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Do Asset Fire Sales Exist? An Empirical Investigation of Commercial Aircraft Transactions

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ABSTRACT

This paper uses commercial aircraft transactions to determine whether capital constraints cause firms to liquidate assets at discounts to fundamental values. Results indicate that financially constrained airlines receive lower prices than their unconstrained rivals when selling used narrow-body aircraft. Capital constrained airlines are also more likely to sell used aircraft to industry outsiders, especially during market downturns. Further evidence that capital constraints affect liquidation prices is provided by airlines' asset acquisition activity. Unconstrained airlines significantly increase buying activity when aircraft prices are depressed; this pattern is not observed for financially constrained airlines.

> Eastern needs substantial liquidity to implement its business plan and expects that it will continue to sell assets to provide such liquidity.
>
> —Texas Air, *1989 Annual Report*

OPTIMAL CAPITAL STRUCTURE THEORIES suggest that firms choose debt levels such that tax and agency benefits of debt are balanced with expected costs of financial distress. Although direct costs of financial distress (e.g., legal and administrative costs of bankruptcy) are well documented, comparatively little evidence exists on indirect costs.[1] This paper presents evidence on a specific

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[1] For estimates of direct costs of bankruptcy, see Warner (1977), Altman (1984), and Weiss (1990). Each of these studies finds that direct bankruptcy costs amount to less than 5 percent of firms' prebankruptcy market values. Maksimovic and Phillips (1996), Chevalier (1995), Opler and Titman (1994), Brown, James, and Ryngaert (1992), Kim and Maksimovic (1990), and Altman (1984), examine indirect costs of financial distress.

indirect cost, namely, price discounts associated with distressed asset sales. Using a large sample of commercial aircraft transactions, I estimate the magnitude of the discount at which distressed airlines liquidate assets.

Empirical efforts to measure discounts at which assets are liquidated are complicated by the inability to measure fundamental values.[2] As a result, previous studies have focused on stock price reactions to liquidation announcements; they generally interpret positive reactions to mean that assets are not being liquidated at discounts to fundamental values, but instead are being reallocated to higher-value users. However, these studies find conflicting results (e.g., see Brown, James, and Mooradian (1994) and Lang, Poulsen, and Stulz (1995)).[3] Lang et al. (1995) argue that a possible cause of the conflict is that announcements of decisions to sell assets convey information not only about the value of the asset sold, but also about the intended use of proceeds and the financial health of the firm. They conclude that disentangling these effects may require analysis of a larger sample of less significant asset sales than has been used in previous empirical studies.

Unlike prior research, I estimate liquidation discounts by examining *prices* at which assets are liquidated. I motivate this empirical work by applying the Shleifer and Vishny (1992) industry-equilibrium model of asset liquidation to the commercial aircraft market. According to their model, discounts at which assets are sold will be particularly large in depressed industries where assets are industry-specific. The reason is that competitors of distressed firms may be facing financial constraints of their own and therefore will be unable to pay fundamental values for assets. The result is that, during industry recessions, the market for industry-specific assets will be illiquid. Rather than selling to the highest-value user, distressed firms may be forced to sell to well-financed, low-value users.

Empirical results presented in this paper show that airlines' financial conditions are key determinants of prices they receive for aircraft. Airlines with low spare debt capacities (defined to be airlines with above-industry-median leverage ratios and below-industry-median current ratios) sell aircraft at a 14 percent discount to the average market price. This discount exists when the airline industry is depressed but not when it is booming. An examination of the effect of the quantity of sales provides some evidence that this is driven in part by thinness in the market for used aircraft. Especially during industry recessions, an increase in the number of aircraft sold by an airline in a given calendar-quarter results in a reduction in the price that the seller receives.

Examination of aircraft buyers provides additional evidence that financially constrained airlines receive lower prices than unconstrained rivals. Because financial institutions (e.g., banks and leasing companies) are lower-

[2] I define "fundamental value" to be the net present value of cash flows generated by an asset.

[3] Also see Hite, Owers, and Rogers (1987), Alexander, Benson, and Kampmeyer (1984), and Jain (1985).

value users of commercial aircraft than airlines, they tend to pay lower prices. This is the case particularly during industry recessions when competition for used aircraft is weak and the risk associated with finding a lessee for the aircraft is high. During market recessions, financial institutions pay a discount of 30 percent to the average market price. Furthermore, as sellers' financial constraints become more severe, the likelihood of selling to financial institutions increases, but only during market recessions.

Finally, the pattern of airlines' used aircraft purchases supports the hypothesis that financially constrained airlines liquidate aircraft at discounts to fundamental values. Airlines with high spare debt capacities tend to buy more used aircraft than airlines with low spare debt capacities, particularly when aircraft prices are depressed.

These results have important implications for firms' capital structure decisions. They suggest benefits to limiting financial leverage; rather than being forced to sell assets at discounts, maintaining spare debt capacity allows firms to be on the "buy-side" of industry fire sales. Results presented in this paper also have implications for investment theories. They confirm that investment abandonment is costly, and consistent with previously published empirical findings, they imply higher costs of capital stock adjustment than standard neoclassical theories of investment assume (Hubbard (1995) and Cummins, Hassett, and Hubbard (1994)).

Finally, results presented in this paper have implications for the debate over bankruptcy law reform. Some authors argue that insolvent firms should be forced into immediate cash liquidation via Chapter 7 of the U.S. bankruptcy code (e.g., Baird (1986)), but opponents object to this solution on the grounds that it may fail to maximize proceeds to liquidating firms' claimholders (e.g., Aghion, Hart, and Moore (1992)). They argue that problems associated with raising capital and lack of competition for distressed firms' assets will cause liquidating firms to sell assets at discounts to fundamental value. According to the Shleifer and Vishny (1992) model, assets will be transferred to well-financed industry outsiders who, because of the industry-specific nature of assets, are less productive users. Results presented in this paper imply that immediate cash liquidation of distressed firms' assets via Chapter 7 of the U.S. bankruptcy code could result in suboptimal outcomes; claimholders may get only a fraction of the value of their assets and assets may be distributed to financially unconstrained buyers rather than high-value users.

Section I presents a brief summary of the Shleifer and Vishny (1992) model as well as an application of their model to the used aircraft market. Testable hypotheses are also identified in this section. Section II describes the sample of aircraft transactions used in the paper's empirical analyses. Section III presents the empirical methodology and results, and also discusses implications of these results for the hypotheses presented in Section I. Section IV discusses an alternative explanation and Section V summarizes the main results and conclusions.

I. Theory

A. The Shleifer and Vishny Model

Shleifer and Vishny (1992) consider the scenario where a firm responds to financial distress by selling assets. Whether the assets are sold to a buyer within the industry or to an outside buyer depends both on buyers' fundamental values and their abilities to pay. Differences in valuations between inside and outside buyers depend largely on characteristics of the assets being sold. If assets are industry specific, an inside buyer is likely to place a higher value on the assets than an outsider. Oil refineries exemplify industry-specific assets; they generate large cash flows when used to refine oil but significantly smaller cash flows when deployed elsewhere. If assets are generic, then inside buyers and outside buyers are likely to place similar values on the assets. Computers exemplify generic assets; they can be used productively in any number of industries.

Even if the inside buyer is a more productive user, and therefore places a higher value on the assets, the selling firm may sell to the industry outsider. This will be particularly true during industry recessions when factors that force the seller to liquidate also create financial constraints for potential inside buyers. In this situation, the inside buyer is unable to offer fundamental value for the selling firm's assets. If the insider's financial constraints are much more severe than those of the outsider, the outsider will outbid the insider and assets will be redeployed to a lower-value use.

B. Description of the Used Aircraft Market

There are many participants in the market for used commercial aircraft. In addition to airlines, aircraft are often purchased by governments, air cargo companies, and financial institutions. Some financial institutions are leasing companies whose primary business involves "placing" aircraft with lessees. However, banks and limited partnerships have also been active in buying, leasing, and selling commercial aircraft.

The market for used commercial aircraft has historically been dominated by privately negotiated transactions. Most major airlines have staff devoted to the acquisition and disposition of aircraft. Independent aircraft brokers have also been used to match buyers and sellers. Since the mid- to late 1980s, firms dedicated to tracking commercial aircraft (by serial number) have emerged, making it much easier for potential buyers to determine the owner of any given aircraft. These firms have also begun to publish "classified advertisements" for commercial aircraft, thus reducing the need for brokers. For example, Federal Express Aviation Services' Availability Reports list aircraft available for sale or lease along with owners' identities and phone numbers. However, asking price is rarely disclosed.

In the mid-1990s, auctions were organized to further improve liquidity in the used aircraft market. One of the first such auctions was held in Las Vegas, Nevada, in November 1994. Of 35 aircraft offered for sale, only nine were sold. Subsequent auctions were even less successful. An auction in Seattle, Washington, in September 1995 ended without a single sale—a subsequent auction scheduled for October 1995 was canceled because of lackluster interest at the Seattle auction. At least for the time being, the structure of the used commercial aircraft remains, as it has been for the past 20 years, dominated by privately negotiated transactions.

In a typical month, approximately 20 used commercial aircraft trade hands worldwide. For any given aircraft model, there are, on average, only one or two transactions per month. Thus, compared to financial markets, the market for used commercial aircraft is extremely "thin." This makes it difficult for buyers and sellers to establish "market values." Because of difficulty in establishing a benchmark market price, the relative bargaining powers of buyers and sellers are potentially important determinants of transaction price. Motivated sellers are more likely to agree to a low transaction price and motivated buyers are more likely to agree to a high transaction price. This paper focuses on one particular source of motivation, namely, the financial condition of the seller.

C. Application of Shleifer and Vishny to the Used Aircraft Market

In deciding whether to keep or sell an aircraft, distressed airlines compare the net benefit from keeping the aircraft to the cash obtained by selling it. The net benefit from keeping an aircraft is comprised of the difference between the cash flow generated by the aircraft and the cost incurred in raising capital necessary to avoid default on existing loans. There are a number of potential sources of costs of raising capital. If the seller attempts to obtain capital from the external capital market, he must overcome information asymmetry.[4] Costs of doing so will be particularly high when the seller is financially distressed because distress may signal managerial incompetence. Furthermore, investors may not share management's opinion about the value of assets in place. To entice investors to provide additional capital, securities may have to be offered at a discount (Myers and Majluf (1984)). In the extreme case, debt overhang will prevent the seller from issuing new securities (Myers (1984)).

Because proceeds from positive net-present-value (NPV) projects can be used to pay existing creditors, the debt overhang that prevents the seller from issuing new securities does not eliminate the possibility of rescheduling debt. Nevertheless, debt rescheduling may also be expensive. First, coordinating dispersed creditors may be costly (Gertner and Scharfstein (1991), Asquith, Gertner, and Scharfstein (1994)). Second, creditors may worry that delaying debt payments will allow managers to pursue highly volatile negative NPV projects (Jensen and Meckling (1976), Myers (1997)). To prevent this, creditors incur increased monitoring costs, which are ultimately passed along to the debtor.

[4] For an example of costly investor communication, see Healy's and Palepu's (1995) clinical study of CUC International, Inc.

As the cost of raising capital increases, the net benefit (i.e., cash flows generated from aircraft less the cost of raising capital) to the seller from keeping the aircraft decreases. Therefore, the price at which the seller is indifferent between keeping and selling the asset is decreasing in the seller's degree of financial distress (or, equivalently, increasing in the seller's spare debt capacity) and decreasing in the dispersion of the seller's creditors.

In order for an aircraft transaction to take place, it must be that buyers are both willing and able to pay a price that exceeds the seller's reservation price. The maximum price that buyers are willing and able to pay depends both on their valuations of the aircraft being sold and on their access to capital. Other airlines (industry insiders) are likely to be the most productive users of used aircraft and are therefore likely to place the highest values on these aircraft. However, if factors causing the seller's distress are industry-wide, other airlines may not be in the financial position to acquire additional aircraft even though doing so represents a positive NPV project. The price they will be able to pay equals the difference between the net present value of cash flows generated by the aircraft and the cost of raising capital to finance the purchase. In an industry-wide recession, financial constraints faced by other airlines may be so severe that lower-value users (industry outsiders) are able to outbid airlines for their distressed competitors' assets.

