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ALLAN C. EBERHART and RICHARD J. SWEENEY*

ABSTRACT

This study shows the extent to which deviations from the absolute priority rule increase or decrease the bankruptcy emergence payoff to traded (i.e., usually junior claimants) bondholders. The data indicate that, on average, bondholders benefit, albeit slightly, from absolute priority rule (APR) violations. This paper also examines the degree to which the bond market, in the bankruptcy filing month, anticipates departures from the APR and other influences on the payoff to bondholders. In other words, we investigate the informational efficiency of the market for bankrupt bonds. Overall, despite the complex and lengthy nature of bankruptcy proceedings, the results support efficiency.

THE FINANCE LITERATURE HAS traditionally assumed that when a firm enters bankruptcy, the creditors become the owners and the value of the firm is distributed according to the absolute priority rule (APR). The APR states that senior creditors should be fully compensated before junior creditors receive any portion of the bankrupt firm's value, and junior creditors should receive full payment before shareholders receive any compensation. In practice, formal bankruptcy proceedings are complex processes that often violate the APR. Brown (1989) captures some of the intricacies of this process in a game theoretic model, showing that the solution to the bargaining process in bankruptcy can involve deviations from the APR (although the solution closely approximates the APR).[1]

* School of Business Administration, Georgetown University. This is a substantially revised version of our earlier paper, "Bond Prices as Unbiased Forecasts of Bankruptcy Settlements." We would like to thank Reena Aggarwal, Ed Altman, Bill Baber, Brian Betker, Lisa Fairchild, Jerome Fons, Stuart Gilson, Michael Jensen, Dana Johnson, Imre Karafiath, Alan Roshwalb, Lemma Senbet, Arthur Warga, Jerry Warner, and seminar participants at the 1992 meetings of the American Finance Association, American University, Georgetown University Workshop on Financial Distress and Bankruptcy, Lund University, University of Maryland, New York University Conference on Corporate Bankruptcy and Distressed Restructurings and the Stockholm School of Economics for many insightful comments. We would also like to thank Kenji Berliner, Peter Eldredge and, especially, Mario Mansilla for their excellent research assistance. We received funding from Georgetown University summer research grants. The Center for Business-Government Relations at Georgetown (directed by David Walker) also provided support.

[1] Also, see Giammarino (1989) for some recent game theoretic modelling of the bankruptcy process.

Empirical evidence of departures from the APR is provided by Betker (1991), Eberhart, Moore, and Roenfeldt (1990), Franks and Torous (1989, 1991) and Weiss (1990). These studies find that the APR is violated in about 75% of the cases examined. They also discuss several features of the bankruptcy law (i.e., Chapter 11 of the 1978 Bankruptcy Act) that facilitate departures from the APR. In essence, Chapter 11 gives managers and shareholders some important bargaining powers that can be used to induce creditors to part with a significant portion of the bankrupt firm's value. Eberhart, Moore, and Roenfeldt (1990) report that, on average, 7.6% of the firm's value is given to shareholders in violation of the rule; with different samples, Franks and Torous (1991) and Betker (1991) find that the average proportion of firm value received by shareholders in violation of the APR is 4% and 2.4%.[2]

Though shareholders can only benefit from APR violations, bondholders may be aided or harmed.[3] To see this, consider a firm with three priority classes of claimants: senior creditors, (junior) bondholders, and shareholders. If the bankrupt firm's value is less than the amount owed to senior creditors, then any payment to bondholders is a departure from the APR in their favor, even if shareholders also receive a payment. Conversely, if the bankrupt firm's value is greater than the amount owed to the bondholders and more senior claimants, then any payment to these bondholders less than the amount owed is an APR violation to their detriment.

This paper has two purposes. First, it documents the magnitude of the benefit or harm of APR violations for bondholders. The results show that, on average, deviations from the APR benefit, albeit slightly, traded (i.e., usually junior claimants) bondholders; this is consistent with the Betker's (1991) findings.[4] There are several cases, however, where bondholders receive much less than they would receive under the APR.

Second, the paper examines how well the bond market, in the bankruptcy filing month, anticipates departures from the APR as well as other influences on the payoff to bondholders on the bankruptcy emergence date.[5] In other

[2] Although they do not explicitly mention the term APR violations, Haugen and Senbet (1978) argue that payoffs to shareholders in states of default can be viewed as a way of avoiding bankruptcy costs. Eberhart and Senbet (1991) show that APR violations can play an important role in mitigating the risk incentive for financially distressed firms.

[3] The terms aided or harmed should perhaps be placed in quotation marks because they imply that APR violations represent unanticipated wealth transfers. The capital markets should, however, anticipate departures from the APR. The latter part of this paper provides evidence on the extent to which the bond market anticipates APR violations and other influences on bankruptcy settlements.

[4] Even with APR violations, payoffs to senior claimants are generally higher than the payoffs to junior claimants. With this in mind, Brown, James, and Mooradian (1990) argue that the priority of claims accepted by private lenders in workouts sends an important signal about the firm's future prospects.

[5] More specifically, we test whether the announcement month bond prices are unbiased forecasts of the price on the emergence month or the last price in the *Standard and Poor's Bond Guide*, whichever comes first.

words, we test the informational efficiency of the market for bankrupt bonds. The results generally support efficiency.

A brief review of the literature is presented in Section I. In Section II, we discuss the sample and also report the degree to which deviations from the APR benefit or harm bondholders. The market efficiency tests are derived in Section III. The estimation procedures are presented in Section IV. Section V presents the test results and Section VI summarizes the results and discusses their implications.

I. Review of the Literature

The efficient market hypothesis has traditionally been tested by averaging cumulative abnormal returns (*CARs*) across assets and testing whether the average *CAR* (*ACAR*) differs significantly from zero. Warner (1977) uses this methodology to test the efficient market hypothesis with a sample of 20 railroad bankruptcies (73 bonds) that occurred between 1926 and 1955. Notwithstanding a period during the early 1940s, he finds an insignificant *ACAR* for his sample and concludes that the bonds are efficiently priced.

Betker (1991) provides some corroboration for Warner's conclusion. Unlike Warner's study (and this one), the focus of Betker's paper is not to test the efficient market hypothesis. He analyzes the returns to all classes of traded securities for a sample of 78 firms that went bankrupt between 1982 and 1990 and presents a number of important results. For example, he finds that weakening of the net operating loss carryforwards tax provision in 1986 diminished returns to the bonds in his sample. As a sidelight, he presents some results consistent with market efficiency.[6] For the purposes of our study, his most relevant finding is that the average abnormal return to bondholders is insignificantly different from zero during the bankruptcy period. This result is generated using market adjusted returns; as we argue below, this is one reasonable way to address nonstationarity problems that inevitably arise in using estimated market model parameters with a sample of bankrupt firms. To test for statistical significance, he employs a simple t-statistic that uses a standard error estimate based on the cross-sectional variation in cumulative excess returns; by using a standard error calculation

[6] Other studies that find evidence consistent with the efficient pricing of financially distressed or bankruptcy securities include Clark and Weinstein (1983). They examine the stock price response to the bankruptcy announcement for 36 firms that declared bankruptcy between 1938 and 1979; they report that the average negative reaction is less severe for stocks that retain value in the confirmation plan than for stocks that eventually become worthless. Morse and Shaw (1988) find that no abnormal returns appear to be available by investing in the stocks of bankrupt firms. Gilson, John, and Lang (1990) report that negative stock price reactions to debt restructuring announcements are more precipitous for firms whose restructuring attempts ultimately fail. Eberhart, Moore, and Roenfeldt (1990) find that the amount shareholders receive in adherence to the APR and in violation of the rule is significantly reflected in stock prices on the bankruptcy announcement date. Warner's (1977) study, however, is the only one whose focus is the test of market efficiency.

that incorporates information contained in the estimation period data, we find several cases where the null of efficiency is rejected.[7]

Betker (1991) argues that rigorous tests of efficiency are not possible because of the nonstationarity problem in estimating market model parameters and the poor quality of bond prices in the *Standard and Poor's Bond Guide* (BG) (his, and our, main data source). Of course, nonstationarity is not a problem unique to a sample of bankrupt bonds.[8] It is undoubtedly a more severe problem with bankruptcy, but it is clear that many common corporate events can lead to biased estimates of market model parameters during the period before the event is officially announced (e.g., mergers). We approach this important problem by testing for efficiency under a number of different plausible assumptions about the market model parameters.[9] Further, we present evidence that the BG data represent a reasonable proxy for prices in the OTC market.[10]

We offer two extensions to Warner's (1977) study. First, the dramatic change in bankruptcy law in 1978 (effective in October of 1979) has been posited as one explanation for more frequent APR violations in favor of equityholders (Franks and Torous (1989)). Thus, it is of interest to test the market's forecasting ability under a new set of rules. Second, we test whether the price of a bond after bankruptcy, grossed up by factors reflecting the time value of money, risk, and market movements since the event date, is an unbiased estimate of the settlement price.[11] We refer to this as the price-unbiasedness test; it is analogous to many efficiency tests in the macroeconomics literature. The test asks whether each pair of settlement price and event-date price (grossed up to reflect the time-value of money, risk, and subsequent market movements) falls along a 45° line. The price-unbiasedness test and the usual $ACAR$ test are not equivalent. If price-unbiasedness holds ex ante, $ACAR = 0$ also holds ex ante; an ex ante $ACAR = 0$ does not, though, imply price-unbiasedness.

