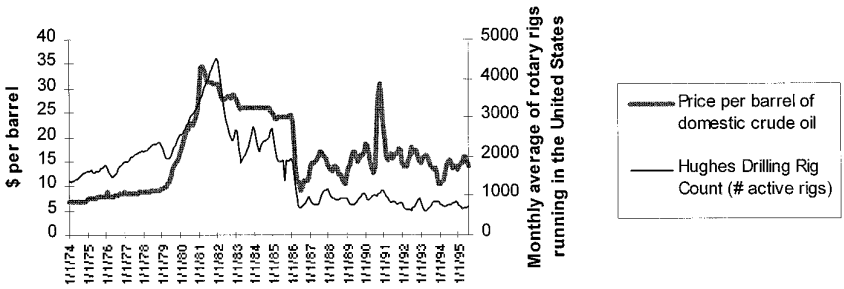

FIG. 1. Identifying industry distress: Drilling activity and the price of domestic crude oil.

buyers divided by the book value of the assets in the subindustry. Since segment data are used to calculate the book value of assets, it is necessary to combine the subindustries. The average free cash flows to potential buyers in the well-drilling categories are less than the value of the assets in the industry. In contrast, the free cash flows to potential buyers of pipelines, refineries, and service stations are greater than the total value of the assets in the subindustries (161%). The difference in the means is statistically significant.[4]

3.3. *Changes in Relative Liquidity during Business Cycle*

If asset liquidity depends on the depth of the buyer's market, then it should fall when the industry is distressed. The illiquid assets should be more affected by industry conditions than the highly liquid assets. I test this hypothesis by looking for changes in the asset turnover ratio.

To identify the industry distress period, I examine the time series of the price of crude oil and the Hughes drilling rig count (see Fig. 1). The Hughes drilling rig count gives the monthly average number of rotary rigs running in the United States. The rig count is a good measure of industry welfare, since it reflects the primary source of contract drilling revenues. The rig count falls almost continuously from a high of 4521 in December 1981 to 925 in July 1986. The price of crude oil falls over the same period. Thus I define the period of industry distress as 1982–1987.

Table 2 presents the change in asset turnover when the industry becomes distressed and as the industry emerges from the distressed period. I find that turnover drops significantly for the less liquid assets when the industry is distressed, but it does not drop for the more liquid assets. Also, the recovery in turnover is marginally significant for the less liquid assets, but

[4] The fourth chart in Table 3B shows that the results are unchanged if the financial constraints condition is dropped.

there is no procyclicality for the more liquid asset types. This indicates that liquidity varies with industry profitability and that industry profitability has a different effect on different asset types.

4. RESULTS: EFFECTS ON MANAGERIAL DECISIONS

4.1. *Do Firms Delay Sales of Illiquid Assets? A Test of the Liquidity Costs Hypothesis*

The first test of the liquidity costs hypothesis is that the firms selling relatively illiquid assets should be more financially constrained than firms selling relatively liquid assets. The results in Table 4 indicate that the average interest coverage ratio for sellers of illiquid assets is significantly lower than the average ratio for sellers of liquid assets. I also find that the average interest coverage ratio for firms that sell drilling rigs and service assets is significantly lower than the average ratio for buyers. In contrast, I cannot reject the null hypothesis that the sellers of oil fields, pipelines, and refineries are just as financially unconstrained as the buyers of these assets. These results are supportive of the liquidity costs hypothesis.

4.2. *Are Firms with Larger Holdings of Liquid Assets More Likely to Sell Assets? A Second Test of the Liquidity Costs Hypothesis*

The results from the first test of the liquidity costs hypothesis indicate that managers avoid selling illiquid assets until they are so financially constrained that they apparently have no other choice. This suggests that the likelihood of asset sales is affected by the percentage of relatively illiquid assets in the firm's asset portfolio, which provides a second test of the liquidity costs hypothesis. In order to test this hypothesis, I use a probit model for the likelihood of asset sales. I create a single cohort of firms that were active in the industry as of 1982, and I follow that set of firms through 1990. This sample selection methodology reduces survivorship bias by including firms that exit from the industry in later years and by excluding new entrants.[5] The price received for the asset will be more valuable to the firm when the firm faces high cost alternative sources of capital (is financially constrained). I use the interest coverage ratio (truncated at 25 and 0.001) to measure the effects of financial constraints. The firm's profitability (return on assets) captures the likelihood that firms with low profitability assets are more likely to undertake asset sales. I include firm

[5] The results are basically identical if I use the sample that starts in 1978, but there are fewer observations.