Financial institutions (e.g., banks and aircraft leasing companies) tend to be lower-value users of used aircraft. The reason is that, unlike airlines, financial institutions cannot immediately place aircraft in service and generate revenue—they must first find a lessee. Although this is relatively easy when demand for aircraft is high, it can be quite difficult and expensive when demand is low. Thus, net cash flows generated by financial institutions tend to be lower than those generated by other airlines by an amount at least as large as the cost of "placing" the aircraft.[5] Therefore, we would expect to see, on average, lower transaction prices when the buyer is a financial institution. Because of this, sellers will prefer to sell to high-value insiders; desperate sellers will be more likely than patient sellers to sell to financial institutions. This effect should be particularly strong during market recessions, when competition from other airlines for the distressed seller's assets is weak.

The foregoing discussion assumes that there is limited competition among industry buyers for distressed firms' assets. This may be an unreasonable assumption in extremely liquid financial markets, but it is reasonable in the

[5] When airlines have multiple years of negative earnings, profitable financial institutions may actually be higher value users of commercial aircraft. The reason is that the value of the depreciation tax shield will be zero for an airline with negative earnings and positive for a profitable financial institution. Depending on the magnitude of this tax shield, realized cash flows may be greater for the financial institution. In this case, financial institutions would be willing to pay more for used aircraft than would other airlines, especially during market recessions. However, this is not consistent with empirical evidence presented in a later section of this paper; financial institutions tend to pay lower prices than other airlines, particularly during depressions in the used aircraft market.

used aircraft market where transactions are less frequent and search costs that sellers incur to find high-value buyers are relatively high. Evidence that the used aircraft market is often illiquid is provided by the following disclaimer commonly included in aircraft appraisals:

> The 'Fair Market Value' of the Aircraft . . . is the price which, in the opinion of Avmark [the appraiser], could be negotiated in an arm's length free market transaction between a willing seller and a willing and able buyer, neither of whom is under undue pressure to complete the transaction. In the event a distress sale is required, realization could be significantly less than the Fair Market Value.[6]

This implies that an opportunity exists for well-financed airlines. If aircraft sell at distressed prices during market recessions, we would expect to observe increased buying activity by those insiders with relatively low costs of accessing capital.

D. Testable Hypotheses

Based on the above discussion, the following null and alternative hypotheses are obtained:

$H_0$1: *Price is independent of the seller's financial condition.*
H_A1: *Price is decreasing in the seller's cost of raising capital.*
(i) *Price is increasing in the seller's spare debt capacity.*
(ii) *Price is decreasing in the number of seller's creditors.*

$H_0$2: *Price is independent of the seller's valuation of the aircraft.*
H_A2: *Price is positively related to the seller's valuation of the aircraft.*

$H_0$3: *Price is independent of buyer identity (i.e., airline versus financial institution).*
H_A3: *Price is lower when the buyer is an industry outsider, especially during industry recessions.*

$H_0$4: *Buyer identity is independent of the seller's financial condition.*
H_A4: *Financially constrained airlines are more likely to sell to financial institutions, particularly during market recessions.*

$H_0$5: *The number of used aircraft purchases per calendar-quarter is independent of the buyer's spare debt capacity.*
H_A5: *Spare debt capacity is positively related to the number of used aircraft purchases, particularly during market recessions.*

[6] Source: People Express 14% Secured Equipment Certificate Prospectus, June 13, 1985, p. 11.

II. Data Description

Empirical analyses presented in this paper are based on used aircraft transactions that occurred from 1978 to 1991. Examination of aircraft sales has three advantages over the plant or division sales examined in previous studies. First, aircraft of a given model are relatively homogeneous. This makes it easier to isolate effects of transacting parties' characteristics on transaction attributes (e.g., price, timing of sale). Second, the U.S. airline industry provides a sample of firms with widely varying capital structures and profit levels. This variability allows inferences regarding effects of firms' financial conditions on asset liquidation decisions to be made. A final advantage of using aircraft transactions is that, because of the global nature of the market for commercial aircraft, there are many buyers and sellers. This increases liquidity and diminishes the importance of transacting parties' characteristics. Results presented in this paper are likely to be amplified in industries where used asset markets are less liquid.

Data used in this paper are based on Department of Transportation (DOT) and Federal Aviation Administration (FAA) filings assembled by Avmark Inc., an aircraft appraisal and aviation consulting firm.[7] Both the DOT and the FAA track histories of all commercial aircraft operating in the United States. They record the aircraft serial number, buyer identity, seller identity, price at which the aircraft was traded, date of trade, and whether the transaction involved a straight sale or a sale/leaseback. Additionally, they provide technical information including engine type, engine stage categorization, and aircraft age.[8]

Avmark assembled data on transactions from 1978 to 1993 for which price was disclosed. Prior to 1992, the Department of Transportation required price disclosure for all aircraft purchased or sold by U.S. corporations. Therefore, except for aircraft transactions associated with airline mergers or as part of lease agreement terminating conditions, the pre-1992 data set contains virtually all transactions that involved at least one U.S. party.[9]

After the DOT eliminated its price disclosure requirement, airlines and leasing companies generally stopped reporting transaction prices. Thus, post-

[7] Avmark obtained most of the data from Department of Transportation Forms 41B-6 and 41B-7.

[8] Stage categorization refers to engine noise output. Stage 1 aircraft are the loudest; they are restricted from operating in U.S. airspace. Stage 2 aircraft are quieter, but they too will be restricted from operating in U.S. airspace by the year 2000. All new aircraft, as well as some older aircraft such as the DC-10, comply with Stage 3 requirements. Stage 2 aircraft can be retrofitted to comply with Stage 3 requirements. For example, upgrading a Boeing 727 aircraft from Stage 2 to Stage 3 costs \$1.8 million to \$2.6 million depending on the exact aircraft model (Source: Federal Express Aviation Services).

[9] Avmark claims that their database contains all transactions that occurred from 1978 to 1991. To check completeness of the Avmark database, I assemble end-of-year fleet descriptions from airlines' 10-Ks and annual reports. Changes in reported fleet sizes between years are compared to changes implied by transactions contained in Avmark's database. Differences are small, implying that the Avmark database is fairly comprehensive. Inconsistencies that are detected generally involve military conversions or decisions to scrap older aircraft.

Table I

Summary of Aircraft Purchase and Sale Transactions

Table entries indicate the total numbers of purchases and sales of used narrow-body aircraft over the 1978–1991 time period.

Airline	Number of Used Narrow-Body Purchases	Number of Used Narrow-Body Sales
Air Florida	11	15
AIRCAL	0	3
Alaska Airlines	17	9
Aloha Airlines	0	3
America West Airlines	16	8
American Airlines	37	48
Braniff Airlines	1	55
Continental Airlines	28	15
Delta Airlines	5	50
Eastern Airlines	47	162
Frontier Airlines	6	0
Hawaiian Airlines	0	4
Midway Airlines	43	6
Muse Air	7	0
New York Air	2	0
Northwest Airlines	10	71
Ozark Airlines	12	2
Pacific Southwest	4	25
Pan Am World Airways	7	33
People Express Airlines	44	0
Piedmont Airlines	28	5
Republic Airlines	21	9
Southwest Airlines	1	0
Trans World Airlines	9	48
United Airlines	38	82
USAIR	36	26
Western Airlines	6	25
Total	436	704

1991 transactions are included in the Avmark database only when prices were voluntarily disclosed or reported in other public sources. To preclude sample selection bias, transactions that occurred after 1991 are excluded from the analyses that follow.

Analyses presented in this paper focus on purchases and sales of used narrow-body aircraft by U.S. airlines listed in Table I. Sales by other parties, primarily financial institutions, air cargo services, and foreign airlines, are used only to establish market prices. This eliminates the possibility that results are biased by uncontrolled cross-industry or cross-country effects.[10]

[10] Much of the analysis that follows relates firms' financial characteristics to their buying and selling behaviors. Because financial institutions have capital structures that are very different from airlines' capital structures, including financial institutions in the analysis would make results difficult to interpret.

Data on U.S. airlines are obtained from a number of sources. Financial data and fleet descriptions are obtained from COMPUSTAT, company 10Ks and 10Qs, and the 1978 through 1991 volumes of *Moody's Transportation Manual*. When available, quarterly data are used; otherwise annual data are collected. Airlines' operating statistics are obtained from *Air Carrier Traffic Statistics* (1978–1984 and 1985–1991). Specific dates of airline mergers and bankruptcies are obtained from the *Capital Changes Reporter*, published by Commerce Clearing House, Inc.

III. Empirical Methodology and Results

To distinguish between the null and alternative hypotheses listed in Section I, in this section I examine (A) determinants of transaction price, (B) effect of the seller's spare debt capacity on buyer identity, and (C) factors affecting airlines' purchase decisions. Empirical methodologies, results, and theoretical implications are presented.

A. Effects of Seller's Financial Characteristics and Buyer's Identity on Price

A.1. Methodology

According to the null hypothesis, buyers' and sellers' financial characteristics should not affect aircraft prices. Conversely, the alternative hypothesis predicts that price will be increasing in the seller's spare debt capacity, decreasing in the number of the seller's creditors, and increasing in the seller's valuation of the aircraft. The alternative hypothesis also predicts that observed prices will be lower when the buyer is a financial institution. One possible way to test these hypotheses would be to assemble a sample of transaction pairs with transactions matched by aircraft model, aircraft age, and the calendar-quarter in which they occurred. The only difference between transactions in a pair would be the financial condition of the seller or the identity of the buyer. Unfortunately, there are not enough transactions to employ this methodology—generating an adequate number of pairs would require excessive relaxation of the requirements that transactions within a pair be of the same model and age, and occur in the same calendar-quarter. Therefore, to determine the effects of sellers' financial characteristics and buyers' identities on transaction prices, I employ hedonic regression methodology.[11] Use of the hedonic procedure eliminates the need to match transactions. It also avoids estimation of time-varying supply and demand equations; calendar-quarter dummies included as independent variables account for temporal changes in equilibrium price.

[11] For an overview of hedonic regression models, see Berndt (1991), Chapter 4. The approach used in this paper is similar to that used by Lerner (1994) in his analysis of rigid disk drive pricing.

The hedonic regression approach requires a two-step procedure. First, hedonic prices for narrow-body aircraft are calculated using the following equation:

$$\log(\text{PRICE}) = \beta_o + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{\text{AGE}} \log(1 + \text{AGE}) + \epsilon, \quad (1)$$

where PRICE = transaction price,[12] QTR = dummy variables representing calendar-quarters, MODEL = dummy variables representing aircraft models,[13] STAGE = dummy variables representing engine stage categories, and AGE = aircraft age at time of transaction. Independent variables included in the hedonic regression are identified based on discussions with industry participants concerning important determinants of commercial aircraft prices. Logarithm of the transaction price (as opposed to simply price) is used as the dependent variable to impose a (price) nonnegativity constraint on the model.

Only narrow-body models for which at least 15 transactions occurred between 1978 and 1991 are used to estimate equation (1). This results in a total of 13 narrow-body models.[14] Although including other aircraft models would increase the sample size, it may also diminish the accuracy of the hedonic regression coefficients. Limiting aircraft models to those with more than 15 transactions mitigates this possibility. To avoid singularity, dummy variables representing the third quarter of 1991, Stage 3 aircraft, and Airbus 300B4-200 models are omitted when estimating equation (1). Therefore, e^{β_0} represents the estimated price in third quarter 1991 of an Airbus 300B4-200 that is zero years old.[15] Results from estimation of equation (1) are presented in Appendix A.

To the extent that MODEL, STAGE, and AGE control for quality differences, residuals from this estimation are independent of aircraft quality and overall market conditions. Therefore, in the second step of the hedonic pricing procedure, residuals (RES) are regressed on transaction-specific explanatory variables.

An alternative to the two-step procedure described here would be to perform only one estimation; price could be regressed on aircraft variables

[12] All prices are inflation-adjusted using the producer price index.

[13] Equation (1) is also estimated after including additional dummy variables to represent engine type. Including these dummies substantially reduces the number of degrees of freedom but only increases the adjusted R^2 from 0.762 to 0.766. Therefore, engine variant dummies are omitted from the analysis.

[14] For a list of narrow-body models included in this analysis, see model dummy variables in the hedonic regression results presented in Table A.I.