With any sample of returns, the more relevant question is the statistical power of the two tests. We demonstrate that neither test is uniformly more powerful than the other. Thus, it is important to do both in order to perform a more rigorous test of the efficient market hypothesis.

[7] t-tests of average abnormal returns based on cross-sectional variation in returns are less powerful than our approach because they ignore the estimation period data (Brown and Warner (1985)); with a variance increase in the window, however, the relative power of our approach is less clear (see Bremer and Sweeney (1991)).

[8] Bond betas are inherently unstable; as a bond approaches maturity its beta will decline, ceteris paribus. See Weinstein (1981) for a thorough analysis of bond betas.

[9] This approach can be couched under the rubric of sensitivity analysis; this is not uncommon in the literature. For example, many event studies calculate excess returns using market model parameter estimates from a pre- and post-event period (Bremer and Sweeney (1991), and Mais, Moore, and Rogers (1989)).

[10] The OTC bond market is more liquid than the exchange-based market; hence, OTC bond data are generally thought to be more reliable (Warga and Welch (1990)).

[11] See footnote 5.

We test for a zero *ACAR* and price-unbiasedness using a sample of all bonds and a sample where we average all bonds from the same firm (i.e., use "one" bond per firm). Because of high correlation among bonds from the same firm, we view the sample of "one" bond per firm as statistically more reliable. Overall, we find zero *ACARs* and price-unbiasedness. In other words, the bond market appears to take account of APR violations and other influences on the ultimate payoff/settlement to bondholders. We report several cases, though, where results are not consistent with market efficiency. In some cases both tests reject market efficiency; in others, one will support efficiency but the other will not. As discussed below, we believe these results are less convincing than the results that support market efficiency because the results rejecting efficiency have more severe statistical problems. We will highlight the cases where the *ACAR* and price-unbiasedness tests provide conflicting results because they underscore the point that financial researchers should perform both.

II. Data Description

A. Construction of the Sample

The initial sample of 350 firms that declared bankruptcy under Chapter 11 after October 1, 1979 (the effective date of the 1978 Bankruptcy Act) was constructed from a variety of sources: a list of firms that had completed the bankruptcy process between January 1, 1980 and December 31, 1990 as provided by the Bankruptcy Datasource (published by New Generation Research); the Bankruptcy heading in the *Wall Street Journal Index*; a Dow Jones News Retrieval search using the key words Bankruptcy and Emerge; samples listed in Altman (1986), Altman and Nammacher (1985), Daigle and Maloney (1990), and Johnson (1989).

From this initial sample, we identified 74 firms, with 187 bonds, that had emerged from bankruptcy by December of 1990 with prices available in the BG.[12] BG prices reflect end-of-the-month transaction prices from the New York Stock Exchange or the American Stock Exchange. If no transaction occurs at the end of the month, a bid, ask or matrix (i.e., estimated) price is used (in that order). Bankruptcy filing announcements are made in every year between 1980 and 1990. The average time in reorganization is 25.6 months (2.1 years), similar to what other studies report.[13] The shortest reorganization period is 4 months for the pre-packaged Crystal Oil bankruptcy; the 75-month Manville reorganization period is the longest.

[12] There are two firms in the sample (First Republic Bank and Public Service Corporation of New Hampshire) that actually emerged in 1991, although the plans were confirmed in 1990. Furthermore, there are two firms (Dart Drug Stores and Imperial Corporation of America) that are still completing their liquidations.

[13] The average reorganization period in Betker (1991) and Eberhart, Moore, and Roenfeldt (1990) is 2.1 years; 2.6 years for Franks and Torous (1989) (for the 15 firms in their sample which filed for bankruptcy subsequent to October 1, 1979); 2.5 years for Weiss (1990).

The bankruptcy announcement month bond prices range from a low of $20 for the 6% Subordinated Income Debentures for Financial Corporation of America to a high of $933.75 for the 13.625% Texaco Notes. The average price per bond is $361.22.[14] The highest bankruptcy emergence payoff is $1,600 for the 18% Public Service Corporation of New Hampshire General and Refunding Bonds,[15] the lowest is zero for the 13% Wedtech Convertible Debentures. The average payoff is $537.87. The following information sources were used in finding the payoff to each bond: the bankruptcy reorganization plan (if available); the *Capital Changes Reporter*; the *Wall Street Journal*; the Bankruptcy Datasource; Standard and Poor's *Daily Stock Price Record*; the BG; annual reports, 10-Ks and 8-Ks as listed in the Q-File or in the SEC reading room (see Eberhart and Sweeney (1992) for a listing of the price and payoff for each bond).

B. Bond Data Quality

An important criticism of exchange-based bond data is thinness of the market. For example, of the 2,931 bonds listed on the NYSE, the average number of trades per bond for the first 10 months of 1990 was 144 transactions.[16] This implies an average of less than one trade per day. Warga and Welch (1990) argue that the dearth of trading for exchange-based bond data reduces the reliability of the BG data. Blume, Keim, and Patel (1991), however, argue that the BG data can be reliable. They support this by reporting a correlation coefficient of 0.92 between an index based on BG prices and an index of month-end bid prices from Drexel Burnham Lambert and Salomon Brothers.

To test the sensitivity of our results, we use dealer quotes from the OTC bond market; these data were obtained from the Bankruptcy Datasource. The cross-sectional correlation coefficient is 0.8 between the BG price and the OTC price on the bankruptcy announcement month for the 28 bonds with both prices available. It is of interest to note that the correlation is 0.91 between the BG transaction prices and the OTC prices, though it is only 0.71 between the nontransaction prices (i.e., the price is either a bid, ask or matrix price) and the OTC prices. Despite this difference, however, Asquith and Wizman (1990) use the BG data to compute bondholder returns around a leverage buyout announcement and their results do not change qualitatively when they only use BG transaction prices.[17] Hence, the BG data appear to be reasonably reliable.

[14] The prices and payoffs are expressed in terms of a $1,000 face value bond.

[15] The difference between the payoff and the face value of the bond ($1,000) represents compensation for unpaid interest during bankruptcy.

[16] As provided by Arthur Warga in an NYSE study that is in progress.

[17] Crabbe (1991) shows that the negative bond price reaction to leveraged buyout announcements (documented by Asquith and Wizman (1991) and Warga and Welch (1990)) has led to the increased use of covenant provisions that allow bondholders to sell their bonds back to the firm at face value in the event of a leveraged restructuring and subsequent downgrading to speculative grade.

C. Measurement of Absolute Priority Rule Violations

The extent to which APR violations (on a per—$1,000 face value—bond basis) help or harm bondholders is captured in the variable Ω as defined by: $\Omega = PAYMENT - APR$; where $PAYMENT$ = payment per bond on the bankruptcy emergence date, and APR = amount that would have been paid per bond if the APR had been followed.[18] This measure explicitly takes the payment required by the APR as the benchmark; the harm or benefit to an individual bondholder is relative to this benchmark. This measure does not address the harm or benefit to society of a bankruptcy system that allows for systematic APR violations (see Jensen (1989) for an argument against APR violations from a public policy perspective).

Table I shows the value of Ω for 13 firms (40 bonds). The lowest value for Ω is −$449.93 for the 9% Wickes convertible subordinated debentures and the highest value is $576.59 for the 10% Baldwin United subordinated debentures; the average value for Ω is $7.34. Thus, while there is a great deal of variation in Ω, APR violations approximately net to zero.

The information in Table I suggests that though seniority provisions in bond covenants generally imply a higher payout, they can also be associated with a larger detrimental effect from APR violations. For example, in the BASIX case, the 8.75% convertible senior subordinated debenture holders received $851.22 per bond but they should have received $1,021.87 if the APR had been followed (i.e., $\Omega = -\$170.65$). Similarly, the 11.625% subordinated debenture holders were given $548.21 per bond, $370.18 more than they would have received if the APR had been applied ($\Omega = \$370.18$). On the other hand, in the Southmark and Wickes cases, subordination provisions resulted in a lower payment and less of a benefit, or more harm, from APR violations. Thus, there does not appear to be any systematic relationship between priority provisions and Ω for the bonds in this sample.[19]

APR violations add an additional element of uncertainty to the market's forecast of bankruptcy settlements. The market must forecast not only how valuable the firm will be upon emergence from bankruptcy but also the extent to which APR violations will affect the payoff to bondholders. The next section delineates the tests that gauge the market's predictive ability.

III. Comparison of ACAR and Price-Unbiasedness Tests

Event studies often examine asset market efficiency. Efficiency is taken to say that the return on any asset differs only randomly from the expected return conditional on the asset's risk. A frequent interpretation is that an asset's price today is an unbiased estimate of the asset's discounted future price and its intermediate cash flows (such as dividends or interest pay-

[18] Because all bonds are expressed in terms of $1,000 face value, there is no need to standardize Ω in order to make cross-sectional comparisons.

[19] Betker (1991) reports similar results. See Smith and Warner (1979) for a lucid discussion of ambiguities in the priority provisions of bond covenants.