TABLE 4
Do Sellers of Different Asset Types Face Different Credit Constraints?
Interest Coverage Ratios for Buyers and Sellers

Whole sample: interest coverage ratios for all firms (1978–1990)	
Mean	5.27
SE	(0.28)
Num. obs	503

	Relatively illiquid: Well service and rigs	Relatively liquid: Oil fields, refineries, pipelines
Sellers during distress: interest coverage ratios for sellers during (1982–1988)		
Mean	2.189**	4.83**
SE	(0.48)	(1.10)
Num. obs	23	30
All sellers: interest coverage ratios for all sellers (1978–1990)		
Mean	3.55	4.48
SE	(0.51)	(0.67)
Num. obs	40	53
All buyers: interest coverage ratios for all buyers (1978–1990)		
Mean	6.5	5.44
SE	(0.63)	(0.46)
Num. obs	60	73

	Well service	Drilling rigs	Oil fields	Refineries, etc.
Sellers during distress: interest coverage ratios for sellers during (1982–1988)				
Mean	1.862	2.267	5.044	4.187
SE	(0.62)	(0.70)	(1.60)	(0.88)
Num. obs	10	14	20	11
All sellers: interest coverage ratios for all sellers (1978–1990)				
Mean	3.94	3.167	4.489	4.336
SE	(0.95)	(0.59)	(0.95)	(0.63)
Num. obs	16	25	36	18
All buyers: interest coverage ratios for all buyers (1978–1990)				
Mean	7.09	6.24	5.83	4.51
SE	(1.16)	(0.73)	(0.60)	(0.49)
Num. obs	23	38	53	21

Note. Financial constraints facing buyers and sellers of different asset types are compared, using the interest coverage ratio. The interest coverage ratio is defined as EBITDA/interest expense. I truncate the statistic to reduce the influence of outliers, by setting values below 0.001 equal to 0.001 and values above 25 equal to 25. The interest coverage ratio is measured in the year before the transaction.

** Difference between sellers of different types is significant at the .05 level.

size because managers may be more inclined to sell assets when the firm is larger.

In order to measure the effects of differences in the firm's asset portfolio on the likelihood of asset sales, I include a measure of the percentage of the book value of the firm's assets that can be assigned to contract drilling or well service (% illiquid assets) and the percentage of the firm's assets that are involved in oil fields, pipelines, refineries, or service stations (% liquid assets).[6] I use segment data to estimate the book value of assets in each category. I create a dummy variable for the industry distress period and an interaction term which separates the incremental effect of differences in the asset portfolio during the distressed period from its effect outside the distressed period.

The results are reported in Table 5. As predicted, firms are significantly more likely to sell assets when they face higher financial constraints (measured by the interest coverage ratio). Also, I find that larger firms are significantly more likely to sell assets. The likelihood of asset sales is lower when the firm is more profitable, as we would expect, but the effect is not statistically significant. The composition of the firm's asset portfolio does not significantly affect the likelihood of asset sales when the entire sample period is considered. However, when the effects during the distressed period are considered separately, I find that the firm is significantly less likely to sell assets when it holds a higher percentage of illiquid assets. This indicates that the relative liquidity of the less liquid assets falls during industry distress, and it is consistent with my previous results.[7]

4.3. *Is There a Reason for Managers to Avoid Asset Sales? A Test of the Pecking Order Hypothesis*

Myers' (1984) pecking order theory is motivated, in part, by the empirical observation that firms issuing equity experience a negative announcement effect. The implicit claim is that managers prefer to avoid drops in the firm's stock price, and therefore they avoid or delay issuing equity until they have used their alternate sources of capital. There are several reasons for managers to prefer to avoid drops in stock price. In some cases, managers' compensation is linked to stock price performance. Empire builders may have different reasons to avoid a loss in firm value.