[15] Such an aircraft does not exist; Airbus stopped building 300B4-200s in the late 1980s. But if it did exist, its price would be e^{β_0}. (This example is given only to demonstrate coefficient interpretations.)

(MODEL, STAGE, AGE), time dummies, and transaction-specific explanatory variables. The disadvantage of this single-step procedure is that only data points for which second-stage independent variables exist (i.e., when the seller is a U.S. airline) can be included in the regression. The two-step procedure on the other hand uses all transactions to estimate time, model, age, and stage coefficients. This results in more accurate hedonic prices.[16]

A.2. Variables

Explanatory variables include proxies for sellers' spare debt capacities and future prospects. Also included are the number of aircraft sold in the calendar quarter and dummy variables specifying buyer identity (i.e., whether the buyer is an industry insider or outsider).

As proxies for spare debt capacity, I construct variables based on airlines' leverage and current ratios relative to industry medians in each calendar-quarter.[17] Leverage ratio is defined as book value of debt plus capitalized lease obligations divided by the sum of book value of debt, capitalized lease obligations, and book value of equity. Capitalized lease obligations are included in the leverage ratio calculation to account for the fact that, under Section 1110 of U.S. bankruptcy code, capitalized leased obligations are essentially treated as "super-senior" debt. Under Section 1110, aircraft lessors are relieved from automatic stay provisions that affect most creditors during Chapter 11 proceedings; lessors have the right to seize "collateral" 60 days after the lessee violates the lease contract. Book value of equity is used instead of market value of equity to minimize the possibility of leverage measuring economic rather than financial distress.

Because firms classified as having high leverage ratios are likely to be facing debt overhang, new investors will be reluctant to provide cash for positive NPV projects. However, the mere existence of debt overhang should not prevent firms from undertaking positive NPV projects. An airline with severe debt overhang but a large cash balance will be able to finance investment projects without accessing the external capital market. To control for this possibility, I calculate current ratio, defined as current assets divided by current liabilities. Firms with high current ratios are unlikely to be facing liquidity crises or capital constraints, regardless of leverage ratio. Only firms

[16] Unreported estimations using the single-step procedure yield results similar to those obtained using the two-step approach.

[17] A potential problem with this procedure is that by characterizing firms relative to the industry median, I may be classifying firms as having low spare debt capacities even though they (and every other firm in the industry) have high spare debt capacities. However, this is not likely to be a problem in the U.S. airline industry. Since the Airline Deregulation Act of 1978, there has been a continuous and abundant supply of highly leveraged and distressed airlines. Between January 1978 and December 1992, cumulative net income for U.S. airlines included in the COMPUSTAT database was *negative* \$3.06 billion in 1993 dollars. If anything, the approach followed in this analysis classifies low-spare-debt-capacity firms as having high spare debt capacities.

with both high leverage ratios and low current ratios are likely to be financially constrained. Based on the discussion presented in Section I, it is these firms that are most likely to sell assets at discounts to fundamental values.

The dummy variable, CAPLO, identifies firms with low spare debt capacities. It takes the value of one if the selling firm's leverage ratio is above the industry median *and* its current ratio is below the industry median in the calendar-quarter preceding the transaction. It takes the value of zero otherwise. Thus, firms with CAPLO equal to one are likely to be facing short term constraints (as indicated by current ratio) as well as substantial long-term debt obligations (as indicated by leverage ratio).

A similar variable is constructed to identify firms with relatively high spare debt capacities. CAPHI takes the value of one only if a firm's leverage ratio is below the industry median *and* its current ratio is above the industry median. Approximately 31 percent of aircraft sales included in this analysis are by firms classified as having low spare debt capacities, 25 percent by firms classified as having high spare debt capacities, and 44 percent by firms classified as having neither low nor high spare debt capacities.

To check whether the dummy variables, CAPLO and CAPHI, accurately distinguish between sales by distressed and nondistressed firms, seller identities for each transaction are examined. Of 144 transactions by firms classified as having low spare debt capacities (CAPLO = 1), 107 (74 percent) were by airlines that eventually went bankrupt (Air Florida, Continental, Eastern, Midway, Pan Am, TWA). In contrast, only 18 of the 116 (15 percent) transactions by firms classified as having high spare debt capacities eventually filed for bankruptcy court protection. Without exception, these 18 transactions occurred more than two years prior to the Chapter 11 filing date. This simple examination of the data indicates that the dummy variable categorization scheme accurately identifies distressed firms.

Creditors' dispersion is measured by the variable ISSUES which equals the number of outstanding debt issues at the end of the fiscal year preceding the transaction. If coordination of dispersed creditors is costly, then, ceteris paribus, firms with more issues outstanding should face higher debt renegotiation costs. The effect of ISSUES should be particularly significant for firms whose only alternative to liquidation is debt renegotiation. Because these are likely to be firms with low spare debt capacities (CAPLO = 1), the interaction effect between CAPLO and ISSUES is also included in the regression.

To measure effects of buyer identity on selling price, I generate two dummy variables, FIN and OTHER. FIN takes the value of one if the buyer is a financial institution or a leasing company, and zero otherwise. OTHER takes a value of one if FIN equals zero *and* the buyer is not one of the U.S. airlines listed in Table I. Thus, when OTHER equals one, the buyer is a regional airline, foreign airline, foreign government, or cargo company. Finance and leasing companies are buyers in approximately 43 percent of the transactions studied, U.S. airlines listed in Table I account for 20 percent of the purchases, and other buyers account for the remaining 37 percent.

In order to separate the effects of financial distress from effects of economic distress, three variables that measure firm prospects are included in the regression. The first variable is an estimate of Q, equal to the sum of book value of debt and market value of equity divided by the sum of book value of debt and book value of equity. As has been noted in the investment/cash flow literature, this measure of Q is flawed in that it measures average rather than marginal Q. Many authors posit that empirical findings of positive relationships between investment and cash flow are simply a manifestation of average Q's inability to measure firm prospects; that is, cash flow measures firm prospects that are not correlated with average Q (Fazzari, Hubbard, and Petersen (1988), Kaplan and Zingales (1997)). Therefore, I include two measures for firms' abilities to generate future cashflows. REV equals load factor (revenue-passenger-miles divided by available-seat-miles) times revenue per revenue-passenger-mile. This variable provides a measure of airlines' abilities to fill their planes with high-revenue passengers. The second proxy for selling firms' abilities to generate cashflows is COST, which equals cost-of-goods-sold divided by available-seat-miles. This provides a measure of airlines' cost efficiencies and may, for a given level of REV, provide a more accurate proxy for "marginal" prospects.

To determine whether market thinness contributes to asset sale discounts, the variable NSALE is computed. NSALE equals the number of narrow-body aircraft that the selling airline sold in the calendar quarter of the transaction. If market liquidity is important, we should observe a negative relationship between number of narrow-body sales in the calendar-quarter and transaction price.

Finally, I construct a price index variable, INDEX, which measures inflation-adjusted prices of narrow-body aircraft for each calendar-quarter, net of model type, and aircraft quality differences. INDEX is generated from coefficients of calendar-quarter dummies used in the hedonic regression (equation (1)). By holding quality constant (as measured by AGE, STAGE, and MODEL) and arbitrarily setting INDEX equal to 1.0 for the third quarter of 1991, the price index for quarter j can be obtained by calculating e^{β_j} where β_j is the coefficient of the quarter j dummy variable. Because the sample used in this study covers 56 calendar-quarters, INDEX takes on 1 of 56 different values in each calendar-quarter. Low values of INDEX indicate that the used aircraft market is depressed, high values indicate that it is booming.

All airlines that sold at least one of the 13 aircraft types used to estimate equation (1), and for which financial data are available, are included in the second stage of the hedonic procedure. Exceptions are liquidating trusts, Chapter 7 liquidations, and most Chapter 11 sales.[18] Although these transactions are particularly pertinent to hypotheses being tested in this paper, they are only used if financial data for the calendar-quarter before the transaction is available. Over the 1978–1991 time-period, only Braniff and East-

[18] The effect of bankruptcy court protection on asset sale discounts is studied explicitly in Pulvino (1996).

ern had significant numbers of narrow-body sales for which reliable financial data are unavailable. From 1984 to 1990, Braniff Airlines and Braniff Liquidating Trust omissions consisted of 36 transactions at an average discount of 9.0 percent (significantly different from zero at the 0.1 percent level). There are 79 Eastern Airlines sales for which accurate financial data are unavailable. These aircraft were sold at an average discount of 5.2 percent, significantly different from zero at the 5 percent level. None of Pan Am's narrow-body sales are omitted.

A.3. Results

Table II summarizes both the residual from estimation of equation (1) and the independent variables used in the cross-sectional analysis of residuals. Summaries are provided for the whole sample and also for subsamples segmented by selling firms' spare debt capacities. Table II indicates that price residual is strongly correlated with spare debt capacity. Firms classified as having low spare debt capacities sell aircraft at a 14 percent discount to hedonic price. Discounts for firms classified as having either medium or high spare debt capacities are indistinguishable from zero. The difference in discounts between these two groups and the low spare debt capacity group is significant at the 5 percent level.

Table II also shows that airlines classified as having low spare debt capacities have more debt issues outstanding, have lower levels of operating income/sales, are smaller (as measured by book value of assets), and tend to sell younger airplanes than firms classified as having medium spare debt capacities. These differences are all significant at or beyond the 5 percent level. The difference in number of outstanding issues results from correlation of leverage ratio with both number of issues outstanding and spare debt capacity. Firms with higher leverage ratios are likely to have more debt issues and, by definition, lower spare debt capacities. Similarly, differences in operating income/sales are likely driven by correlation between current ratio and both spare debt capacity and past operating income/sales.

Unlike financial variables, differences in firm size and aircraft age are not caused by the construction of variables. The result that low spare debt capacity firms sell "younger" airplanes is consistent with the alternative hypothesis. That is, sales by financially constrained firms may be driven by the need to raise cash. Even though newer aircraft cost less to operate than older aircraft, ceteris paribus, more cash is generated from the sale of a new aircraft than an old aircraft.

Neither operating statistics (load factor $\times$ revenue per revenue passenger mile and cost of goods sold divided by available seat mile) nor Q vary systematically with sellers' financial conditions. However, the percentage of sales to financial institutions is greater for firms with low spare debt capacity. Financial institutions were buyers in 54 percent of the sales by low spare debt capacity sellers compared to 29 percent for high spare debt capacity

Table II

Data Summary

This table summarizes sales of used narrow-body aircraft by selected U.S. airlines from 1978 to 1991. Price residual equals the residual from estimation of equation (1):

$$\log(\text{PRICE}) = \beta_0 + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{AGE} \log(1 + \text{AGE}) + \epsilon,$$

where PRICE equals transaction price, MODEL_i are dummy variables representing aircraft models, QTR_j are dummy variables representing calendar-quarters, STAGE_k are dummy variables representing engine stage categories, and AGE equals aircraft age at the time of the transaction. Firms classified as having low spare debt capacities have leverage ratios above the industry median and current ratios below the industry median. Firms classified as having high spare debt capacities have leverage ratios below the industry median and current ratios above the industry median. All other firms are classified as having medium spare debt capacities. Leverage ratio equals total book value of debt divided by the sum of book value of debt and book value of equity; Current ratio equals current assets divided by current liabilities; Coverage ratio equals operating income divided by interest expense where operating income equals income before depreciation, amortization, and taxes; Q equals the sum of market value of equity and book value of debt divided by the sum of book value of equity and book value of debt; Load factor equals the number of revenue-passenger-miles divided by the number of available-seat-miles; COGS equals cost of goods sold. Standard deviations are in parentheses. *t*-statistics for difference-in-means tests are presented between columns.