Table I

Absolute Priority Rule (APR) Violation Measurements

This table shows the extent to which APR violations increase or decrease the bankruptcy emergence payoffs for 13 firms (40 bonds) filing under Chapter 11 between 1980 and 1990. The magnitude of APR violations is captured in the variable Ω as defined by: $\Omega = PAYMENT - APR$; where $PAYMENT$ = payment per ($1,000 face value) bond and APR = amount that would have been paid per ($1,000 face value) bond under the APR.

Firm	Bond	Coupon Rate (%)	*PAYMENT* ($)	*APR* ($)	Ω ($)
AM International	Deb.	9.375	1,353.77[a]	1,000	353.77
Baldwin United	Sub. Deb.	10	576.59	0	576.59
BASIX	CV Sen. Sub. Deb.	8.75	851.22[a]	1,021.87	−170.65
	Sub. Deb.	11.625	548.21[a]	178.03	370.18
Charter	Sub. Deb.	10.625	694.17	1,000	−305.83
	Sub. Deb.	14.75	630.73	1,000	−369.27
Coleco	Sub. Deb.	14.375	245[a]	310.45	−65.45
	Sub. Deb.	11.125	245[a]	310.45	−65.45
	CV Sub. Deb.	11	245[a]	310.45	−65.45
Continental Air	CV Sub. Deb.	3.5	811.50[b]	811.50	0
	Sub. SF Deb.	10.875	1,342.25[a]	1,342.25	0
Global Marine	Sen. Sub. Deb.	16	54.83	0	54.83
	Sen. Sub. Deb.	16.125	56.91	0	56.91
	CV Sen. Sub. Deb.	13	55.48	0	55.48
	Sen. Sub. Deb.	12.375	63.03	0	63.03
Lionel	Sub. SF Deb.	10.625	919.38	1,000	−80.62
Revere Copper	CV Sub. Deb.	5.5	1,025.27	1,020.01	5.26

Table I—*Continued*

Firm	Bond	Coupon Rate (%)	*PAYMENT* ($)	*APR* ($)	Ω ($)
Saxon Industries	CV Deb.	5.25	334.68	0	334.68
	Deb.	6	334.68	0	334.68
Southmark	Sen. Notes	11.875	261.74[a]	0	261.74
	Sen. Notes	11.5	261.74[a]	0	261.74
	Sen. Notes	10.875	261.74[a]	0	261.74
	Sen. Sub. Notes	13.25	20.83	0	20.83
	Sub. Notes	15.25	14.84	0	14.84
	CV Sub. Deb.	8.5	5.82	0	5.82
Texaco	SF Deb.	5.75	784.10	784.10	0
	SF Deb.	7.75	881.10	881.10	0
	SF Deb.	8.5	914.50	914.50	0
	SF Deb.	8.875	939.20	939.20	0
	Notes	9	1,112.70	1,112.70	0
	Notes	11	1,152.30	1,152.30	0
	Notes	13	1,197.40	1,197.40	0
	Notes	13.625	1,239.40	1,239.40	0
Wickes	SF Deb.	6	874.72	1,024.16	−149.44
	SF Deb.	7.875	886.51	1,038.19	−151.68
	SF Deb.	8.875	886.51	1,028.21	−141.70
	Notes	8.25	886.51	1,026.22	−139.71
	SF Deb.	10.25	886.51	1,028.36	−141.85
	CV Sub. Deb.	5.125	583.09	1,024.85	−441.76
	CV Sub. Deb.	9	593.71	1,043.64	−449.93
Average Value			633.76	618.48	7.34

[a] A portion or all of this payment is expressed in terms of face value of securities received or assumed values given in the reorganization plan.
[b] Partially based on a matrix (i.e., nonmarket) price as listed in *Standard & Poor's Bond Guide* (August 1986).

ments) when the appropriate risk factor is used and account is taken of market movements.[20] The efficient markets hypothesis is then that the price of a bond after bankruptcy is an unbiased estimate of its future (discounted) price; alternatively, the post-announcement price, grossed up by factors reflecting the time value of money, risk, and market movements since the event date, is an unbiased estimate of the settlement price.[21]

Event studies typically test unbiasedness propositions of this type by averaging *CARs* across assets and testing whether the *ACAR* differs significantly from zero. *ACAR* methods are well known. Section V reports results of tests using *ACAR* methods plus another test of unbiasedness (the price-unbiasedness test). The difference between the *ACAR* and price-unbiasedness tests is formally discussed below.

A. Ex Ante Comparison

Consider the standard market model. The *ACAR* approach finds the expected return on asset i in period t, conditional on period t's return on the market,[22] as

$$E(R_{it}|R_{Mt}) = \alpha_i + \beta_i R_{Mt}. \tag{1}$$

The abnormal return in period t is

$$AR_{it} = R_{it} - E(R_{it}|R_{Mt}) = R_{it} - \alpha_i - \beta_i R_{Mt}. \tag{2}$$

Under market model assumptions, AR_{it} is uncorrelated with R_{Mt} and is serially uncorrelated. It is well known that the *CAR* does not give actual wealth changes because of how compounding is handled; similarly, the initial price grossed up arithmetically with actual returns is not the same as the settlement price. For comparison of the price-unbiasedness test with the *ACAR* test, it is useful to consider a price measure (the "pseudo price") that results from arithmetically grossing up the initial price with actual rates of return. The pseudo price in the settlement period T_i is:

$$P'_{i,Ti} = P_{i0}(1 + \Sigma_{t=1}^{Ti} R_{it}). \tag{3}$$

The expected value of the pseudo price at T_i, conditional on the returns on the market from times 0 to T_i, is

$$EP'_{i,Ti} = P_{i0}(1 + \Sigma_{t=1}^{Ti} ER_{it}) = P_{i0}\left[1 + \Sigma_{t=1}^{Ti}(\alpha_i + \beta_i R_{Mt})\right]. \tag{4}$$

[20] This assumes a market model is used. With multifactor models, movements in all risk factors are included.

[21] If the bankruptcy-date price is grossed up by factors reflecting the time value of money and risk-factors, the predicted settlement price is not conditioned on actual market movements. Conventional tests based on cumulative abnormal returns very often adjust for market movements from the event date to the settlement date; the *CARs* are thus conditioned on market movements not known at the event date.

[22] This discussion assumes that the parameters of the market model are known. Parameter estimation errors are discussed below.

The percentage difference:

$$(P'_{i,T\iota} - EP'_{i,Ti})/P_{i0} = (1 + \Sigma_{t=1}^{T\iota} R_{\iota t}) - (1 + \Sigma_{t=1}^{Ti} ER_{\iota t})$$
$$= (AR_{\iota 1} + AR_{\iota 2} + \cdots + AR_{\iota,T\iota}) = e_{\iota,Ti'} \quad (5)$$

gives the cumulative abnormal rate of return, $CAR_{\iota,Ti}$, for asset i from the event date to T_i.

Event studies often test whether the *ACAR* differs significantly from zero. Alternatively, this tests whether on average the difference between the pseudo price at time T_i and the expected future value of the price at time 0, grossed up arithmetically and conditional on the realizations of R_{Mt}, with both pseudo prices divided by the initial price, is significantly different from zero. The null is that the expected value of $CAR_{i,Ti} = P'_{i,Ti}/P_{i0} - E\,P'_{i,Ti}/P_{i0}$ is zero, or $E(P'_{\iota,T\iota} - EP'_{i,Ti})/P_{i0} = ECAR_{\iota,T\iota} = 0$, implying that the market is efficient at the event date in valuing the (discounted) future payout. Formally, the *ACAR* is:

$$ACAR = (1/N)\Sigma_{i=1}^{N} CAR_{\iota,Ti}; \quad (6)$$

under the null, the expectation of *ACAR* is zero, or

$$EACAR = (1/N)\Sigma_{\iota=1}^{N} ECAR_{\iota,T\iota} = 0. \quad (7)$$

Over the N assets, call the mean $P'_{\iota,Ti}/P_{\iota 0} = p'$ and the mean $EP'_{i,Ti}/P_{i0} = Ep'$. Then the *ACAR* is

$$ACAR = p' - Ep' = (1/N)\Sigma_{\iota=1}^{N} e_{\iota,T\iota}. \quad (8)$$

The *ACAR* test is a test of means; it tests whether p' equals Ep'. The alternative price-unbiasedness regression test asks whether $a = 0$ and $b = 1$ in

$$P'_{i,T\iota}/P_{\iota 0} = a + b(EP'_{i,T\iota}/P_{\iota 0}) + e_{\iota,T\iota}, \quad (9)$$

across the observations $i = 1, N$, where once again the error $e_{\iota,T\iota}$ is the $CAR_{\iota,T\iota}$. From the above assumptions, the true intercept a equals zero and b equals unity, or

$$P'_{i,T\iota}/P_{\iota 0} = EP'_{\iota,T\iota}/P_{i0} + e_{\iota,T\iota}; \quad (10)$$

the $Ee_{\iota,T\iota} = 0$ and the errors are uncorrelated with the $(EP'_{\iota,T\iota}/P_{\iota 0})$s by the assumptions of the market model. OLS estimates a', b' are unbiased and consistent, though generally not efficient; under the above assumptions that the $e_{\iota,Ti}$s are distributed normal iid, OLS is also efficient.[23]

[23] This is simply for convenience to demonstrate the relative properties of the *ACAR* and price-unbiasedness tests. *Mutatis mutandis*, the same points can be made with heteroskedastic errors. The text's assumption would hold if errors for all assets have the same finite variance iid distribution, the windows do not overlap, the estimation periods for the market models do not overlap (or the covariances of parameter estimates are zero) and the payoff date *Ti* is the same for all assets. Discussion below shows how to take account of heteroskedasticity in the errors.