To examine the asset-liquidity pecking order hypothesis, I use an event study to look at the stock price reactions to asset sales announcements. If firms selling illiquid assets experience negative stock price reactions, this

[6] Since many of the firms in my sample are diversified outside of the oil industry, I can include both variables without creating a multicollinearity problem.

[7] The results are basically unchanged if an OLS regression is used, where the left-hand side variable is the amount of asset sales from Compustat.

TABLE 5A
The Effects of Asset Composition on the Likelihood of Asset Sales

	Probit results		
	Coefficient	*t* statistic	Slope
Constant	−0.68		
% of assets in drilling	0.34	0.96	0.08
% in drilling ∗ distr. dummy	−1.08	−2.35	−0.25
% of asset in oil fields	−0.14	−0.39	−0.04
% in oil fields ∗ distr dummy	−0.21	−0.43	−0.05
Interest coverage	−0.07	−4.11	−0.02
ROA	0.06	0.31	0.01
Firm size (book value)	0.00	2.91	0.00
Distressed period dummy	0.36	1.30	0.08
Number of observations	579		
Pseudo-R^2	0.44		
Cases correct: Model	468		
Number of asset sales	151		
Cases correct: Null	428		

	Description of variables		
	Mean	SE	Num. obs
Asset sales dummy variable	0.11	0.31	1378
% of assets in drilling	0.19	0.63	618
% in drilling ∗ distr. dummy	0.16	0.28	618
% of asset in oil fields	0.28	0.30	620
% in oil fields ∗ distr. dummy	0.14	0.25	620
Interest coverage	5.98	6.40	973
ROA	0.01	0.29	953
Firm size (book value)	1525.11	4779.02	1008
Distressed period dummy	0.44	0.50	1378

Note. The model is estimated using pooled cross-section and time-series data: Pr(asset sale$_t$) = $b1$ + $b2$*(% of assets in drilling$_{t-1}$) + $b3$*(% of assets in oil fields$_{t-1}$) + $b4$*(Interest coverage$_{t-1}$) + $b5$*(ROA$_{t-1}$) + $b6$*(Firm size$_{t-1}$) + $b7$*(Distressed period dummy) $b8$*(Interaction term with % of assets and distressed period). All values of explanatory variables are lagged 1 year with respect to the dependent variables. The dependent variable equals 1 when the firm sells an asset in that year. The sample is defined as the set of firms that were active in the drilling industry as of 1982 and goes from 1982–1990. The independent variables control for the effects of financial constraints, asset composition, firm profitability, firm size, and the industry distress period (1982–1988). The square of the interest coverage ratio is included to account for nonlinearities (diminishing marginal effects) of increasing the interest coverage ratio. The interest coverage ratio is also truncated at 0 and 25 to avoid nonlinearities and infinite values. To assess the model's fit, the pseudo-R^2 is included (as calculated by Greene, 1993). Also to check goodness-of-fit, the number of times the model is correct is compared with the null hypothesis that no assets are purchased. The slope may be interpreted as the marginal change in the probability of a sale associated with a change in the independent variable. Variable definitions are given in Table 5B. Covariances of independent variables are reported in Table 5C.

TABLE 5B
Definitions of Independent Variables

Variable name	Variable definition
% of assets in drilling	Book value of assets in contract drilling and well service segments, divided by the total book value of the firm's assets.
% of assets in oil fields	Book value of assets in oil production, transportation, refining, and marketing segments, divided by the total book value of the firm's assets.
Interest coverage	(Net income + depreciation + interest expense)/interest expense
ROA	{Net income + [(1-tax rate)*interest expense] + minority interest in earnings of subsidiaries—discontinued operations}/book value of total assets
Firm size	Book value of total assets
Distressed period dummy	1 if year is 1982–1988, otherwise 0