Variable	Complete Sample (N = 467)	Low Spare Debt Capacity Subsample (N = 144)	*t*-Statistic (difference between low and medium subsamples)	Medium Spare Debt Capacity Subsample (N = 207)	*t*-Statistic (difference between medium and high subsamples)	High Spare Debt Capacity Subsample (N = 116)
Price residual	−0.05	−0.14	3.46***	0.001	0.22	−0.01
	(0.41)	(0.35)		(0.41)		(0.45)
Leverage ratio	0.68	0.89	8.98***	0.62	5.06***	0.51
(based on book values)	(0.29)	(0.30)		(0.24)		(0.15)
Current ratio	0.89	0.70	6.37***	0.86	9.67***	1.17
	(0.31)	(0.20)		(0.27)		(0.28)
Coverage ratio	3.65	1.14	8.61***	4.37	1.64	5.49
	(4.98)	(1.52)		(5.08)		(6.27)
ln (book value of assets)	7.62	7.23	5.47***	7.84	1.26	7.71
	(1.00)	(1.14)		(0.84)		(0.92)
Number of debt	12.09	13.93	2.39*	12.16	4.31***	9.69
issues outstanding	(6.30)	(7.24)		(6.21)		(4.07)
Operating income/sales	0.07	0.03	7.94***	0.08	2.47*	0.10
	(0.06)	(0.06)		(0.05)		(0.06)
Aircraft age	14.8	13.4	3.45***	15.5	0.55	15.2
	(5.26)	(6.17)		(4.67)		(4.72)
Q	1.03	1.08	3.19**	1.01	0	1.01
	(0.19)	(0.24)		(0.13)		(0.18)
Load factor × revenue per	0.08	0.077	3.23**	0.070	5.17***	0.082
revenue-passenger-mile	(0.02)	(0.02)		(0.02)		(0.02)
COGS/available-seat-mile	0.07	0.068	0.92	0.070	0.43	0.069
	(0.02)	(0.02)		(0.02)		(0.02)
Percentage of sales	0.43	0.54	2.03*	0.43	2.54*	0.29
to financial institutions	(0.50)	(0.50)		(0.50)		(0.46)

*, **, *** Significant at 5, 1, and 0.1 percent levels, respectively.

sellers. The difference between these percentages is significant at the 0.1 percent level.

$$\text{RES} = \beta_0 + \beta_1\text{CAPLO} + \beta_2\text{CAPHI} + \beta_3\text{ISSUE} + \beta_4(\text{CAPLO} \times \text{ISSUE}) + \beta_5\text{FIN} + \beta_6\text{OTHER} + \beta_7\text{Q} + \beta_8\text{REV} + \beta_9\text{COST} + \beta_{10}\text{NSALE} + \epsilon. \tag{2}$$

Equation (2) is used to assess effects of sellers' spare debt capacities and firm prospects on price residuals from the hedonic regression (RES). The typical assumption used to make statistical inferences based on regressions like that specified in equation (2) is that error terms are independently and identically distributed. In this sample of used aircraft transactions, the independence assumption may be problematic. Prices obtained for different aircraft sold by the same airline in the same calendar quarter are likely to be correlated. Furthermore, for an airline executing a fleet liquidation over time, serial correlation in error terms is likely. Although ignoring this problem would not bias coefficient estimates, it would cause errors in estimates of standard errors. Therefore, in addition to presenting OLS standard errors, I present "pseudo-Newey–West" standard errors developed by Conley (1996). These standard errors account for correlation between observations by weighting the coefficient covariance matrix according to similarities between transactions. For example, in a simple time-series setting, correlation between two observations is assumed to be greatest when the observations are close in time. Newey–West covariance matrix weighting factors are close to one for transactions that occur close in time and decrease to zero for transactions that are distant in time. In the cross-section/time-series setting of this paper, transactions that have the same seller, buyer, date, and aircraft model are assumed to be close in terms of "economic distance." These transactions are assigned a covariance weighting factor of one. Observations that are separated by greater economic distances are assigned lower weighting factors. Detailed descriptions of weighting factors and standard error calculations are included in Appendix B. Here I will simply point out that assumptions used to calculate standard errors are intentionally conservative—true standard errors are likely to lie somewhere between OLS standard errors and Conley (1996) standard errors. For this reason, both are presented in subsequent tables.

Results from estimating equation (2) are presented in Table III. After controlling for firm prospects, firms classified as having low spare debt capacities (CAPLO = 1) sell aircraft at 13 percent discounts compared to firms classified as having neither low nor high spare debt capacities.[19] This effect

[19] Because the dependent variable, RES, equals the logarithm of the ratio of price to hedonic price, discounts are calculated by taking the absolute value of one minus the exponent of the coefficient. For example, the discount associated with having low spare debt capacity equals $|1 - \exp(\beta_1)|$.

Table III

OLS Regressions of the Determinants of Sale Price

This table presents OLS regressions relating narrow-body transaction prices to selling airlines' financial characteristics for 467 aircraft transactions. The dependent variable is the residual from the hedonic regression (equation (1)):

$$\log(\text{PRICE}) = \beta_0 + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{\text{AGE}} \log(1 + \text{AGE}) + \epsilon,$$

where PRICE equals transaction price, MODEL_i are dummy variables representing aircraft models, QTR_j are dummy variables representing calendar-quarters, STAGE_k are dummy variables representing engine stage categories, and AGE equals aircraft age at the time of the transaction. Panel A presents results using the entire sample, Panel B presents results using the subsample of transactions that occurred when the INDEX of used aircraft prices was in the lowest quartile, and Panel C presents results using the subsample of transactions that occurred when the INDEX of used aircraft prices was in the highest quartile. INDEX is calculated by exponentiating calendar-quarter dummy coefficients; CAPLO is a dummy variable equal to 1 if the selling airline's leverage ratio was above the industry median and its current ratio was below the industry median in the calendar-quarter preceding the transaction; CAPHI is a dummy variable equal to 1 if the selling airline's leverage ratio was below the industry median and its current ratio was above the industry median in the preceding quarter; ISS equals the number of debt issues outstanding in the calendar-quarter preceding the transaction; FIN is a dummy variable equal to 1 if the buyer is a financial or leasing company; OTHER is a dummy variable equal to 1 if the buyer is not a financial institution, leasing company, or large U.S. airline; Q equals market value of equity plus book value of debt divided by book value of equity plus book value of debt; REV equals load factor (equal to revenue-passenger-miles divided by available-seat-miles) times revenue per revenue-passenger-mile; COST equals cost-of-goods-sold divided by available-seat-miles; NSALE equals the number of narrow-body sales by the selling airline in the calendar-quarter of the transaction. Results are relative to transactions where the seller has medium spare debt capacity and the buyer is a major U.S. airline. Both OLS and Conley (1996) standard errors are presented in parentheses (OLS standard errors are first). The Conley (1996) procedure corrects for correlation of observations based on proximity in economic distance.

Dependent Variable: Hedonic Regression Residual											
CAPLO	CAPHI	ISS	CAPLO × ISS	FIN	OTHER	Q	REV	COST	NSALE	Const.	Adj R^2
Panel A: Entire Sample (N = 467)											
−0.15	−0.04					0.15	4.77	−8.62	−0.004	0.09	0.06
(0.044/0.073)*	(0.046/0.088)					(0.101/0.137)	(2.57/3.84)	(2.63/5.64)	(0.006/0.011)	(0.128/0.170)	
−0.15	−0.04			−0.13	−0.06	0.13	3.68	7.02	−0.01	0.17	0.07
(0.044/0.073)*	(0.047/0.084)			(0.052/0.089)	(0.054/0.100)	(0.102/0.134)	(2.63/3.92)	(2.72/5.85)	(0.006/0.013)	(0.133/0.172)	
0.15	−0.03	−0.003	−0.02	−0.11	−0.06	−0.03	2.22	−4.32	−0.002	0.27	0.11
(0.093/0.142)	(0.047/0.079)	(0.004/0.008)	(0.006/0.010)*	(0.051/0.076)	(0.053/0.093)	(0.106/0.106)	(2.62/3.78)	(2.83/5.35)	(0.006/0.010)	(0.138/0.207)	
Panel B: Low INDEX Quartile (N = 168)											
−0.15	0.01					0.59	3.27	−11.54	−0.04	0.10	0.11
(0.105/0.135)	(0.011/0.179)					(0.267/0.305)	(7.68/8.70)	(6.74/7.80)	(0.016/0.021)	(0.438/0.477)	
−0.07	0.01			−0.37	−0.23	0.53	−1.55	−4.62	−0.05	0.30	0.16
(0.108/0.109)	(0.109/0.148)			(0.113/0.124)**	(0.114/0.205)	(0.262/0.282)	(7.63/9.28)	(6.90/8.32)	(0.015/0.019)*	(0.432/0.519)	
0.76	−0.09	0.008	−0.05	−0.35	−0.27	−0.02	11.28	−6.21	−0.02	−0.29	0.21
(0.267/0.221)***	(0.119/0.134)	(0.009/0.008)	(0.015/0.012)***	(0.117/0.096)**	(0.111/0.179)	(0.300/0.283)	(8.32/9.11)	(6.71/7.38)	(0.017/0.019)	(0.452/0.486)	
Panel C: High INDEX Quartile (N = 104)											
−0.01	0.08					−0.17	−2.42	1.27	−0.02	0.31	0.00
(0.092/0.094)	(0.078/0.164)					(0.484/0.543)	(5.20/5.90)	(6.32/8.47)	(0.024/0.025)	(0.459/0.566)	
−0.01	0.06			0.04	0.09	−0.07	−0.95	−0.29	−0.02	0.15	—
(0.096/0.086)	(0.084/0.166)			(0.109/0.096)	(0.098/0.091)	(0.500/0.500)	(5.61/5.47)	(6.79/7.86)	(0.027/0.027)	(0.494/0.544)	0.01
−0.56	0.02	−0.05	0.06	0.14	0.13	−0.69	−3.72	6.14	0.004	0.91	0.21
(0.235/0.414)	(0.074/0.122)	(0.010/0.020)*	(0.018/0.031)	(0.010/0.113)	(0.090/0.082)	(0.465/0.505)	(5.20/5.99)	(6.24/7.31)	(0.025/0.026)	(0.465/0.523)	

*, **, *** Significant at 5, 1, and 0.1 percent levels, respectively.

is significant at the 5 percent level when Conley (1996) standard errors are used and even higher when OLS standard errors are used. The discount is similar in magnitude to those suggested by Shleifer and Vishny (1992) for hurried asset sales.[20] Comparable results are obtained when the sample is limited to industry recessions (Panel B). However, reducing the sample size increases the standard error and reduces statistical significance. Furthermore, when buyer identity is included in the regression, the CAPLO coefficient is reduced. As discussed below, this is probably caused by the propensity of financially distressed firms to sell to financial institutions during market downturns. Thus, it is difficult to disentangle the effect of capital constraints on price from the effect of buyer identity on price. Discounts associated with financial distress are substantially reduced when the used aircraft market is booming (Panel C).

As an alternative to using the dichotomous variables CAPLO and CAPHI to classify firms' levels of financial distress, continuous variables are also considered. Coverage ratio, equal to operating income divided by interest expense, is a commonly suggested proxy for financial distress. However, there are two problems with using coverage ratio. First, especially during market recessions, operating incomes are often negative. Assessing relative degrees of financial distress for firms with negative coverage ratios is difficult. For example, very distressed firms (those with high interest expense and modestly negative operating income) have coverage ratios similar to those of moderately distressed firms (those with low interest expense and slightly negative operating income). This is particularly problematic during severe market recessions when even the median industry coverage ratio is negative. The second problem with using coverage ratio to proxy for financial distress is that, because operating income is in the numerator, coverage ratio may also proxy for economic distress. Nevertheless, using coverage ratio yields results similar to those obtained using the previously described dichotomous variables. Aircraft sold by airlines with low coverage ratios are sold at a 15 percent discount; those sold by airlines with medium coverage ratios are sold at a 4 percent discount, and those sold by airlines with high coverage ratios are sold at a 5 percent premium. Differences in these discounts are significant at the 5 percent level.[21]

Interaction effects shown in Table III indicate that, for firms classified as having low spare debt capacities, the number of debt issues outstanding is negatively correlated with transaction price. Summing the ISSUES and interaction term coefficients in the third specification of Panel A implies that a one standard deviation increase in the number of debt issues outstanding reduces price by 15 percent. This effect is more pronounced when the used

[20] For example, Shleifer and Vishny (1992) cite real estate appraisers' estimates that rapid real estate sales lead to price discounts of 15 to 25 percent relative to orderly sales (p. 1358).

[21] Low-coverage ratio transactions correspond to the 100 transactions with the lowest coverage ratios. High-coverage ratio transactions correspond to the 100 transactions with the highest coverage ratios.

aircraft market is depressed (Panel B) and nonexistent when the market is booming.