The OLS estimate a' is

$$a' = p' - b'Ep'. \tag{11}$$

Normalize so the mean $Ep' = 1$. Then,

$$p' = a' + b' \tag{12}$$

and

$$ACAR = p' - Ep' = a' + b' - 1, \tag{13}$$

or for a value of $ACAR = 0, 0 = a' + b' - 1$. Thus, when $ACAR$ takes on its expected value of zero, the estimates a' and b' can have any values as long as $a' + b' = 1$; an $ACAR$ of zero does not imply price-unbiasedness. Figure 1 provides a graphical illustration of this point. As long as the price-unbiasedness regression line passes through p' and $E(p')$, the intercept and slope can take on any values. If price-unbiasedness holds exactly, $ACAR = 0$; price-unbiasedness implies $a' = 0$ and $b' = 1$, so

$$p' = a' + Ep' = 1 \tag{14}$$

and thus

$$ACAR = p' - Ep' = a' + b' - 1 = 0. \tag{15}$$

Hence, price unbiasedness is a stronger requirement than $EACAR = 0$.

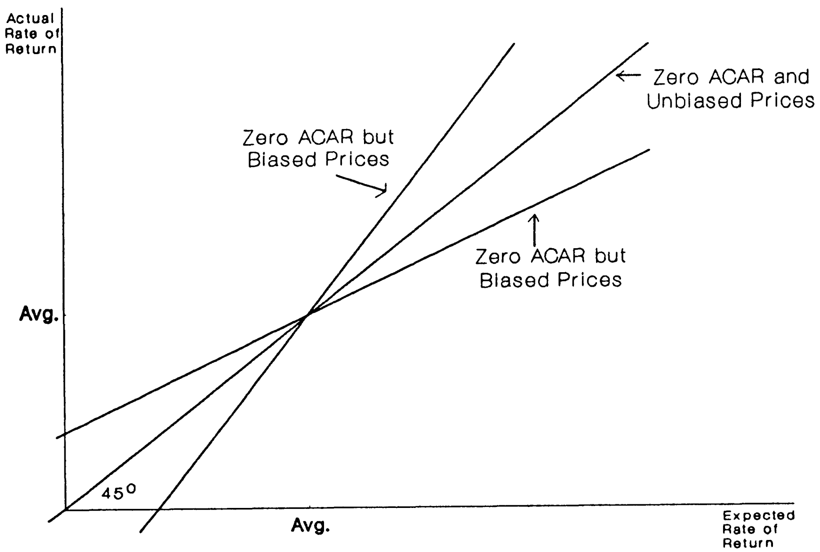

Figure 1. Ex ante comparison of ACAR and price-unbiasedness tests. This figure demonstrates that if price-unbiasedness holds ex ante, $ACAR = 0$ also holds ex ante; an ex ante $ACAR = 0$ does not, though, imply price-unbiasedness.

B. Relative Statistical Power

With any sample of returns, rejection either of $EACAR = 0$ or of price unbiasedness does not imply rejection of the other. Supposing for convenience that the $e_{i,Ti}$ are distributed normal iid with the known standard deviation σ,[24] tests of $EACAR = 0$ that compare $ACAR$ to $1.96\sigma/N^{1/2}$ examine whether

$$-1.96\sigma/N^{1/2} < a' + b' - 1 < 1.96\sigma/N^{1/2}. \tag{16}$$

The 95% confidence bounds are then given by the equations

$$a' = 1 + 1.96\sigma/N^{1/2} - b' \tag{17a}$$

$$a' = 1 - 1.96\sigma/N^{1/2} - b', \tag{17b}$$

parallel lines in the a', b' parameter plane with slopes equal to -1. Any pair a', b' between these lines gives an $ACAR$ insignificantly different from zero at the 95% confidence level.

The 95% confidence level ellipse for price unbiasedness centers around $a' = 0$ and $b' = 1$. It can be shown (Theil 1971, pp. 132–134) that the quadratic form $\mathbf{b}'\mathbf{C}\mathbf{b}$ is distributed chi-squared[25] with two degrees of freedom, where $\mathbf{b}'$ is the vector

$$\mathbf{b}' = [a' - 0, b' - 1] \tag{18}$$

and $\mathbf{C}$ is the matrix

$$\mathbf{C} = (1/\text{det})\begin{bmatrix} \text{varb}' & \text{cov}' \\ \text{cov}' & \text{vara}' \end{bmatrix}, \tag{19}$$

and

$$\text{det} = \text{varb}'\,\text{vara}' - (\text{cov}')^2; \tag{20}$$

vara$'$ is the variance of the estimate of a, varb$'$ the variance of the estimate of b, cov$'$ the covariance of the estimates of a and b, and det the determinant of the covariance matrix of parameter estimates, all of these taken with σ known. With two degrees of freedom, the chi-squared value at the 95% confidence level is very close to 6.0. Thus, in a joint test of the null that $a = 0$ and $b = 1$, values of a', b' that give $\mathbf{b}'\mathbf{C}\mathbf{b} < 6$ fail to reject the null at the 95% confidence level.

In expanded form, the boundary of the region is

$$(1/\text{det})\left[a'^2\text{varb}' + (b' - 1)^2\text{vara}' - 2a'(b' - 1)\text{cov}'\right]$$
$$= (N/\sigma^2)\left\{a'^2 + (b' - 1)^2[\text{var}(Ep_i') + 1] + 2a'(b' - 1)\right\} = 6. \tag{21}$$

The critical region for price-unbiasedness depends on $N^{1/2}$ and σ, as do the parallel lines for the $ACAR$ test. Unlike the parallel lines for the $ACAR$

[24] This assumes that the value of the common variance is known.

[25] The distribution is chi-squared rather than F because σ is assumed known rather than estimated.

test, the critical region for price-unbiasedness also depends on the sample spread in the independent variable, var(Ep_i').

Along (21), at $b' = 1, a' = \pm(\sigma/N^{1/2})6^{1/2} = \pm(\sigma/N^{1/2})2.45$, or the vertical spread of the ellipse at $b' = 1$ depends on σ, N and the confidence level chosen, but not on var(Ep_i'); at $a' = 0, b' = 1 \pm \{2.45/[\mathrm{var}(Ep_i') + 1]^{1/2}\}\sigma/N^{1/2}$ or an increase in the spread of the independent variable moves the b'-axis intercepts closer to unity. Along (21),

$$da'/db' = -\{2(b' - 1)[\mathrm{var}(Ep_i') + 1] + 2a'\}/[2a' + 2(b' - 1)]. \quad (22)$$

At $b' = 1, da'/db' = -1$; at $a' = 0, da'/db' = -\mathrm{var}(Ep_i') + 1, da'/db' >/< 0$ as $1 >/< \mathrm{var}(Ep_i')$; these slopes are independent of σ, N and the chosen confidence level. The ellipse is oriented in a negative direction in the a', b' plane. As σ falls (N rises), the ellipse shrinks for a given confidence level, with the same slopes as before at $b' = 1$ and $a' = 0$. As the spread of the independent variable grows, at $b' = 1$ the ellipse keeps the same values of a' and same slopes, but contracts towards unity along the b' axis and has a steeper tilt.

At $b' = 1$ the values of a' on the ellipse are $\pm(\sigma/N^{1/2})2.45$; on the *ACAR*-test parallel lines, the values of a' are $\pm(\sigma/N^{1/2})1.96$. Thus, the ellipse always has some area outside the parallel lines. At $a' = 0$, (21) gives $b' = 1 \pm \{2.45/[\mathrm{var}(Ep_i') + 1]^{1/2}\}\sigma/N^{1/2}$ and the *ACAR* test's parallel straight lines give $b' = \pm 1.96\sigma/N^{1/2}$. For values of var($Ep_i'$) > 0.5652, the ellipse's b'-axis intercepts are within those of the parallel lines. Rejection of the null in the price-unbiasedness test does not imply rejection in the *ACAR* test, or vice versa. With increases in the spread of the independent variable the ellipse shrinks so that a smaller area of it is outside the parallel lines. Figure 2 provides a graphical illustration of the different critical regions of the *ACAR* versus the price-unbiasedness test.[26]

Consider power. If the price-unbiasedness null is false, the 95% confidence level region for the true values of a', b' will have the same shape and area as the null ellipse. The true ellipse might be centered on the line through $a' = 0, b' = 1$ with a slope of -1, and be far enough away that it does not overlap the null ellipse. Then, in at least 95 percent of the realizations the null of unbiasedness will be rejected; for many of these same realizations the *ACAR* null will not be rejected. Further, as var (Ep_i') grows, both ellipses shrink (though both still have areas outside the parallel lines) and the price-unbiasedness test becomes less and less likely not to reject. On the other hand, the true ellipse may lie outside the parallel lines and overlap with the null ellipse in the region outside the parallel lines. In the 95% of the cases that fall within the true ellipse, the *ACAR* test will reject the null; in some of these same cases, the price-unbiasedness test will incorrectly fail to reject the null.