TABLE 5C
Correlation Matrix for Independent Variables in Probit Model

	% of assets in drilling	% in drilling * distress dummy	% of assets in oil fields	% in oil fields * distress dummy	Interest coverage	ROA	Firm size (book value)
% of assets in drilling	1.000	0.656	**−0.449**	−0.255	−0.092	−0.029	−0.176
% in drilling * distress dummy	0.656	1.000	−0.254	0.008	−0.107	−0.039	−0.098
% of assets in oil fields	**−0.449**	−0.254	1.000	0.644	0.039	−0.004	−0.038
% in oil fields * distress dummy	−0.255	0.008	0.644	1.000	−0.027	−0.077	0.002
Interest coverage	−0.092	−0.107	0.039	−0.027	1.000	**0.239**	0.075
ROA	−0.029	−0.039	−0.004	−0.077	**0.239**	1.000	0.053
Firm size (book value)	−0.176	−0.098	−0.038	0.002	0.075	0.053	1.000
Distressed period dummy	0.055	0.578	0.028	0.540	−0.166	−0.103	0.074

Note. This table provides simple correlations {cov (x, y)/[std dev (x) * std dev (y)]} for the independent variables in the profit analysis. Variable definitions are provided in Table 5B. As expected, the percentage of assets in oil fields is negatively correlated with the percent of assets in drilling rigs. A substantial proportion of the firms in the sample are well diversified and do not have a substantial holding of either type of asset. The relatively low correlation between interest coverage and ROA reflects the wide variation in leverage in the industry.

would provide an explanation for the pecking order effect. I compare the announcement effects for sales of illiquid assets (rigs and well service assets) to the announcement effects for sales of relatively liquid assets (oil fields, refineries, pipelines).

For my tests, I found the earliest announcement dates for as many transactions as possible. Then I eliminated any observations for which there were simultaneous announcements during the 3-day event window as well as all transactions which involved takeovers. To run the event study, I follow the methodology of Mitchell and Netter (1994). It should be noted that the asset sales announcements may have been anticipated by the market, which would reduce the stock price reaction on the announcement date.

The results from the event study are presented in Table 6. I find that the average CAR for sellers of well service and drilling assets is negative and significantly different from zero. In contrast, the average CAR for sellers of oil fields, pipelines, refineries, and service stations is positive, though not significantly different from zero. The difference between the announcement effects is statistically significant. When I restrict the sample observations to events that occur during the industry distress period (1982–1988), the results are similar, but the absolute values of the average CARs are slightly larger. Using four asset categories instead of two reduces the sample size, and the mean CARs are no longer significantly different from zero.

There are several alternative explanations for the different stock price reactions. The stock price reaction incorporates the information implicit in the decision to sell the asset. The decision to sell a relatively illiquid asset may send a stronger adverse signal regarding the firm's prospects than the decision to sell a relatively liquid asset. In addition, the loss in value associated with firesale pricing could cause a drop in the market value of the firm's equity. A third possibility is that the drop in stock price may not reflect a drop in firm value, but rather a transfer of value from stockholders to creditors (as in Brown, James, and Mooradian, 1994). Since the relatively illiquid assets are associated with relatively risky lines of business, their sale may represent a drop in the riskiness of the firm, which benefits bondholders but hurts stockholders. Whatever the explanation for the announcement effect, it is likely that the negative stock price reaction motivates managers to avoid sales of illiquid assets.

4.4. *A Second Test of the Pecking Order Hypothesis: Evidence at the Individual Firm Level*

The pecking order refers to the order in which an individual firm sells its assets. In particular, when I compare the liquidity of an asset sold with the liquidity of the last asset the firm sold, the second asset sold should be

TABLE 6
Stock Price Reactions to Announcements of Asset Sales, by Type of Asset

		Mean CAR	SEM	*t* statistic	Num. obs
Relatively illiquid	Well service or drilling rigs	−0.0114	0.0055	−2.05	50
Relatively liquid	Oil fields, refineries, pipelines	0.0116	0.0091	1.28	73
	During industry downturn (1/1/82–12/31/87)				
Relatively illiquid	Well service or drilling rigs	−0.0187	0.0091	−2.04	24
Relatively liquid	Oil fields or downstream	0.0241	0.0157	1.53	40
	Subdividing the categories				
Relatively illiquid	Well service	−0.0178	0.0117	−1.52	19
	Drilling rigs	−0.0075	0.0054	−1.38	31
	Oil fields	0.0113	0.0145	0.78	42
Relatively liquid	Downstream	0.0121	0.0086	1.41	31
	During industry downturn (1/1/82–12/31/87)				
Relatively illiquid	Well service	−0.0284	0.0156	−1.82	12
	Drilling rigs	−0.0091	0.0095	−0.95	12
	Oil fields	0.0241	0.0236	1.02	25
Relatively liquid	Downstream	0.0242	0.0160	1.51	15