According to the null hypothesis, price should be independent of buyer identity. The alternative hypothesis predicts that price will be lower when the buyer is an outsider. This will be particularly true during market recessions when industry insiders are most likely to be financially constrained. Table III shows that sales to financial institutions and leasing companies result in an average price discount of 10 percent when the entire sample is used. This discount is statistically significant based on OLS standard errors but only marginally significant when Conley (1996) standard errors are used to make inferences. When the sample is limited to time periods when the market is depressed, the discount associated with selling to a financial institution increases to 30 percent, significant at the 1 percent level. When the market is booming, the discount disappears. Although a 30 percent discount is substantial, it is not inconsistent with rates of return required by speculators. The cost of capital is the primary cost associated with speculating in used aircraft. Mothballing costs are typically less than $1000 per month and transporting an aircraft to a storage location (usually the desert) costs $10,000 to $20,000.[22] Thus, assuming a $6 million purchase price and a 15 percent discount rate, speculators would have to "place" the aircraft within 1.85 years in order to break even. If a 25 percent discount rate is assumed, break-even placement time is reduced to 1.16 years. At first glance this may seem like ample time in which to find a buyer for the aircraft. However, the time between recessions and peaks in the airline industry has historically averaged 4 or 5 years. Industry participants indicate that it is not uncommon for aircraft to be mothballed for one or more years before being placed, particularly during market downturns. Thus, the 30 percent discount is not unreasonable compensation for assuming the risk of placing the aircraft.

In addition to buyer identity, the number of sales in a calendar-quarter appears to have a negative impact on price. During depressed times, price is reduced by 2 to 5 percent for each additional aircraft sold in the quarter. This provides evidence that the market for used aircraft is indeed illiquid, especially during industry recessions.

A final implication of the alternative hypothesis is that firm prospects should be positively correlated with prices received by sellers, especially during market downturns. Results from Table III indicate that when the market is depressed, firm prospect coefficients are of expected signs but are not precisely estimated. For example, transaction price is increasing in the seller's Q, implying that firms with better prospects receive higher prices when selling used aircraft. Similarly, the coefficient multiplying REV, which measures the degree to which airlines fill their planes with high-revenue pas-

[22] Because mothballing costs are so low, it is not uncommon for airlines to store unused aircraft in the desert. During the market recession in the early 1990s, airlines flew brand new planes from the manufacturing facility to the desert. Doing so was apparently cheaper than selling the aircraft at severe discounts.

sengers, is positive. The coefficient multiplying COST, which measures airlines' cost efficiencies is generally negative, but again not statistically significant. Consistent with the alternative hypothesis, firm prospect coefficients are less significant (both economically and statistically) when the sample is limited to time periods when the market is booming.

An alternative explanation for observed discounts is that the hedonic regression may not accurately control for aircraft age. Specifically, the effect of aircraft age on transaction price may change with market conditions. To the degree that the premium associated with selling a younger plane falls during recessions, residuals from the hedonic regression specified in equation (1) may cause one to incorrectly conclude that younger planes are sold at a discount. Because financially constrained airlines sell younger planes, a spurious correlation may be driving the conclusion that financially constrained airlines liquidate their aircraft at discounts. To determine whether this explanation is driving the results, analyses are performed using a different hedonic specification. Rather than restricting the coefficient of the age variable to be constant throughout the sample, it is allowed to take different values in each calendar-quarter, thus allowing the age premium to vary with changing market conditions. Results from this analysis indicate that misspecification of the age effect is not driving the results. The hedonic regression adjusted R^2 increases from 0.762 to 0.786 and results from the second stage analyses are virtually identical to those presented.

Overall, results presented in this section indicate that sellers' financial conditions affect liquidation prices, but only when competition for assets is weak. This is consistent with the alternative hypothesis; when competitors are financially constrained, firms with low spare debt capacities liquidate assets at discounts to fundamental value.

B. Effect of Seller's Capital Constraints on Buyer Identity

B.1. Methodology

According to the null hypothesis ($H_0 4$), the seller's financial condition should not be a determinant of buyer identity. Conversely, the alternative hypothesis predicts that the likelihood of selling to a financial institution is greater for a financially constrained seller than for an unconstrained seller. To test this hypothesis, the following probit model is used to calculate the probability of selling to a financial institution:

$$\begin{aligned} \text{FIN} = \beta_0 &+ \beta_1 \text{CAPLO} + \beta_2 \text{CAPHI} + \beta_3 Q + \beta_4 \text{REV} + \beta_5 \text{COST} \\ &+ \beta_6 \text{NSALE} + \beta_7 \tau_{\text{industry}} + \epsilon. \end{aligned} \tag{3}$$

The dependent variable (FIN) in equation (3) takes the value of one if the buyer is a financial institution and zero otherwise. Independent variables are the same as those used in the transaction price regressions. The only exception is τ_{industry} which equals the weighted average of U.S. airlines' marginal tax rates using firm values as weights. Industry tax rate is included to control for the possibility that airlines are more likely to sell aircraft to buyers that get the greatest benefit from depreciation tax shields. If other airlines have low marginal tax rates, profitable financial institutions that can make use of depreciation tax shields may be the highest-value users of commercial aircraft. When available, marginal tax rates are obtained from Graham (1996a, 1996b). For missing values, a marginal tax rate of 0.46 is assumed if the transaction occurred before 1986 and the airline's before-tax income was positive. After 1986, a marginal tax rate of 0.34 is assumed. Marginal tax rates of zero are assumed for airlines for which Graham tax rates are unavailable and before-tax income was negative.

Regression coefficients in equation (3) represent effects of the independent variables on the probability that the buyer is a financial institution. Equation (3) is estimated using the entire sample, and also after segmenting the sample by INDEX. According to the alternative hypothesis, β_1 should be greater than β_2. The magnitude of the difference between these coefficients should be greatest when the industry is depressed (i.e., when INDEX is low). Because airlines' marginal tax rates are likely to be lowest during market recessions, the coefficient on the airline industry's tax rate should be particularly negative during market downturns.

As with the price regression results, the standard assumption that transactions are independent may be problematic. Therefore, standard errors are estimated under the assumption that observations are independent across airlines—no assumption is made regarding independence within airlines.

B.2. Results

Results from estimating equation (3) are presented in Table IV. Panel A contains results from the estimation when the entire sample is used. Estimates of the CAPLO and CAPHI coefficients indicate that financially constrained sellers are more likely than unconstrained sellers to sell to financial institutions. However, neither coefficient is significantly different from zero. This is not the case when the sample is limited to time periods when the used aircraft market is depressed. Evaluated at the means of independent variables, going from high spare debt capacity to low spare debt capacity increases the probability of selling to a financial institution by 0.35 (from 0.14 to 0.49). A likelihood ratio test of the null hypothesis that this increase in probability equals zero rejects it at the 1 percent level.

Coefficients of other independent variables suggest that, consistent with the alternative hypothesis, economically distressed firms are also more likely to sell to financial institutions. These effects are particularly strong during market recessions. As Q increases, the probability of selling to an industry outsider decreases. Furthermore, firms that have a greater ability to fill their planes with high revenue passengers are less likely to sell to financial institutions. High cost airlines are more likely to sell to financial institutions. The effect of cost structure is significant at the 5 percent level, except

Table IV

Estimates of the Probability of Selling to a Financial Institution

This table presents probit analyses used to determine whether distressed sellers are more likely to sell to financial institutions. The dependent variable is a dummy variable that takes the value of one if the buyer is a financial institution (i.e., bank or leasing company) and zero otherwise. Panel A presents results using the entire sample, Panel B presents results using the subsample of transactions that occurred when the INDEX of used aircraft prices was in the lowest quartile, and Panel C presents results using the subsample of transactions that occurred when the INDEX of used aircraft prices was in the highest quartile. INDEX is calculated by exponentiating calendar-quarter dummy coefficients in the hedonic pricing model described in equation (1):

$$\log(\text{PRICE}) = \beta_0 + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{\text{AGE}} \log(1 + \text{AGE}) + \epsilon,$$

where PRICE equals transaction price, MODEL_i are dummy variables representing aircraft models, QTR_j are dummy variables representing calendar-quarters, STAGE_k are dummy variables representing engine stage categories, and AGE equals aircraft age at the time of the transaction. CAPLO is a dummy variable equal to 1 if the selling airline had a leverage ratio above the industry median and a current ratio below the industry median in the calendar-quarter preceding the transaction; CAPHI is a dummy variable equal to 1 if the airline had a leverage ratio below the industry median and a current ratio above the industry median in the preceding quarter; Q equals market value of equity plus book value of debt divided by book value of equity plus book value of debt; REV equals load factor (revenue-passenger-miles divided by available-seat-miles) times revenue per revenue-passenger-mile; COST equals cost-of-goods-sold divided by available-seat-miles; NSALE equals the number of narrow-body sales by the selling airline in the calendar-quarter of the transaction; τ_{industry} is the weighted average of U.S. airlines' marginal tax rates using firm values as weights. Standard errors are in parentheses and are calculated under the assumption that transactions between airlines are independent. No assumption is made regarding independence of transactions within airlines.

Dependent Variable = 1 if Buyer is a Financial Institution, 0 Otherwise								
CAPLO	CAPHI	Q	REV	COST	NSALE	τ_{industry}	Constant	Pseudo R^2
Panel A: Complete Sample (N = 467)								
0.44 (0.335)	−0.34 (0.362)	−1.45 (0.852)	−16.39 (14.26)	31.26* (13.25)	−0.01 (0.067)		0.45 (1.01)	0.08
0.42 (0.335)	−0.32 (0.381)	−1.44 (0.857)	−14.88 (13.99)	28.75 (14.77)	−0.01 (0.067)	−0.62 (1.69)	0.68 (1.13)	0.08
Panel B: Low INDEX Quartile (N = 168)								
1.16 (0.429)**	0.11 (0.553)	−0.98 (1.35)	−46.4 (33.40)	54.94 (27.78)*	−0.09 (0.085)		0.66 (2.07)	0.14
1.16 (0.426)**	0.11 (0.555)	−0.97 (1.35)	−47.36 (31.33)	56.53 (27.45)*	−0.10 (0.085)	0.32 (3.05)	0.52 (2.49)	0.14
Panel C: High INDEX Quartile (N = 104)								
0.80 (0.510)	0.44 (0.404)	3.23 (1.86)	−25.31 (27.52)	36.55 (34.62)	−0.30 (0.090)***		−3.31 (1.62)*	0.19
0.94 (0.486)	0.87 (0.410)*	5.31 (2.32)*	2.94 (30.84)	−6.65 (42.38)	−0.31 (0.090)***	−5.01 (2.09)*	−3.25 (1.64)*	0.23

*, **, *** Significant at 5, 1, and 0.1 percent levels, respectively.

when the market is booming. Neither the number of aircraft sales by a given airline in a calendar-quarter nor the industry tax rate significantly affect the probability of selling to a financial institution. These results support the alternative hypothesis—financially constrained airlines are more likely to sell to industry outsiders, especially during industry recessions.

C. Effect of Capital Constraints on U.S. Airlines' Decisions to Buy

C.1. Methodology

A final empirical implication associated with the alternative hypothesis is that used aircraft purchases will be limited to airlines that are not financially constrained. Conversely, the null hypothesis predicts that firms' financial conditions will not influence asset acquisition decisions—only expected cash flows matter. To distinguish between these hypotheses, I analyze the relationship between the number of used aircraft purchases per calendar-quarter and proxies for the cost of raising capital. I also analyze how this relationship changes with the state of the used aircraft market. If capital constraints cause aircraft to sell for prices below fundamental value during market recessions, spare debt capacity should have a significant effect on the number of aircraft purchases when prices decline.

The dependent variable in this analysis is a count variable that equals the number of used narrow-body aircraft purchased in a firm-quarter. Firms' financial characteristics, as well as the state of the used aircraft market, are treated as exogenous independent variables. To avoid simultaneity bias, all independent variables are lagged one period.

Because the dependent variable is a "count" variable with many observations equal to zero, I assume a Poisson model for aircraft purchases. Unlike OLS, this specification is particularly well suited to modeling nonnegative integers.[23] In this paper, I follow the methodology pioneered by Hausman, Hall, and Griliches (1984) in their study of the effects of R&D expenditure on the number of patents produced. Following their approach, the expected number of purchases by firm i during quarter t, $\mathrm{E}(n_{it})$, equals the Poisson parameter, λ_{it}. Because the expected number of used aircraft purchases, λ_{it}, must be nonnegative, I assume the following exponential form:

$$\lambda_{it} = \mathrm{e}^{X_{it-1}\beta}, \tag{4}$$

where X_{it-1} is a matrix of explanatory variables.