[26] The values for σ and var(Ep') in Figure 2 are taken from the data (market adjusted returns case).

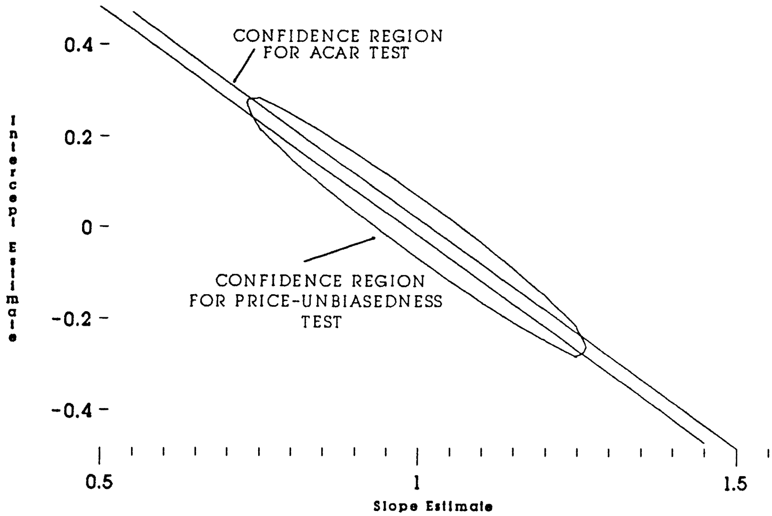

Figure 2. Statistical power of ACAR vs. price-unbiasedness tests. In the figure sigma = 0.11 and var(Ep') = 0.06. The graph shows that neither test of efficiency is uniformly more powerful than the other. The confidence regions are for 95% level of confidence.

Neither the *ACAR* nor the price-unbiasedness test has uniformly greater power than the other; relative power depends on the true parameter values. Some of the ambiguity about power arises because the price-unbiasedness test is based on regression, and like all regression tests depends in part on variation in the independent variable. If the null is false but the true parameters lie within the parallel lines, then with a large enough var(Ep_i'), the critical region for the null will not overlap with that for the true parameters,[27] and the price-unbiasedness test will be superior in terms of power.[28]

IV. Estimation Procedures

The error structure assumed above was for illustrative purposes only. The following sections delineate the estimation procedures under more compli-

[27] Save in the case where the true $b = 1$ and the true a is not equal to zero.

[28] For the size of the test, consider the implications of Figure 2 comparing the price-unbiasedness critical region with the parallel lines. The null ellipse always lies partly outside the parallel lines. Over many repetitions, 95% of the observations will fall inside the true ellipse and will not be rejected by the price-unbiasedness test. Some of these same observations will fall outside the *ACAR* lines and will be erroneously rejected. Thus, among the less extreme outcomes (that is, those in the 95% ellipse), the *ACAR* is likely to reject the true null too frequently. On the other hand, some of the remaining 5% of realizations that fall outside the null's 95% ellipse will fall inside the parallel lines and will not lead to rejection of the null. Thus, overall, the *ACAR* test may have approximately the size users have in mind; this is consistent with simulation tests in Brown and Warner (1980, 1985).

cated error schemes; both market-model adjusted and market adjusted schemes are considered.

A. Market-Model Adjustment

Suppose that the rate of return on asset i in period t (from times t to $t + 1$) is

$$R_{it} = \alpha_i + \beta_i R_{Mt} + v_{it}, \tag{23}$$

where v_{it} is normal i.i.d. The estimated market model parameters are a_i and b_i. The out-of-sample forecast error AR_{it} is

$$AR_{it} = \alpha_i + \beta_i R_{Mit} + v_{it} - (a_i + b_i R_{Mit}) = u_{ai} + u_{bi} R_{Mit} + v_{it}, \tag{24}$$

where $u_{ai} = \alpha_i - a_i$ and $u_{bi} = \beta_i - b_i$, the subscript t now refers to time in the window rather than calendar time, and the asset i subscript on R_{Mit} shows that for any t in event time the R_{Mt} is likely different for assets i and j. The variance of AR_{it}, conditional on the realized R_{Mit} and assuming the out-of-sample vs are uncorrelated with the benchmark parameter estimation errors (u_{ai} and u_{bi}), is then

$$\sigma^2_{ARit} = \sigma^2_{uai} + \sigma^2_{ubi}(R_{Mit})^2 + 2\sigma_{uai,ubi} R_{Mit} + \sigma^2_{vit}; \tag{25}$$

this is the formula used in many later event studies to account for the fact that the market model parameters are estimated with error (Travlos (1987), Warner, Watts, and Wruck (1988)). The CAR for asset i for the event window of T_i periods is

$$\begin{aligned} CAR_{Ti} &= \Sigma_{t=1}^{Ti} AR_{it} = \Sigma_{t=1}^{Ti}(u_{ai} + u_{bi} R_{Mit} + v_{it}) \\ &= T_i u_{ai} + u_{bi} \Sigma_{t=1}^{Ti} R_{Mit} + \Sigma_{t=1}^{Ti} v_{it} \\ &= T_i u_{ai} + T_i u_{bi} R_{Mi} + \sum_{t=1}^{Ti} v_{it} \end{aligned} \tag{26}$$

and its variance is

$$\sigma^2_{\mathrm{CAR},T_i} = (T_i)^2 \sigma^2_{uai} + (T_i)^2 \sigma^2_{ubi}(R_{Mi})^2 + 2(T_i)^2 \sigma_{uai,ubi}(R_{Mi}) + T_i \sigma^2_{vi}, \tag{27}$$

where R_{Mi} is the sample mean of R_{Mit} over the window for asset i. Many event studies continue to use T_i times the formula in (25) for the variance, but recent discussions have proposed the formula in (27), or variants, to account for the fact that the market-model estimation errors are the same across each period in the event window for i.[29]

From (27), the error in the price-unbiasedness test is heteroskedastic across assets. Further, this error is correlated with the independent variable in (9) through the benchmark period's estimation error.[30] If the α_i and β_i are estimated, the price-unbiasedness test's dependent variable is $R_{Ti} = T_i \alpha_i +$

[29] See Karafiath and Spencer (1991), Mikkelson and Partch (1988), Salinger (1991), and Sweeney (1991).

[30] We are grateful to Imre Karafiath for initially raising this issue.

$T_\iota \beta_i R_{Mi} + \Sigma_{t=1}^{Ti} v_{it}$, the regressor is $R'_{Ti} = T_\iota a_i + T_\iota b_i R_{Mi}$ and the error is the $CAR_{Ti} = T_i u_{ai} + T_\iota u_{bi} R_{Mi} + \Sigma_{t=1}^{Ti} v_{it}$. Under Section III's illustrative assumption, $u_{ai} = u_{bi} = 0$, and $a_i = \alpha_\iota$ and $b_\iota = \beta_\iota$; with estimated market model parameters, the covariance of the independent variable and the error, $R'_{T\iota}$ and $CAR_{T\iota}$, is $\sigma_{\mathrm{CAR}i,R'Ti} = -(T_i)^2[\sigma^2_{uai} + \sigma^2_{ubi}(R_{M\iota})^2 + 2\sigma_{ua\iota,ubi}(R_{Mi})]$.

Intuitively, an overestimate of β_ι on average gives too large forecasts of returns (because the R_{Mi} is positive on average) and thus negative errors; this negative correlation biases downwards the OLS estimate of b in the price-umbiasedness regression. In graphs like Figure 1, large values of the independent variable are likely due in part to overestimates of the average return on that asset, and thus these points tend to lie below the 45° line, while small values of the independent variable are likely due to underestimates of the average rate of return, and thus these points tend to be above the 45° line; the estimated line is likely to have a slope less than unity and a positive intercept when there is in fact price-unbiasedness.

Test procedures must correct for both the heteroskedasticity in the errors and the bias in the estimates of the cross-sectional parameters a and b. In the absence of event clustering, dividing the dependent and independent variables by $\sigma'_{CAR\iota}$, the estimate of $\sigma_{CAR\iota}$, appropriately corrects for heteroskedasticity. Letting $R_{T\iota}/\sigma'_{CAR\iota} = r_{Ti}$, $R'_{Ti}/\sigma'_{CARi} = r'_{Ti}$, and $e'_\iota = e_i/\sigma'_{CAR\iota}$, then $r_{Ti} = r'_{T\iota} + e'_\iota$; the new error e'_ι now has a zero mean and unit variance. Thus, the transformed version of the price-unbiasedness equation (9) is

$$r_\iota = a + br'_\iota + e'_\iota; \tag{28}$$

price-unbiasedness implies $a = 0, b = 1$, as before. OLS *estimates* of b are biased down from unity and of a are biased up from zero because of correlation of the regressor r'_ι and the error e'_ι. Tests below use large-sample results; we calculate the bias's large-sample value and adjust OLS estimates for this bias. Appendix A discusses large-sample results for the bias.