Note. An event study was performed to compare the stock price reactions to announcements of sales of different types of assets. The first two charts compare the average reaction for liquid assets with the average reaction for illiquid assets, both for the whole sample period and during the industry distress period. The last two charts subdivide the asset categories, which reduces sample size. The market model is used to estimate betas and daily abnormal returns. I require at least 50, and include up to 200, consecutive trading days of data for beta estimation. The event window is [−1, 1]. I cumulate abnormal returns over the 3 day period by taking the product of abnormal returns for each of the days. Takeovers and announcement dates with simultaneous events are excluded.

less liquid than the first asset. Also, since the liquidity differences become exaggerated when the industry is distressed, firms should choose to sell assets from higher liquidity categories when the industry becomes distressed.

I use a nonparametric procedure to test the pecking order hypothesis. The procedure creates a trinomial variable that indicates whether the liquidity category of assets sold by a firm is rising, falling, or remaining the same over time. To test the hypothesis that firms are choosing to sell assets from higher liquidity categories as the industry becomes distressed, I collect all liquidity changes for which the first year is before 1982, and the second

TABLE 7
Time Series Results: Does Asset Liquidity Affect the Order in Which Assets Are Sold?

	Num. obs	Mean liq. change	Std. error of mean	Wilcoxon est. median	Wilcoxon p value*
Whole sample	69	−0.015	0.096	0	0.899
Predistress to distress	12	0.333	0.188	0.5	0.173
Distress to postdistress	19	−0.053	0.179	0	0.824
During the distress period	29	−0.069	0.164	0	0.721

Note. The liquidity rankings are used as an ordinal measure of the liquidity of the asset sold. If more than one asset type is sold in a year, the average liquidity ranking is calculated. The rankings are based on the liquidity proxies, and are described in the chart below:

More liquid 4	3	2	Less liquid 1
Refineries Pipelines Marketing	Oil fields	Drilling rigs	Well service assets

If the firm sells an illiquid asset, and then sells a more liquid asset in a subsequent year, the change in the liquidity rankings is set equal to +1. If the firm sells a relatively illiquid asset after selling a more liquid asset, the change in the liquidity rankings is set equal to −1. If there is no change in the liquidity rankings, the change is set equal to zero. The mean liquidity change is the average of the column of zeroes, ones, and negative ones, and the Wilcoxon medians test is used to test the null hypothesis that the ''average'' firm does not change the liquidity of the assets it sells over time. The results are separated into subcategories based on the timing of the liquidity change. For example, if the first year was prior to the distressed period but the second year was during the distressed period, that observation would be put into the category Predistress to distress.

* The Wilcoxon p value represents the level of significance at which we can reject the null hypothesis that the estimated median equals zero (two-tailed test).

year is between 1982 and 1988. I use the Wilcoxon (nonparametric) test to test the hypothesis that the median liquidity change is nonzero.

The results are presented in Table 7. I find that firms that sold assets before the industry became distressed tended to sell assets from a higher liquidity category when the industry was distressed. There are very few observations, so the results should be taken as suggestive, not conclusive ($n = 12, p$-value $= 0.17$). Although the results are not statistically significant, they suggest that managers respond to the change in relative liquidity during industry distress by selling from higher liquidity categories, which is consistent with the hypothesis. The results from within the distressed period are also not statistically significant, but again the direction of the change is consistent with the hypothesis. The median change in liquidity indicates that firms follow the pecking order by selling more liquid assets before selling less liquid assets.

4.5. *Does Debt Capacity Depend on Asset Liquidity? A Test of the Debt Capacity Hypothesis*

Table 8 reports the average debt ratios for firms with relatively illiquid assets and for firms with relatively liquid assets. I assume that a firm has relatively illiquid assets if over 50% of the firm's sales are from the contract drilling or well service sector, and relatively liquid assets if less than 50% of the firm's sales are from contract drilling or well service. The debt ratio is calculated as debt minus cash, divided by total assets at the firm level. The table is subdivided by the size of the firm because small firms may have lower debt capacities due to asymmetric information. I also subdivide the table by the time period, because predistress debt ratios are more likely to reflect the optimal debt level of the firm than the debt levels during the distressed period.