A potential problem with the Poisson specification is the implicit assumption that the mean and variance of the dependent variable are equal. Indeed, estimations using aircraft purchase data indicate that the variance of the number of purchases is more than five times greater than the mean.

[23] The Poisson specification has been used extensively to model count variables. For example, Rose (1990) uses an unmodified Poisson distribution to study the effect of airlines' financial conditions on the number of accidents.

This ratio is significantly different from one beyond the 0.1 percent level. To correct for this "overdispersion" I employ a maximum likelihood procedure with a negative binomial probability density function developed by Hausman et al. (1984).[24] A description of this procedure is provided in Appendix C.[25]

A sample of 1027 firm-quarters for the period 1978 to 1991 is assembled to estimate the negative binomial model. Because of entry, exit, mergers, and missing data, many airlines are not represented throughout the entire 1978–1991 time-period. Aircraft transactions resulting from mergers are excluded from analyses presented in this section. Each data point includes the number of used aircraft purchased per quarter, as well as financial variables and firm-prospect proxies used in the second stage of the hedonic price analysis. Additionally, two variables that characterize airlines' fleets are included. DELIV equals the number of new deliveries in the previous fiscal quarter divided by the number of narrow-bodies owned. This variable is included to control for the effect of new aircraft deliveries on used aircraft demand. To the degree that used purchases are substitutes for new purchases, we would expect the coefficient of DELIV to be negative. The second "fleet" variable is the logarithm of the number of narrow-bodies owned, log(OWN), at the end of the previous fiscal quarter. This variable is included to control for size effects—airlines with larger fleets may be more frequent purchasers of narrow-body aircraft.

Based on the null hypothesis that airlines' financial conditions do not affect aircraft acquisition and liquidation decisions, financial variables (CAPLO and CAPHI) should not affect the likelihood of purchasing used narrow-body aircraft. According to the alternative hypothesis, purchasing activity should be dominated by buyers with high spare debt capacities, especially during market recessions. To test these hypotheses, I analyze numbers of purchases after segmenting the data by INDEX, where INDEX measures relative levels of used aircraft prices over time.

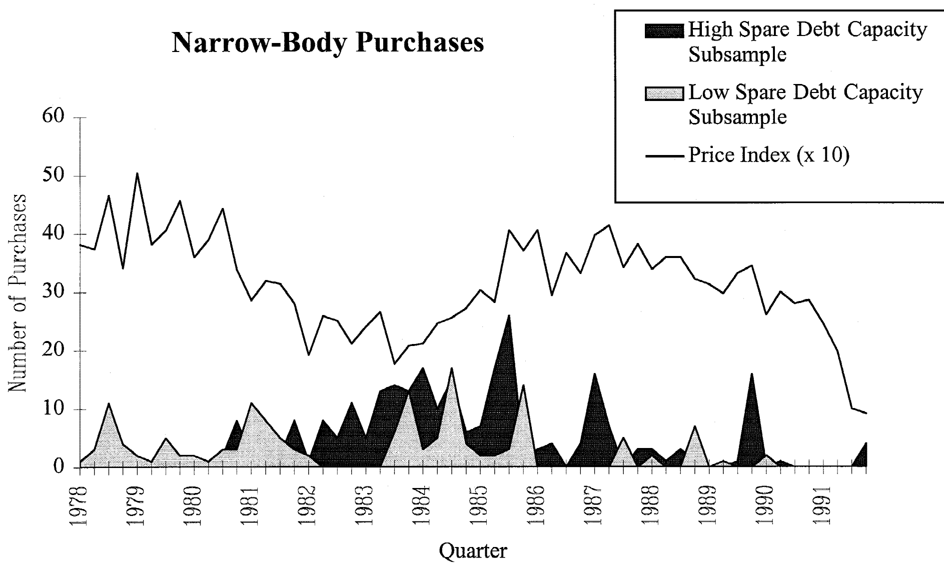
C.2. Results

Figure 1, Panel A, shows the number of aircraft purchases by low and high spare debt capacity airlines from 1978 through 1991. During the market boom in the late 1970s and very early 1980s, used aircraft purchases were limited to low spare debt capacity firms. However, during the market de-

[24] Although the negative-binomial model allows for differences between the dependent variable's mean and variance, it assumes independence of the observations. To test whether observations are indeed independent, I perform a test for serial correlation of the error terms by regressing residuals on lagged residuals. When using the entire sample, weak evidence of serial correlation is detected; lagged residuals are significant at the 10 percent level. However, after segmenting the data by INDEX (the analyses of interest in this section) the coefficient of the lagged residual term is insignificantly different from zero.

[25] In addition to the negative binomial maximum likelihood procedure, I also analyze airlines' purchasing behavior using an OLS specification. Results are robust to changes in specification.

Panel A: Effects of Spare Debt Capacity and Prices on Narrow-Body Purchases



Panel B: Effects of Spare Debt Capacity and Prices on Net Narrow-Body Purchases

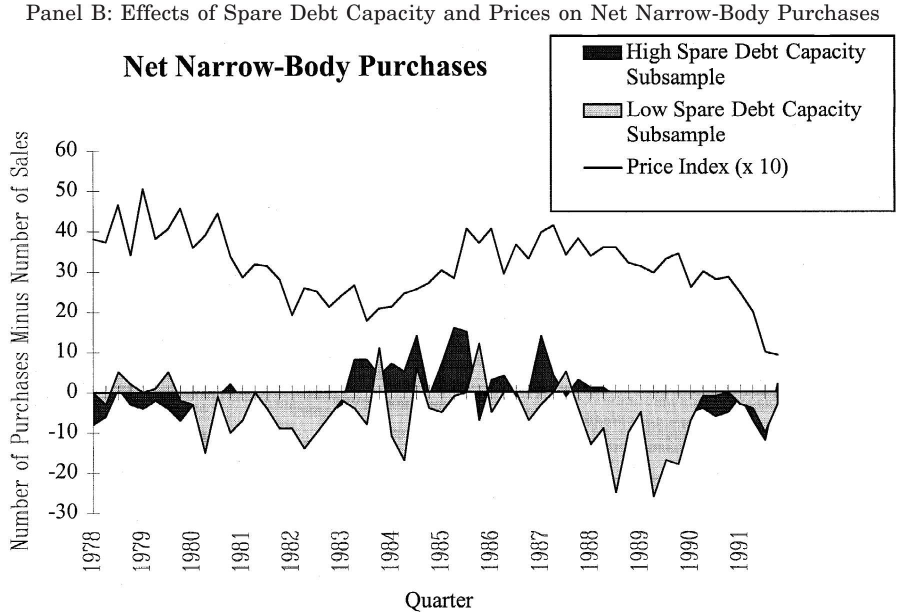


Figure 1. Aircraft acquisition and liquidation summaries for firms with both low and high spare debt capacities. Firm-quarters are segmented based on the quotient of current ratio and leverage ratio. Current ratio equals current assets divided by current liabilities; leverage ratio equals book value of debt divided by book value of debt plus book value of equity. Firm-quarters whose quotient is less than the calendar-quarter's industry median are placed in the low spare debt capacity subsample. Other firm-quarters are placed in the high spare debt capacity subsample. This classification procedure ensures that the two groups have roughly equal numbers of firms.

pression between 1981 and 1985, airlines with high spare debt capacities greatly increased their buying activity; a much smaller increase in buying activity was observed for low spare debt capacity firms. When the market turned around in 1986, high spare debt capacity firms curtailed their buying activity.

Used narrow-body net-purchases (used narrow-body purchases minus sales) are shown in Figure 1, Panel B. This figure confirms that high spare debt capacity airlines tend to be net purchasers during market depressions and net sellers during market booms. This pattern is not observed for low spare debt capacity airlines.

Results from the negative binomial maximum likelihood procedure are presented in Table V. Results using the complete sample indicate that after controlling for firm prospects and fleet characteristics, airlines' spare debt capacities significantly affect the number of used aircraft purchased. For example, airlines classified as having low spare debt capacities purchased 34 percent ($1 - e^{(-0.41)}$) fewer aircraft per calendar-quarter than airlines classified as having neither low nor high spare debt capacities. Conversely, airlines classified as having high spare debt capacities purchased 51 percent ($e^{(0.41)} - 1$) more aircraft per calendar-quarter.

When the sample is limited to time periods corresponding to market recessions (INDEX in the lowest quartile), the effect of CAPHI is strong and statistically significant. Holding firm prospects and fleet characteristics constant, firms classified as having high spare debt capacities purchased 192 percent ($e^{(1.07)} - 1$) more used aircraft per calendar-quarter than firms classified as having neither high nor low spare debt capacities. This coefficient is significant at the 1 percent level. When price index is in the highest quartile, the coefficient of CAPHI is reduced from 1.05 to 0.05 and is no longer statistically significant.

Marginal tax rate is also a significant determinant of the number of used narrow-body purchases in a calendar-quarter. Especially when the market is depressed, the number of used narrow-body purchases is increasing in buyer's marginal tax rate. This supports the theory that airlines that are able to benefit from the depreciation tax shield are more likely to buy aircraft. Regardless of the level of the price index, proxies for firm prospects do not have significant effects on airlines' used aircraft purchases. These findings are consistent with the alternative hypothesis: During industry downturns, assets are redeployed to financially unconstrained buyers—not necessarily buyers with the highest fundamental valuations.

D. Summary of Findings

Results presented in this section indicate:

1. Airlines with high leverage ratios and low current ratios receive lower prices for their aircraft than more conservatively financed rivals.
2. For sellers with low spare debt capacities, price is negatively related to the number of outstanding debt issues.

Table V

Maximum Likelihood Estimates for Timing of Used Narrow-Body Purchases

Maximum likelihood estimates presented in this table are based on a Poisson specification with an adjustment to allow for differences between the distribution's mean and variance. The estimated Variance/Mean ratio equals $(1 + \delta)/\delta$. The dependent variable is the number of used narrow-body aircraft purchased in a calendar-quarter. INDEX is calculated by exponentiating calendar-quarter dummy coefficients in the hedonic pricing model described in equation (1):

$$\log(\text{PRICE}) = \beta_0 + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{\text{AGE}} \log(1 + \text{AGE}) + \epsilon,$$

where PRICE equals transaction price, MODEL_i are dummy variables representing aircraft models, QTR_j are dummy variables representing calendar-quarters, STAGE_k are dummy variables representing engine stage categories, and AGE equals aircraft age at the time of the transaction. High values of INDEX correspond to calendar-quarters where prices are relatively high (in the sample's highest quartile). Low values of INDEX correspond to calendar-quarters where prices are low (in the lowest quartile). CAPLO is a dummy variable equal to 1 if the selling airline had a leverage ratio above the industry median and a current ratio below the industry median in the calendar-quarter preceding the transaction; CAPHI is a dummy variable equal to one if the airline had a leverage ratio below the industry median and a current ratio above the industry median in the preceding quarter; Q equals market value of equity plus book value of debt divided by book value of equity plus book value of debt; REV equals load factor (revenue-passenger-miles divided by available-seat-miles) times revenue per revenue-passenger-mile; COST equals cost-of-goods-sold divided by available-seat-miles; τ equals the buyer's marginal tax rate; DELIV equals number of new aircraft deliveries in the current quarter; OWN equals the number of narrow-bodies owned by the airline at the end of the previous quarter. Standard errors are in parentheses.

Dependent Variable = Number of Used Narrow-Body PURCHASES per Firm-Quarter										
Model	CAPLO	CAPHI	Q	REV	COST	τ	DELIV	log(OWN)	Const.	log(δ)
Complete Sample	−0.41	0.41	−0.02	−13.98	13.16	1.27	−0.07	−0.15	−1.96	−1.53
(N = 1027)	(0.238)	(0.188)*	(0.013)	(7.95)	(8.83)	(0.578)*	(0.045)	(0.079)	(0.516)***	(0.167)***
Low INDEX Quartile	0.27	1.07	0.10	−7.18	−8.22	2.84	0.01	0.06	−2.96	−1.71
(N = 293)	(0.510)	(0.377)**	(0.074)	(16.04)	(17.00)	(1.04)**	(0.060)	(0.192)	(1.33)*	(0.300)***
High INDEX Quartile	−0.40	0.05	0.01	−19.8	28.0	0.86	−0.09	−0.11	−2.18	−1.35
(N = 272)	(0.417)	(0.367)	(0.018)	(17.76)	(20.82)	(1.21)	(0.088)	(0.163)	(1.06)*	(0.313)***

*, **, *** Significant at 5, 1, and 0.1 percent levels, respectively.