It is also of some interest to test price-unbiasedness for a common T in event time, for example, 12 months. Some firms will have emerged from bankruptcy by this time, and others will not have returns observations available. Thus, the number of bonds or firms varies with T.

B. Market Model Parameter and Standard Error Estimation

Section V reports evidence of shifts in the market model parameter estimates around the bankruptcy announcement. We find a dramatic shift in the estimate of the average alpha, but no significant shift in the average beta estimate. To address this problem, we test for a zero *ACAR* and price-unbiasedness using four different estimates of alpha in the window: benchmark estimate, zero, (1 − Beta)*0.0075, (1 − Beta)*Trate.[31] Because our

[31] Trate is the yield to maturity (expressed in monthly terms) for a two-year Treasury security prevalent at the time each firm files for bankruptcy. The number 0.0075 is the (approximate) average three-month Treasury Bill YTM (expressed in monthly terms) during the 1980s.

benchmark beta estimates are likely to be very noisy estimates of the true betas, we also present results using market adjusted returns; moreover, some authors argue that market adjusted returns provide results approximately as good as market-model adjusted returns (Brown and Warner (1980, 1985)). For the market adjusted returns we assume that the true $\alpha = 0$ and $\beta = 1$ for each bond.[32] With this strong assumption, there is no bias in the intercept or slope estimates in the price-unbiasedness regression. 31,32

The standard error estimates for the case where benchmark alphas and betas are used to calculate excess returns are discussed below. The calculation of the standard errors with the other methods of computing excess returns are presented in Appendix B.

First, a conventional *ACAR* approach to standard errors uses $SE_{it} = s_{ARit} = [s_{uai}^2 + s_{ubi}^2(R_{Mit})^2 + 2s_{uai,ubi}R_{Mit} + s_{vi}^2]^{1/2}$, based on (25), with the variances and covariance taken as estimates from the market-model regression for i in the benchmark period. This standard error takes account of the estimation error in the market model parameter estimates, rather than simply using s_{vi}, but does not fully adjust for the estimation error, because it neglects the correlation of the effects of parameter estimation error across time in the window; we refer to this standard error as "partially adjusted for parameter estimation error." Studies using this approach define standardized abnormal returns for each period, $SAR_{it} = AR_{it}/SE_{it}$; they then form cumulative standardized abnormal returns, $CSAR_{T1,T2} = \Sigma_{t=T1}^{T2} SAR_{it}$, and test under the assumption that $CSAR_{T1,T2}/(T_2 - T_1)^{1/2}$ is distributed standardized normal. *CSAR*s averaged across the N assets are assumed to be distributed normally with mean zero and a standard deviation of $(1/N)^{1/2}$, under the assumption of no clustering.

Second, a number of papers (Mikkelson and Partch (1988), Karafiath and Spencer (1991), Salinger (1991), Sweeney (1991)) suggest a different standard error approach. These papers note that the errors in market model parameter estimates from the benchmark period for i affect all of i's window abnormal returns in the same way; they argue the standard errors should be adjusted to reflect this correlation of errors. The suggested approach is to find the cumulative abnormal return for i over T_i periods, $CAR_{i,Ti} = \Sigma_{t=1}^{Ti} AR_{it}$. From (27), the standard error of this *CAR* is $SE'_{i,T_i} = s_{CARi,Ti} = [(T_i)^2 s_{uai}^2 + (T_i)^2 s_{ubi}^2 (R_{Mi})^2 + 2(T_i)^2 s_{uai,ubi}(R_{Mi}) + T_i s_{vi}^2]^{1/2}$.[33] The standardized *CAR* is $SCAR_{i,Ti} = CAR_{i,Ti}/\mathrm{SE}'_{i,T}$; it is distributed $N(0,1)$. Mikkelson and Partch (1988) average the *SCARs* across the N assets; this gives an average standardized *CAR*, $ASCAR = (1/N)\Sigma_{i=1}^{N} SCAR_{i,Ti}$, which they argue is distributed $N(0, 1/N^{1/2})$. We refer to this approach as "fully adjusted for parameter estimation error."

[32] This assumption can be relaxed and the lack of a large sample bias in the intercept and slope estimates in the price-unbiasedness regression can be demonstrated (see Eberhart and Sweeney (1992)).

[33] This standard error depends critically on the ratio Ti/B_i, where B_i is the number of observations in the benchmark period. The importance of the ratio of the window to the benchmark period is stressed by Salinger (1991) and Sweeney (1991).

C. Choosing Benchmark Periods

Care must be shown in choosing the length of the benchmark periods and their position relative to the windows. There is the usual tradeoff: longer benchmark/estimation periods give more precise estimates but increase the danger of parameter nonstationarities. In addition, the characteristics of bonds' prices change over time as they come closer to maturity; this argues for shorter benchmark periods than otherwise, and for benchmark periods closer to the window. On the other hand, the bonds chosen for this study have all experienced bankruptcy. Their prices tend to show ex post downward trends before bankruptcy. Thus, market models fitted over this period are likely to give downward-biased estimates of α. Further, the bankrupt bonds clearly contain more of an equity component because their payoff heavily depends on the firm value at emergence; thus, the bonds may have higher betas than estimated in prebankruptcy-announcement benchmark periods. In Warner's (1977) sample, he finds post-bankruptcy estimated betas on average of approximately unity. These considerations argue both for care in interpreting results and for experiments using alternative market model parameters. With these considerations in mind, we chose a benchmark/estimation period of 24 months; this allowed us to calculate 23 monthly returns before the bankruptcy announcement month.

D. Sample Selection Bias

For our tests, it is important that no bonds with BG prices available on the bankruptcy announcement month be systematically excluded from the sample. For example, if only bonds with payoffs that are obtainable from popular sources of information (e.g., *Wall Street Journal*) are included, then our sample may be biased towards bonds that generated positive rates of return. In other words, greater investor interest in well performing bonds might imply more readily available information on the emergence payoff.[34] Conversely, firms that are quietly liquidated can disappear from popular information sources.

To counter this potential problem, we searched a wide variety of information sources (detailed in Section II) to ensure that every bond for which we could find a bankruptcy announcement month BG price (67 firms with 170 bonds) was accompanied by a payoff. The large variation in prices and payoffs, detailed below, suggests that selection bias is not a serious problem in this sample.

To allow for rigorous statistical inferences, two additional screens are used. First, the bond must have at least 15 monthly returns available before the bankruptcy announcement month. Having fewer than 15 returns is unlikely to produce reliable market model parameter estimates or standard errors. Second, the bond has to have BG prices available after the bankruptcy announcement. This allows us to test for a zero *ACAR* and price-

[34] We use the term emergence loosely; some of the firms liquidated or were acquired.

unbiasedness using the procedures outlined above. Specifically, we test the hypotheses of a zero *ACAR* and price-unbiasedness from the announcement month BG price through the last BG price available or the BG price at emergence, whichever comes first.[35]

These two screens reduce the sample from 67 firms with 170 bonds to 59 firms with 136 bonds, but no apparent bias is introduced. For the sample of 170 bonds, the average announcement month price is \$361.22 with a standard deviation of \$239.64, skewness of 0.719, and kurtosis of −0.526; the average price for the (sub)sample of 136 bonds is \$384.10 with a standard deviation of \$237.15, skewness of 0.644 and kurtosis of −0.656. The average prices are insignificantly different from one another (t = 1.12). The distribution of payoffs for the full sample versus the (sub)sample is also similar (full sample average payoff = \$537.87 with standard deviation of \$457.63, skewness of 0.515 and kurtosis of −1.017; the (sub)sample of 136 bonds average payoff = \$551.76 with standard deviation of \$460.01, skewness of 0.546 and kurtosis of −0.959). The average payoffs are insignificantly different from one another (t = 0.352). Figures 3–6 show the histograms of prices and payoffs for the sample of 170 bonds and the (sub)sample of 136 bonds.

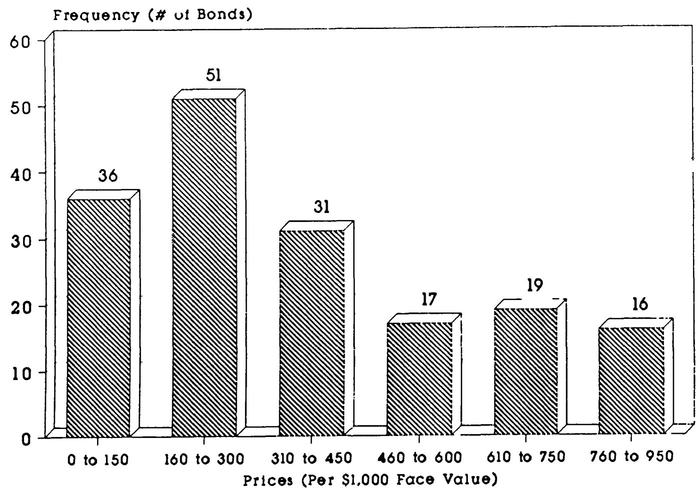

Figure 3. Histogram of sample bankruptcy announcement month prices. This is for the sample of 170 bonds (average = \$361.22; standard deviation = \$239.64; skewness = 0.719; kurtosis = −0.526).