The debt ratios in the predistress period indicate that firms with more illiquid assets have significantly higher debt levels than firms with relatively liquid assets. This result is contradictory to the theory that asset liquidity allows firms to increase their borrowing capacity. One possible explanation is that asset liquidity can sometimes lower the debt capacity of the firm because of the increased risk of managerial misconduct (Myers and Rajan, 1995). Another explanation is that the drilling subindustry was expanding more rapidly during this time than the oil production subindustry. In order to finance their expansion, managers of drilling companies borrowed heavily.

During the distressed period, I can no longer reject the null hypothesis of equal debt ratios for firms with liquid or illiquid assets. When the industry becomes distressed, firms with relatively liquid assets increase their borrowing. This increase in borrowing eliminates the difference in the debt ratios.

The change in debt ratios is driven by increased borrowing from small firms. The small firms with liquid assets show a dramatic increase in their borrowing when the industry becomes distressed. In contrast, firms with relatively illiquid assets do not increase their borrowing. During the distressed period, the average debt ratio is significantly higher for small firms with liquid assets than for small firms with illiquid assets.

One interpretation of these results is that the liquid assets provide an increase in the debt capacity. A larger debt capacity allows smaller firms to increase their borrowing as needed, to meet their growing needs for cash as the industry becomes distressed. Larger firms may not need to increase their debt levels as much as small firms, because they have better access to other sources of capital. Although the small firms with illiquid assets were also in need of cash, it appears that they were not able to increase their borrowing, perhaps because of the drop in the value of their collateral.

TABLE 8
Debt Capacity and Asset Composition

Firm size	Asset composition		
	Liquid	Illiquid	Difference
	Predistress: 1978–1982		
Total sample			
Debt ratio—mean	0.25	0.34	−0.08
t statistic			−(3.16)***
Num. obs	145	88	
Big			
Debt ratio—mean	0.24	0.30	−0.06
t statistic			−(1.86)*
Num. obs	99	31	
Small			
Debt ratio—mean	0.28	0.36	−0.08
t statistic			−(1.54)
Num. obs	46	57	
	Distress: 1982–1987		
Total sample			
Debt ratio—mean	0.33	0.33	0.00
t statistic			(0.00)
Num. obs	219	123	
Big			
Debt ratio—mean	0.25	0.28	−0.75
t statistic			−(0.75)
Num. obs	133	53	
Small			
Debt ratio—mean	0.48	0.38	0.10
t statistic			(2.10)**
Num. obs	86	70	
	Postdistress: 1987–1990		
Total sample			
Debt ratio—mean	0.27	0.25	0.01
t statistic			(0.20)
Num. obs	64	30	
Big			
Debt ratio—mean	0.22	0.28	−0.06
t statistic			−(0.70)
Num. obs	42	17	
Small			
Debt ratio—mean	0.37	0.21	0.17
t statistic			(1.43)
Num. obs	22	13	

Note. This table compares the debt ratios for companies with primarily liquid assets with the debt ratios for companies with primarily illiquid assets. The debt ratio is defined as (book value of total debt- (cash and marketable securities))/(book value of total assets). Firms with primarily liquid assets are identified by segment data. If at least 50% of the firm's sales are from oil production and sales, the firm is classified as having primarily liquid assets. Similarly, if at least 50% of the firm's sales are from well-drilling activities, the firm is classified as having primarily illiquid assets. The differences in debt ratios are reported separately for each time period. The sample is also subdivided according to firm size (book value of assets): the firms in the top 50% of firm ∗ years are included in the ''Big'' group, while firms whose assets fall below the sample median are included in the ''Small'' group. The *t* statistics are in parentheses.