3. Prices are lower when buyers are industry outsiders, primarily when the used aircraft market is depressed.
4. Firms with low spare debt capacities are more likely to sell to well-financed industry outsiders, especially when the used aircraft market is depressed.
5. Airlines with high spare debt capacities are more likely to buy aircraft than those with low spare debt capacities, especially when aircraft prices are depressed.

IV. Alternative Explanation

An alternative explanation for the observed effects of airlines' financial characteristics on price is that financially constrained airlines sell aircraft of lower quality during market depressions. Although the FAA enforces maintenance requirements, airlines are nevertheless able to choose which aircraft in their fleets to sell. To reduce maintenance expenses, financially constrained airlines may choose to sell aircraft that have little time remaining until the next maintenance overhaul. If this is the case, we would expect to see lower transaction prices for financially constrained sellers simply because of quality differences and not because of costs of overcoming capital market imperfections.[26] This explanation is consistent with Rose's (1990) result that financial health is positively correlated with airline safety. However, it can neither explain the observed relationship between airlines' spare debt capacities and levels of used aircraft purchases nor the effect of sellers' financial conditions on buyers' identities.

To control for aircraft quality differences, one would need information describing the time until next airframe overhaul, the number of hours on the engines, and compliance with FAA Airworthiness Directives for each aircraft at the time of the transaction.[27] Unfortunately, these data are generally unavailable. Aircraft maintenance records are transferred to aircraft buyers; duplicates are maintained neither by the selling airline nor by the FAA. Thus, the only large-sample data available to control for quality have already been included in the hedonic regression, namely STAGE and AGE. However, quality data are available for a small subsample of Braniff sales that occurred in April 1984 when that airline was operating under bankruptcy court protection. Braniff sold eleven 727-200 ADV aircraft to People Express, which financed the purchase by issuing secured debt. Included in

[26] In extreme cases, financially constrained airlines may fail to properly maintain their aircraft. For example, in an attempt to reduce maintenance expenditures, Eastern Airlines falsified maintenance records on components such as landing gears, wing flaps, and fuel filters. They were eventually found guilty and fined $3.5 million.

[27] As the FAA becomes more knowledgeable about causes of aircraft failures, they require revisions to air carriers' maintenance plans. These revisions are called "airworthiness directives." For example, in response to the failure of the upper section of an Aloha Airlines 737 fuselage, the FAA implemented a corrosion prevention program that requires more frequent checks for airframe deterioration.

the prospectus for this secured debt issue are appraised values for each of the eleven Braniff aircraft. Appraised values, which were generated by Avmark, Inc., an independent aircraft appraisal firm, account for variability in aircraft quality. Based on Avmark's appraisals, Braniff sold the eleven 727-200 ADVs for an average discount of 32.6 percent. This discount is in excess of the cost of refurbishment incurred by People Express. The estimated discount obtained using the hedonic regression methodology is 25 percent. Therefore, based on this small subsample of aircraft, taking quality variation into account would actually increase previously reported discounts.

Even though detailed aircraft quality data are not available in large sample, a test of the hypothesis that quality effects drive discounts at which airlines sell used aircraft can be performed by repeating the price discount analysis using sale/leaseback agreements.[28] In a typical sale/leaseback agreement, an airline sells an aircraft to an investor and immediately leases the aircraft back from the investor. The yield that the investor receives from a sale/leaseback transaction depends on both the up-front payment (the sale/leaseback price) and the magnitude of contracted lease payments. Because contracted lease payments are likely to be riskier for financially constrained lessees, they have to pay a higher yield than their unconstrained rivals. That is, financially constrained airlines will either receive lower up front payments and/or make larger periodic lease payments.

Because the airline is responsible for maintaining the aircraft throughout the term of the lease, the effect of aircraft quality *at lease inception* on price is much smaller for sale/leasebacks than for straight sales. Therefore, effects of financial variables on sale/leaseback prices are likely to be caused by creditworthiness rather than quality considerations. A finding that sale/leaseback prices are correlated with financial variables would refute the hypothesis that the previously documented relationship between sale price and financial variables is driven by systematic variation in aircraft quality.[29]

Results from the hedonic regression estimation using only sale/leaseback transactions are presented in Table A.I, Panel B. The adjusted R^2 for this regression is 0.94 which is greater than the adjusted R^2 of 0.76 for straight sale transactions. The increase in R^2 for sale/leasebacks may be caused by elimination of quality differences. It may also be caused by the lack of sale/leaseback transactions during used aircraft market depressions, when residuals tend to be large. Sale/leasebacks of aircraft models considered in this paper were virtually nonexistent prior to 1985 but grew rapidly during the booming market in the late 1980s. However, when market values for used aircraft declined during late 1990, sale/leaseback agreements were largely limited to financially healthy airlines—lessors were unwilling to enter long-term lease agreements with financially tenuous lessees.

[28] The idea to use sale/leaseback transactions to mitigate quality concerns was suggested by Ken Raff, Managing Director of Fleet Transactions at American Airlines.

[29] Unfortunately, airlines are only required to disclose the sale/leaseback price (up front payment). Data on contracted lease payments are not available.

Table VI presents results of estimations of equation (2) using sale/leaseback transactions. Results are presented both for the entire sample and for the subsample of transactions that occurred during the 1990–1991 market recession. Consistent with results using straight sale transactions, spare-debt-capacity has the biggest effect on sale/leaseback price during market recessions. Airlines classified as having high spare debt capacity receive a 20 percent premium compared to airlines with low and medium spare debt capacities. This result implies that quality differences do not drive the observed relationship between liquidation price and financial variables and provides further evidence that financial constraints are important determinants of prices at which airlines liquidate used aircraft.

Additional support for the conclusion that quality effects are not driving observed discounts is obtained by replicating the transaction price analysis after segmenting the data according to aircraft age. If unobserved aircraft quality is causing the observed relationship between sellers' financial conditions and transaction prices, then, because quality variation is likely to be greater for older aircraft, one would expect the sum of squared residuals from price regressions to be greatest when the sample is limited to older aircraft. To test this conjecture, two subsamples of data are generated. The first subsample contains all narrow-body transactions (sales, not sale/leasebacks) for which aircraft age is below the sample median. The second subsample contains transactions for which aircraft age exceeds the sample median. The second specification from Table III is then estimated for each subsample. To test whether residuals from the regression using old aircraft are greater than residuals from the regression using young aircraft, the Goldfeld–Quandt Test for heteroskedasticity with respect to age is performed. This test fails to reject the null hypothesis of homoskedasticity with respect to age ($F[197,209] = 0.775 < F_{0.05}[197,209] = 1.0$).

Institutional details also help alleviate the concern that quality differences are driving previously reported results. First, costs of aircraft improvements (e.g., engine overhauls, cabin refurbishment) are often reported by buyers to DOT as part of transaction price. When reported, prices contained in Avmark's database include these improvement costs. Second, the process of performing major airframe overhauls is carrier-specific. Each U.S. airline is required by the FAA to have a maintenance plan for every aircraft model in its fleet. This plan varies across carriers, even for identical aircraft. Thus, for example, if Eastern purchased a 727-200 from United that had just undergone a major airframe overhaul, Eastern would still be responsible for performing maintenance checks required in its own maintenance plan but not United's. Eastern would be able to take credit for United's maintenance, but only to the extent that it can demonstrate to the FAA that United's plan overlaps Eastern's. Any work not performed by United but required by the Eastern plan would have to be performed by Eastern. For minor maintenance checks, this is not likely to be costly. However, for major airframe checks, both the costs of performing additional work as well as costs asso-

Table VI

OLS Regressions of the Determinants of Sale/Leaseback Price

This table presents OLS regressions relating narrow-body sale/leaseback prices to selling airlines' financial characteristics for 524 aircraft transactions. Panel A presents results using the entire sample; Panel B presents results for transactions that occurred during the market downturn in 1990 and 1991. The dependent variable is the residual from the hedonic regression (equation (1)):

$$\log(\text{PRICE}) = \beta_0 + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{\text{AGE}} \log(1 + \text{AGE}) + \epsilon,$$

where PRICE equals sale/leaseback price, MODEL_i are dummy variables representing aircraft models, QTR_j are dummy variables representing calendar-quarters, STAGE_k are dummy variables representing engine stage categories, and AGE equals aircraft age at the time of the sale/leaseback. CAPLO is a dummy variable equal to 1 if the selling airline's leverage ratio was above the industry median and its current ratio was below the industry median in the calendar-quarter preceding the transaction; CAPHI is a dummy variable equal to one if the selling airline's leverage ratio was below the industry median and its current ratio was above the industry median in the preceding quarter; Q equals market value of equity plus book value of debt divided by book value of equity plus book value of debt; REV equals load factor (revenue-passenger-miles divided by available-seat-miles) times revenue per revenue-passenger-mile; COST equals cost-of-goods-sold divided by available-seat-miles; NSLB equals the number of sale/leasebacks by the selling airline in the same calendar-quarter of the transaction; τ is the lessee's marginal tax rate. Results are relative to transactions where the seller has medium spare debt capacity. Both OLS and Conley (1996) standard errors are presented in parentheses (OLS standard errors are first). The Conley (1996) procedure corrects for correlation of observations based on proximity in economic distance.

Dependent Variable: Hedonic Regression Residual								
CAPLO	CAPHI	Q	REV	COST	NSLB	τ	Const.	Adj R^2
Panel A: Entire Sample (N = 524)								
−0.02	0.04	−0.003	1.61	−1.31	−0.001	−0.10	−0.002	0.04
(0.017/0.031)	(0.019/0.035)	(0.046/0.054)	(1.06/1.73)	(1.12/1.65)	(0.001/0.001)	(0.045/0.061)	(0.069/0.091)	
Panel B: 1990–1991 (N = 71)								
0.007	0.18	−0.05	−3.24	6.63	−0.002	0.23	−0.30	0.58
(0.082/0.100)	(0.025/0.059)**	(0.086/0.079)	(5.77/8.80)	(5.49/8.06)	(0.001/0.002)	(0.220/0.151)	(0.209/0.260)	

*, **, *** Significant at 5, 1, and 0.1 percent levels, respectively.

ciated with comparing maintenance plans can be extremely high.[30] This provides incentives for airlines to avoid selling aircraft that have recently undergone major maintenance checks—regardless of financial condition, airlines tend to sell planes with few flight-hours remaining until the next airframe overhaul.

The same argument cannot be made for aircraft engines or airworthiness directives. Engines are typically run until there is a problem, at which time they are overhauled. Financially constrained airlines may face greater incentives than unconstrained airlines to sell aircraft with many flight hours on the engines or aircraft that have not yet been brought into compliance with FAA airworthiness directives.

V. Conclusion

This paper estimates discounts at which assets are liquidated by examining prices from a comprehensive sample of commercial aircraft transactions. Use of aircraft transactions has a number of advantages over previously published work on asset liquidation. Not only does it avoid using stock price reactions to infer costs of liquidation, it also focuses on relatively homogeneous assets. Furthermore, because the market for used aircraft is extremely liquid compared to markets for most real assets, discounts presented in this paper represent estimates of lower bounds of liquidation costs. These costs are likely to be greater in industries where used asset markets are less liquid.

Empirical results presented in this paper are consistent with a model where prices that sellers accept for their assets depend on costs of raising capital. Airlines with high leverage ratios and low current ratios receive lower prices for their assets than more conservatively financed airlines. Furthermore, financially distressed airlines are more likely to sell assets to industry outsiders at low prices. This effect is strongest during market recessions, when capital constraints limit inside buyers from paying full value for distressed firms' assets. Although discounted sales are costly for liquidating firms, they present a buying opportunity for conservatively financed firms. The effect of high spare debt capacity on purchasing activity is greatest when aircraft prices are depressed.