[35] By stopping the event window at the last available BG price, we are providing a less direct test of the extent to which bankruptcy announcement month bond prices are unbiased forecasts of bankruptcy settlements. However, the correlation coefficient between the last available BG price and the bankruptcy settlement in 0.88, suggesting that the last available BG price is a reasonable proxy for the bankruptcy settlement (the correlation between the last BG price and the last pseudo price is 0.6).

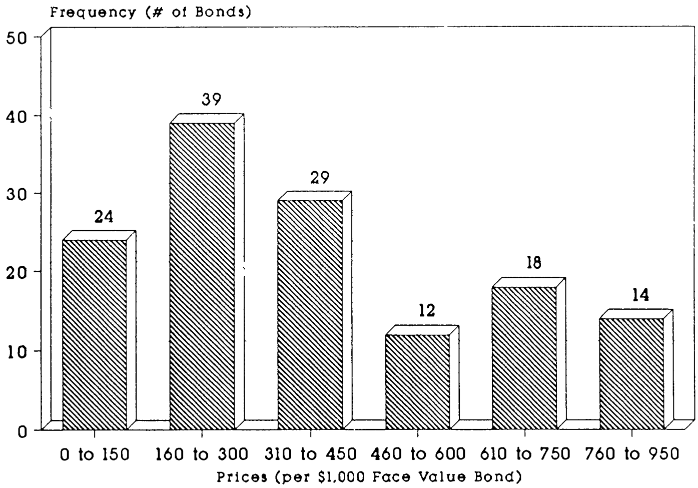

Figure 4. Histogram of sample bankruptcy announcement month prices. This is for the sample of 136 bonds (average = \$384.10; standard deviation = \$237.15; skewness = 0.644; kurtosis = −0.656).

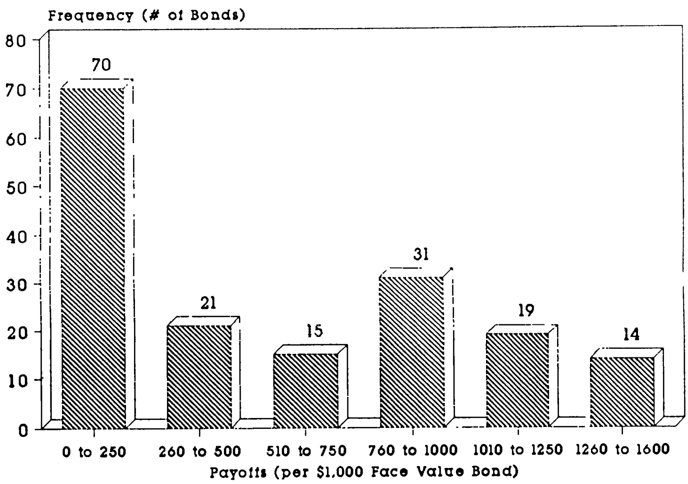

Figure 5. Histogram of sample bankruptcy emergence month payoffs. This is for the sample of 170 bonds (average = \$537.87; standard deviation = \$457.63; skewness = 0.515; kurtosis = −1.017).

V. Empirical Results

This section presents results for the *ACAR* and price-unbiasedness tests; these tests are conducted with a variety of market model parameter estimates and ways of forming standard errors. We also explore the sensitivity of inferences to whether the *ACAR* or price-unbiasedness test is used.

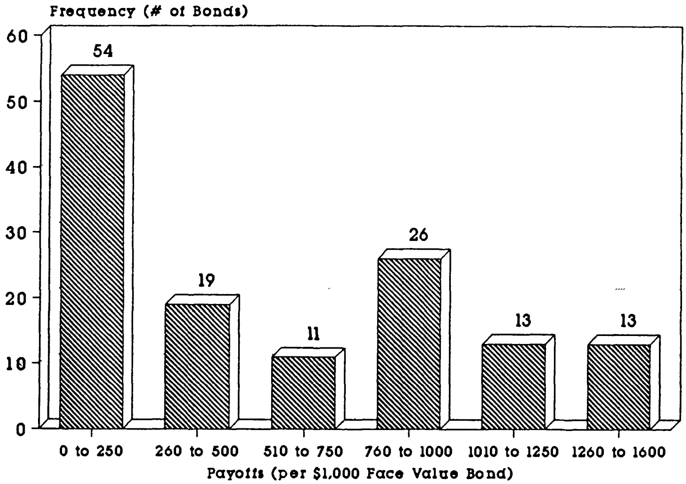

Figure 6. Histogram of sample bankruptcy emergence month payoffs. This is for the sample of 136 bonds (average = \$551.76; standard deviation = \$460.01; skewness = 0.546; kurtosis = −0.959).

A. Market Model Parameter Estimation

Both the *ACAR* and price-unbiasedness tests require estimation of the market model parameters. We used the CRSP value-weighted index for all empirical tests.[36] Bond returns include accrued interest until the bond is listed as trading flat or the bond is in default, whichever comes first.[37]

The average estimation/benchmark alpha is −20.279% per year (i.e., −0.016899*12*100). This is to be expected; the bonds in the sample are for firms that suffered enough financial distress to go into bankruptcy. These downward-biased αs will clearly cause an upward bias in market-model adjusted *ACARs*.[38] The average event/window alpha is 11.382% per year (i.e., 0.0094846*12*100); a simple t-test shows the average αs for the window and benchmark periods differ significantly ($t = 6.608$). In comparing beta estimates, the windows' average of 0.39312 is not significantly different from the 0.29238 of the benchmark period ($t = 0.844$).[39]

B. ACAR Tests

Table II shows some *ACAR* results for market-model adjustments. For comparison purposes, Panels A and B show results using α and β estimates

[36] Betker (1991) finds that his measurement of excess returns is insensitive to the use of the S & P 500 index or the junk bond index used and discussed in Blume, Keim, and Patel (1991).

[37] A bond will trade flat (i.e., with no interest payments) before a formal default date if the firm announces that it will be unable to make a coupon payment.

[38] Of course, using window α estimates would explain away the issue and is thus inadmissible.

[39] Results are similar for the sample of "one" bond per firm.

from benchmark periods, for the case where all bonds are used (Panel A) and the case where bonds are averaged to give "one" bond per firm (Panel B). With standard errors partially or fully corrected for parameter estimation error, the *ACAR* is positive, large, and highly significant; this is expected from the effect of selection bias on αs estimated in benchmark periods. Because the returns for bonds of the same firm tend to be positively correlated, the "all bonds" case overstates significance levels; the case where bonds are averaged for each firm understates significance levels because the returns for a given firm's bonds do not typically show perfect correlation.

Table II's Panels C and D show results for market-model adjusted returns with αs set to zero and βs set to benchmark period estimates. The average return is 19.8% (11.52% on an annual basis)[40] for the "all bonds" case; this is significant at the 1% level using a two-sided test with standard errors adjusted either partially or fully for parameter estimation error. The *ACAR* is 22% (12.54% on an annual basis) for the case where bonds from the same firm are averaged; this is significantly different from zero at the 1% level.[41] Of course, the Z-statistic is biased downward in the "one" bond case, but the bias is less severe than in the "all bonds" case given the high degree of correlation among bonds from the same firm (a random sampling of five firms generated an average correlation coefficient of 0.6). Moreover, the assumption of a zero α may be biasing the *ACAR* upwards, as suggested by test results reported in later tables.

C. Price-Unbiasedness Tests

The price-unbiasedness test results in Table II are generally consistent with the *ACAR* results. Panels E and F use benchmark αs and βs, similar to Panels A and B. Price-unbiasedness is rejected with both samples (although only at the 10% level in Panel F).[42]

Panels G and H set αs to zero and βs to benchmark values, as in Panels C and D. In Panel G price-unbiasedness is rejected, consistent with the *ACAR* result in Panel C. The results from the statistically more reliable sample of "one" bond per firm in Panel H, however, provide strong support for market efficiency. This is inconsistent with the *ACAR* result in Panel D and

[40] For the sample of "all bonds"/"one" bond per firm, there are 20.62/21.05 months on average between the bankruptcy announcement month and emergence, or the last trading month, whichever comes first.

[41] The difference in the *ACAR* between the two cases, where all bonds are used and only "one" bond per firm is used, result simply from the different weighting schemes of the 136 bonds; on average, the bonds from firms with many bonds did less well than those from firms with few or one bond.

[42] The coefficient estimates in the price-unbiasedness tests are not adjusted for bias. However, the hypothesized values in the F-test have been adjusted. Although not reported here, the large sample bias for the intercept and slope is small. The average value of the intercept bias is 0.31 and the average value of the slope bias is 0.08.

Table II

Efficiency Tests

This table reports the market efficiency test results from a sample of 59 firms (136 bonds) filing under Chapter 11 between 1980 and 1990. The first test asks whether the average cumulative abnormal return (*ACAR*) is significantly different from zero. The second is the price-unbiasedness test; this asks if the actual rate of return cross-sectionally regressed on the expected rate of return falls along a 45° line. The returns for both tests are measured from the bankruptcy announcement month through emergence, or the last trading month, whichever comes first.