*** Significance at .01 level; ** significance at .05 level; * Significance at .1 level.

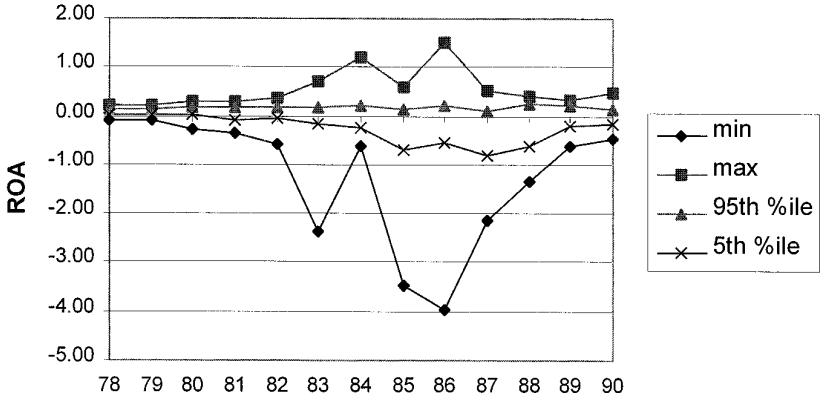

FIG. 2. Cross-sectional distribution of ROA for contract drilling firms. Compustat data are used to calculate ROA for each of the firms in the contract drilling industry, using the following formula:

$$\text{ROA} = (\text{Net income} + \text{interest expense})/\text{total assets}.$$

5. ALTERNATIVE EXPLANATIONS

5.1 *Do Firms with Refineries, Pipelines, or Service Stations Avoid Financial Distress?*

The results from the previous tests suggest that differences in the composition of the firm's asset portfolio cause differences in managerial behavior. But it is possible that differences in the firms' asset portfolios are acting as a proxy for differences in firm profitability and cash flows, because the pipeline and refining subindustries were not as negatively affected by the drop in the price of crude oil as the well drilling and well service subindustries. This raises the possibility that firms with pipelines and refineries were not financially distressed when most of the firms in the contract drilling industry were severely distressed.

If firms holding refineries and pipeline assets were not distressed, there is an alternative explanation for the two sets of results. First, firms selling refineries and pipeline assets during industry distress would not be financially distressed simply because any firm holding this type of asset was not financially distressed during the industry downturn. This would explain the results in Table 4. Also, if firms are more reluctant to purchase from distressed sellers (perhaps because of an implicit signal regarding the likely quality of the asset) then this would explain the probit results as well (Table 5A).

To investigate this alternative explanation, I examine the cross-sectional distribution of profitability during the distressed period (see Fig. 2). Approx-

imately 5% of the firms in the industry show an increase in ROA while profitability for the rest of the industry falls. I eliminate those nondistressed firms and rerun the tests in Tables 4 and 5A. The results are essentially unchanged after eliminating the nondistressed firms. Thus, even when the differences in relative profitability are reduced, the tests still indicate that the differences in asset composition affect managerial behavior. Although it is still possible that differences in asset composition are proxying for differences in profitability, this test does not support that conclusion.

5.2. *Do Managers Avoid Selling Rigs Because Drilling Is Their ''Core Business''*

It is possible that managers identify a ''core business'' of their firm and are reluctant to sell assets from this core business. The core business might be the original (oldest) line of business of the firm; it might be the most profitable line of business; or it might be the largest line of business of the firm. If managers in the contract drilling business regard their drilling activities as the core business of the firm, they might avoid selling those assets for reasons unrelated to the liquidity of those assets.

In order to rule out this explanation, I define the core business of the firm by the largest line of business of the firm. Specifically, I separate the sample of contract drilling firms into a subset that is focused on drilling activities (greater than 50% of assets are from the drilling and well service industries) and a subset that is focused on oil fields, pipeline, and refinery activities (greater than 50% of assets are from oil fields, pipelines, refineries, and service stations). The relevant question is whether firms with a well–drilling focus are more likely to sell oil fields or refineries and whether firms with a production/refinery focus are more likely to sell drilling assets.

The results are reported in Table 9. Although the focus of the firm affects the likelihood of asset sales, it does not appear to affect the type of asset sold. Therefore, the ''core business hypothesis'' is not supported. Firms with a production/refinery/pipelines core business are more likely to sell assets than firms with a drilling core business. But each type of firm appears to be equally likely to sell each type of asset, rather than selling more frequently from their noncore businesses.