These results have important implications for a number of issues in corporate finance. First, they suggest benefits from maintaining spare debt capacity. In addition to avoiding costly liquidation of assets at fire sale prices, maintaining conservative capital structures allows firms to be on the buy-side of industry fire sales. Second, costs of asset liquidation provide a disincentive to invest. This may help to explain high capital stock adjustment costs noted in the investment/cash flow literature. Finally, findings pre-

[30] For example, a major airframe overhaul (D-Check) for a 737 costs approximately $1 million. For a 747 airframe, this cost is closer to $5 million (Source: Mort Beyer, Mort Beyer Associates).

sented in this paper have implications for bankruptcy law reform. They suggest that immediate cash liquidation of insolvent firms may result in socially inefficient outcomes: not only will immediate cash liquidation fail to maximize proceeds to claimholders, but it may also allocate resources to low-value users.

Appendix A

Table AI

Hedonic Regression

This table presents regression results for the model specified in equation (1):

$$\log(\text{PRICE}) = \beta_0 + \sum_{i=1}^{I} \beta_i \text{MODEL}_i + \sum_{j=1}^{J} \beta_j \text{QTR}_j + \sum_{k=1}^{K} \beta_k \text{STAGE}_k + \beta_{\text{AGE}} \log(1 + \text{AGE}) + \epsilon,$$

where PRICE equals transaction price, MODEL_i are dummy variables representing aircraft models (e.g., DC-9-10), QTR_j are dummy variables representing calendar-quarters, STAGE_k are dummy variables representing engine stage categories, and AGE equals aircraft age at the time of the transaction. Dummy variables for Airbus 300B4-200, Stage 3 engines, and the third quarter of 1991 are omitted to avoid collinearity. Column A presents results using sale transactions. Column B presents results using sale/leaseback transactions. Standard errors are in parentheses and are corrected for heteroskedasticity using the methods of Huber (1967) and White (1980). Missing entries are due to lack of transactions and collinearity (e.g., B-737-100 and B-707-320C are the only Stage 1 aircraft in the sample).

Independent Variables	(A) Sales	(B) Sale/Leasebacks	Independent Variables	(A) Sales	(B) Sale/Leasebacks
Model dummies			Quarter dummies		
DC-9-10	−0.40	−0.03	1978.1	1.34	—
	(0.073)***	(0.035)		(0.221)***	
DC-9-30	0.19	0.48	1978.2	1.32	—
	(0.066)**	(0.039)***		(0.205)***	
DC-9-50	0.76	0.69	1978.3	1.54	—
	(0.092)***	(0.041)***		(0.247)***	
B-707-320C	−0.71	—	1978.4	1.23	—
	(0.151)***			(0.199)***	
B-727-100	−0.63	−0.03	1979.1	1.62	—
	(0.069)***	(0.040)		(0.230)***	
B-727-100QC	−0.34	—	1979.2	1.34	—
	(0.071)***			(0.214)***	
B-727-200	−0.07	0.32	1979.3	1.40	—
	(0.081)	(0.028)***		(0.219)***	
B-727-200 ADV	0.46	0.64	1979.4	1.52	—
	(0.077)***	(0.049)***		(0.211)***	
B-737-100	—	0.47	1980.1	1.28	—
		(0.050)***		(0.200)***	
B-737-200	0.14	0.46	1980.2	1.36	—
	(0.073)*	(0.036)***		(0.198)***	
B-737-200 ADV	0.77	0.79	1980.3	1.49	—
	(0.110)***	(0.049)***		(0.230)***	
B-737-300	−0.51	−0.53	1980.4	1.22	—
	(0.170)***	(0.038)***		(0.192)***	

Table AI—*Continued*

Independent Variables	(A) Sales	(B) Sale/Leasebacks
Quarter dummies		
1981.1	1.05 (0.192)***	—
1981.2	1.16 (0.197)***	—
1981.3	1.1.4 (0.202)***	—
1981.4	1.03 (0.200)***	0.04 (0.038)
1982.1	0.65 (0.226)**	—
1982.2	0.95 (0.208)***	—
1982.3	0.92 (0.223)***	—
1982.4	0.75 (0.240)***	0.09 (0.037)*
1983.1	0.88 (0.226)***	—
1983.2	0.98 (0.202)***	—
1983.3	0.57 (0.220)**	0.10 (0.037)**
1983.4	0.73 (0.194)***	−0.16 (0.050)***
1984.1	0.75 (0.191)***	−0.28 (0.043)***
1984.2	0.90 (0.193)***	−0.09 (0.044)
1984.3	0.94 (0.211)***	−0.01 (0.038)
1984.4	1.00 (0.192)***	0.19 (0.048)***
1985.1	1.11 (0.190)***	0.11 (0.036)**
1985.2	1.04 (0.192)***	0.16 (0.12)
1985.3	1.40 (0.193)***	0.07 (0.023)**
1985.4	1.31 (0.193)***	0.29 (0.040)***
1986.1	1.40 (0.206)***	0.22 (0.033)***
1986.2	1.08 (0.243)***	0.04 (0.056)
1986.3	1.30 (0.221)***	0.15 (0.041)***
1986.4	1.20 (0.195)***	0.18 (0.040)***
1987.1	1.38 (0.191)***	0.10 (0.038)**
Quarter Dummies		
1987.2	1.42 (0.206)***	0.13 (0.037)***
1987.3	1.23 (0.186)***	0.18 (0.036)***
1987.4	1.34 (0.190)***	0.17 (0.038)**
1988.1	1.22 (0.236)***	−0.59 (0.217)**
1988.2	1.28 (0.200)***	0.06 (0.044)
1988.3	1.28 (0.191)***	0.11 (0.037)**
1988.4	1.17 (0.196)***	0.23 (0.041)***
1989.1	1.14 (0.195)***	0.24 (0.043)***
1989.2	1.09 (0.189)***	−0.31 (0.038)***
1989.3	1.20 (0.197)***	0.21 (0.034)***
1989.4	1.24 (0.185)***	0.17 (0.041)***
1990.1	0.96 (0.222)***	0.15 (0.041)***
1990.2	1.10 (0.192)***	0.23 (0.034)***
1990.3	1.03 (0.203)***	−0.09 (0.045)*
1990.4	1.05 (0.214)***	0.09 (0.022)***
1991.1	0.90 (0.195)***	0.20 (0.039)***
1991.2	0.69 (0.214)**	−0.002 (0.001)
1991.4	−0.08 (0.409)	0.38 (0.034)***
log(1 + AGE)	−0.16 (0.057)***	−0.29 (0.020)***
St1 Dummy	−2.16 (0.277)***	—
St2 Dummy	−1.73 (0.146)***	−1.56 (0.048)***
Constant	2.83 (0.247)***	3.82 (0.056)***
Number of observations	1079	621
Adjusted R^2	0.762	0.947

*, **, *** Significant at the 5, 1, and 0.1 percent levels, respectively.

Appendix B

Calculation of Conley (1996) Standard Errors

In their analysis of time series data with autocorrelated disturbances of unknown structure, Newey and West (1987) suggest adjusting coefficient standard errors using the following formula:

$$V/T = (X_T' X_T)^{-1}\left[\sum_{t=1}^{T} u_t^2 x_t x_t' + \sum_{v=1}^{L}\left[1 - \frac{v}{L+1}\right] \times \sum_{t=v+1}^{T}(x_t u_t u_{t-v} x_{t-v}' + x_{t-v} u_{t-v} u_t x_t')\right](X_T' X_T)^{-1}, \qquad \text{(B1)}$$

where $\mathbf{X}$ is a matrix of independent variables, $\mathbf{x_t}$ are vectors of independent variables, u_t is the vector of error terms from the OLS regression, and L equals the number of researcher-specified lagged periods. The square root of the column j, row j element of V/T is the Newey–West (1987) OLS-estimator standard error that accounts for both heteroskedasticity and autocorrelation. The weighting factor $w_{ij} = [1 - v/(L + 1)]$, takes values between zero and one and assumes that correlation between error terms diminishes as the time separating observations increases. For example, two observations, i and j, that occurred in consecutive periods are likely to be highly correlated. A weighting factor close to one would be used for these observations. Conversely, two observations distant in time would be assumed to be independent—the coefficient standard error weighting factor would be zero for these observations. The Newey–West weighting factor declines linearly with the time between observations for L lags. After L lags, observations are assumed to be independent.

Standard errors presented in this paper follow Conley (1996) who modifies the Newey–West standard error such that weighting factors depend on the "economic distance" (rather than time) between observations. This is particularly useful when analyzing cross-sectional/time-series data where time is not necessarily a good measure of the "distance" between observations. The general idea behind Conley's approach is that the error term correlation, and therefore the weighting factor, should increase as economic distance gets small.

There is a great deal of latitude in specifying both determinants of "economic distance" and the relationship between these determinants and weighting factors. I assume that economic distance between two transactions is shortest when transacting parties are the same, when the aircraft model is the same, and when the time separating transactions is short. In many cases, airlines sell multiple aircraft to a single buyer on a single date. For these transactions, a weighting factor of 1.0 is applied. In contrast, OLS assumes independence of these observations and applies a weight of zero. A weighting factor of 0.75 is applied if two transactions have the same seller, occur within

Table BI

Conley Standard Errors

Weighting Factor	Condition
w_{ij} = 1.0	$i = j$
w_{ij} = 1.0	$\text{Seller}_i = \text{Seller}_j$ & $\text{Buyer}_i = \text{Buyer}_j$ & $\text{Model}_i = \text{Model}_j$ & $\text{Date}_i = \text{Date}_j$
w_{ij} = 0.75	$\text{Seller}_i = \text{Seller}_j$ & $\lvert \text{Date}_i - \text{Date}_j \rvert < 1$ year
w_{ij} = 0.50	$\text{Seller}_i = \text{Seller}_j$
w_{ij} = 0.0	Otherwise

one year of each other, but have different aircraft models or buyers. A weighting factor of 0.5 is applied if two transactions have the same seller, regardless of how much time separates the transactions. As with OLS, a weighting factor of 1.0 is assigned if $i = j$. All other weighting factors equal zero. Table BI summarizes the weighting scheme used to generate Conley (1996) standard errors. Because the weighting structure described above assumes a high degree of correlation between error terms, Conley's (1996) standard errors tend to be much larger than those generated using OLS. The weights have purposely been chosen in a conservative manner to generate upper bound standard error estimates. True standard errors are likely to lie somewhere between the OLS standard errors and the Conley (1996) standard errors.

Appendix C

Description of Negative-Binomial Model

To model count variables when the variance of the dependent variable is significantly greater than the mean, Hausman et al. (1984) suggest modifying the Poisson-based likelihood function. The modification involves dropping the assumption (implicit in the Poisson specification) that the Poisson parameter, λ_{it}, is a deterministic function of $\mathbf{X}_{it-1}\beta$. Instead, they assume λ_{it} is a gamma-distributed random variable with parameters (γ,δ) where $\gamma_{it} = \exp(\mathbf{X}_{it-1}\beta)$ and δ is constant both across firms and across time. With this modification, the variance to mean ratio is:

$$\frac{V(n_{it})}{E(n_{it})} = \frac{1+\delta}{\delta}, \tag{C1}$$

where δ is a parameter to be estimated. The resulting distribution is a negative binomial with probability density function given by:

$$f(n_{it}) = \frac{\Gamma(\gamma_{it} + n_{it})}{\Gamma(\gamma_{it})\Gamma(n_{it}+1)}\left(\frac{\delta}{1+\delta}\right)^{\gamma_{it}}(1+\delta)^{-n_{it}}. \tag{C2}$$

Consistent and efficient estimation of this model can be achieved via maximum likelihood where the appropriate log-likelihood function is:

$$L(\beta,\delta) = \sum_{1}^{N}\sum_{1}^{T}[\log\Gamma(\gamma_{it} + n_{it}) - \log\Gamma(\gamma_{it}) - \log\Gamma(n_{it} + 1) + \gamma_{it}\log(\delta) - \gamma_{it}\log(1 + \delta) - n_{it}\log(1 + \delta)] \tag{C3}$$

and

$$\gamma_{it} = e^{\mathbf{X}_{it-1}\beta}. \tag{C4}$$

Table V presents results using the negative binomial model. Similar results are obtained using OLS, indicating that general conclusions are robust to changes in model specification.

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