To control for differences in the underlying asset base, the table also presents the turnover ratios for each type of asset. The turnover ratio is calculated as the dollar amount of a given type of asset sales in year t divided by the book value of that type of asset held by the firm in year t-1. The differences between the average turnover ratios are not statistically significant.

In addition, the results are not consistent with a second implication of the ''core business hypothesis.'' That is, the hypothesis predicts that turnover of

TABLE 9
Asset Sales and the Core Business of the Firm

	Firms with core business in oil fields, refineries	Firms with core business in drilling oil wells
Firms that sold the following types of assets:		
Drilling assets	29%	10%
Oil fields, refineries	32%	12%
Nonoil assets	26%	10%
Turnover ratio		
Drilling assets		
Mean	5.60%	2.10%
SE	(1.93%)	(0.78%)
Num. obs	132	149
Oil fields, refineries		
Mean	4.70%	3.10%
SE	(1.45%)	(1.31%)
Num. obs	132	149

Note. This table addresses the question: Are firms avoiding selling assets that are related to the ''core business'' of the firm? It is assumed that a line of business is the core business of a firm if at least 50% of the firm's assets are from that line of business (as reported in segment data). The turnover ratio is calculated as (book value of assets in a given line of business at time t)/(book value of assets of that type at time t-1). The sample consists of 106 public firms identified by S&P as firms that were active in the contract drilling industry (SIC Code 1381) at some point over the time period 1978–1990. Segment data were collected from Compustat's segment data file and from the footnotes to annual reports.

drilling assets should be higher for firms with a oil fields/pipelines/refineries core business and turnover of oil fields/pipelines/refineries should be higher for firms with a well-drilling core business. Again, the results indicate that the differences in turnover rates are not statistically significant.

6. CONCLUSIONS

This paper tests differences in liquidity across four categories of assets in the contract drilling industry. I use two proxies for liquidity. The first is the asset turnover ratio, which measures transaction volume relative to the asset base. The second is the magnitude of the buyer's market, which is measured by summing free cash flows to potential buyers of each asset type. Both proxies provide the same rank-order of relative asset liquidity for the asset types. The proxies also indicate that liquidity differences are exaggerated during industry distress periods, when the assets become more illiquid.

The liquidity costs hypothesis suggests that firms selling illiquid assets should be more financially constrained than firms selling liquid assets. I test this hypothesis at the aggregate level and find that sellers of liquid assets are not financially constrained relative to buyers. In contrast, sellers of illiquid assets are significantly more constrained than buyers, and significantly more constrained than sellers of liquid assets. Thus, there is support for the liquidity costs hypothesis.

The liquidity costs hypothesis also implies that firms with a higher percentage of illiquid assets should be less likely to sell assets, which suggests a second test of the hypothesis. I conduct this test, and also examine the incremental effects of liquidity during industry distress. The results indicate that the liquidity of the firm's assets does affect the likelihood of asset sales, but the effect is only observed when the industry is distressed.

The results from the pecking order tests indicate that firms do tend to follow a pecking order in choosing which assets to sell. During the industry distress period, firms sell assets in order of decreasing liquidity. I also find that firms sell assets from higher liquidity categories when the industry becomes distressed. However, perhaps due to the small size of the sample, neither of these results is statistically significant.

Finally, I look for a connection between the liquidity of assets and the debt capacity of the firm. The results indicate that firms with liquid assets were able to increase their borrowing during industry distress, but firms with comparatively illiquid assets were already at their maximum debt levels.

The paper provides a detailed examination of the effects of asset liquidity on managers' investment and capital structure decisions. It makes a new empirical contribution by finding that liquidity costs can vary considerably even for assets which are all highly specific to the oil industry. The results also provide corroborating evidence for recent papers that find that asset liquidity has a direct effect on asset prices (e.g., Pulvino, 1998) and on debt capacity (e.g., Alderson and Betker, 1995). Future research could be fruitfully directed at testing the various hypotheses on liquidity for other industries, particularly to see if larger sample sizes could provide additional evidence on the pecking order hypothesis.

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