ACAR Tests: Market Model Adjustment

Panel	Sample	Market Model Parameters[a] Alpha	Market Model Parameters[a] Beta	ACAR	Partially Adjusted Z-statistic[b]	Fully Adjusted Z-statistic[c]
A	All bonds (N = 136)	Benchmark	Benchmark	0.484	10.099*	7.599*
B	"One" bond per firm (N = 59)	Benchmark	Benchmark	0.581	8.275*	5.604*
C	All bonds (N = 136)	Zero	Benchmark	0.198	5.100*	4.548*
D	"One" bond per firm (N = 59)	Zero	Benchmark	0.220	3.397*	2.826*

Price-Unbiasedness Tests: Market Model Adjustment[d]

Model: $r_\iota = a + br'_\iota + e'_\iota$[e]

Panel	Sample	Market Model Parameters Alpha	Market Model Parameters Beta	Model Parameter Estimates Intercept	Slope	F-value	R^2
E	All bonds (N = 136)	Benchmark	Benchmark	0.851	0.891	5.856*	0.76
				(0.207)	(0.043)	(0.004)	
F	"One" bond per firm (N = 59)	Benchmark	Benchmark	1.071	0.847	2.525***	0.44
				(0.430)	(0.127)	(0.089)	
G	All bonds (N = 136)	Zero	Benchmark	0.209	1.045	3.489**	0.74
				(0.298)	(0.053)	(0.033)	
H	"One" bond per firm (N = 59)	Zero	Benchmark	0.286	1.029	0.886	0.42
				(0.684)	(0.159)	(0.418)	

Table II—*Continued*

* Significantly different from zero at the 1 percent level.

** Significantly different from zero at the 5 percent level.

*** Significantly different from zero at the 10 percent level.

[a] Benchmark refers to the use of market model parameters estimated from the 23-month period before the firm filed for bankruptcy. A minimum of 15 monthly returns is required.

[b] This is partially adjusted for parameter estimation error. When the benchmark αs and βs are used to compute abnormal returns, the standard error is $\mathrm{SE}_{it} = s_{\mathrm{AR}it} = [s_{uai}^2 + s_{ubi}^2(R_{Mit})^2 + 2s_{uai,ubi}R_{Mit} + s_{vi}^2]^{1/2}$, with the covariances taken as estimates from the market-model regression for i in the benchmark period. This standard error takes account of the estimation error in the market model parameter estimates, but does not fully adjust for the estimation error, because it neglects the correlation of the effects of parameter estimation error across time in the window. Standardized abnormal returns for each period are $\mathrm{SAR}_{it} = \mathrm{AR}_{it}/\mathrm{SE}_{it}$; cumulative standardized abnormal returns are $\mathrm{SCAR}_{T1,T2} = \sum_{t=T1}^{T2}\mathrm{SAR}_{it}$, assumed distributed standardized normal. CSARs averaged across the N assets are assumed to be distributed normally with mean zero and a standard deviation of $(1/N)^{1/2}$, under the assumption of no clustering. See Appendix B for the standard error calculations with the other methods of computing excess returns.

[c] This is fully adjusted for parameter estimation error. When the benchmark αs and βs are used to compute abnormal returns, the standard error of this CAR is $\mathrm{SE}'_{i,Ti} = s_{\mathrm{CAR}i,Ti} = [(Ti)^2 s^2_{uai} + (Ti)^2 s_{ubi}^2 (R_{Mi})^2 + 2(Ti)^2 s_{uai,ubi}(R_{Mi}) + Tis_{vi}^2]^{1/2}$. The standardized CAR is $\mathrm{SCAR}_{i,Ti} = \mathrm{CAR}_{i,Ti}/\mathrm{SE}_{i,T}$; it is distributed $N(0,1)$. Averaging the SCARs across the N assets gives an average standardized CAR, $\mathrm{ASCAR} = (1/N)\sum_{i=1}^{N}\mathrm{SCAR}_{i,Ti}$, which is distributed $N(0, 1/N^{1/2})$ if there is no clustering. See Appendix B for the standard error calculations with the other methods of computing excess returns.

[d] Standard errors of coefficients are in parentheses. The F-value is for the test of the joint hypothesis that the intercept equals zero and the slope equals unity (these hypothesized values have been adjusted for large sample bias); the probability of a larger F value is in parentheses.

[e] The variable r_i is the actual rate of return on firm/bond i; r_i' is the expected rate of return on firm/bond i. Both returns are standardized by their standard errors and measured from the bankruptcy announcement month through emergence, or the last trading date, whichever comes first.

lends credence to the argument that it is valuable to perform the price-unbiasedness test in concert with the *ACAR* test.

D. ACAR and Price-Unbiasedness Tests With Different Parameter Assumptions

Table III presents results for market-model adjusted returns, using benchmark βs and CAPM-inspired intercepts of $(1 - \beta)^*0.0075$ (Panels A, B, E, and F) and $(1 - \beta)^*$T-Note (Panels C, D, G, and H). The *ACAR* results in Panels A through D are all insignificantly different from zero, consistent with efficiency. In sharp contrast to this, the price-unbiasedness test result for the sample of all bonds in Panel G rejects the efficient market hypothesis; the F-value is significantly different from zero at the 1% level. Once again, this result reinforces the view that it is valuable to perform both tests of market efficiency. Of course, the positive correlation among bonds from the same firm biases the results against market efficiency, but this is also true for the *ACAR* result in Panel C that supports efficiency.

With the sample of "one" bond per firm in Table III's Panels F and H, the F-values are insignificantly different from zero at the 5% level (although the F-value is significant at the 10% level in Panel H). In fact, even with the sample of all bonds in Panel E in Table III, the hypothesis of efficiency is supported.

Table IV presents the market-model adjusted results with the bond returns calculated through the twelfth month in bankruptcy, emergence, or the last trading month,[43] whichever comes first. In Panels A and B, $\alpha = 0$, and in Panels C and D the $\alpha = (1 - \beta)^*$Trate; benchmark beta estimates are used in all panels. With the sample of all bonds, Panel A shows an *ACAR* of 7.8%; this is significant at the 1% level. When bonds from the same firm are averaged, however, the *ACAR* of 9.0% is insignificant even with only partial adjustment for parameter estimation error as shown in Panel B. In Panels C and D the *ACARs* are smaller in magnitude and insignificant.

The price-unbiasedness test results for the samples discussed above are presented in Panels E through H of Table IV. Panel E provides corroboration for the efficiency rejecting results presented in Panel A. With the sample of "one" bond per firm in Panel F, efficiency is not rejected at the 10% level. In Panel G efficiency is rejected, contradicting the *ACAR* result in Panel C; this provides another example where the *ACAR* test can lead the researcher to conclude that the market is efficient when in fact this may not be the case. With the sample of "one" bond per firm in Panel F, though, efficiency is not rejected.

Table V displays the market adjusted results. The results in every case, with both tests, provide strong support for efficiency. This suggests that the

[43] The last trading month is the last month for which a price is available in the BG.

efficiency rejecting results presented earlier may be the result of parameter estimation error.

VI. Summary and Conclusions

Corporate bankruptcy is a complicated process that takes an average of about two years to resolve. The resolution rarely adheres to the APR. This study shows the extent to which traded (i.e., usually junior claimants) bondholders benefit or are harmed by APR violations. The data indicate a large cross-sectional variation in benefit and harm but, on average, bondholders benefit, albeit slightly, from APR violations.

The paper also examines the degree to which the bond market, in the bankruptcy filing month, anticipates departures from the APR, as well as other influences on the bankruptcy emergence payoff to bondholders. In other words, we investigate the informational efficiency of the market for bankrupt bonds. This investigation is conducted with two types of tests. First, the well-known method of calculating a *CAR* for each bond/firm and then averaging across bonds/firms (i.e., forming an *ACAR*) is performed. Second, we test whether the price of a bond after bankruptcy is an unbiased estimate of its payoff upon settlement of the bankruptcy, or whether the post-announcement price, grossed up by factors reflecting the time value of money, risk, and market movements since the event date, is an unbiased estimate of the settlement price. We refer to this as the price-unbiasedness test; it is analogous to many efficiency tests in the macroeconomics literature. The test asks whether each pair of settlement price and event-date price (grossed up to reflect the time-value of money, risk, and subsequent market movements) falls along a 45° line. The price-unbiasedness test and the usual *ACAR* tests are not equivalent. If price-unbiasedness holds ex ante, $ACAR = 0$ also holds ex ante; an ex ante $ACAR = 0$ does not, though, imply price-unbiasedness. With any sample of returns, we demonstrate that neither test is uniformly more powerful than the other. Thus, it is important to do both to perform a more rigorous test of the efficient market hypothesis.

We test for a zero *ACAR* and price-unbiasedness using a sample of all 136 bonds and a sample where we average all bonds from the same firm (i.e., use "one" bond for each of the 59 firms). Because of high correlation among bonds from the same firm, we view the sample of "one" bond per firm as statistically more reliable. The market efficiency tests are performed under a number of different scenarios concerning market model parameters and the calculation of standard errors. Overall, we find zero *ACARs* and price-unbiasedness. We report several cases, though, where the results are not consistent with market efficiency. In some cases both tests reject market efficiency and in others one supports market efficiency but the other does not. We think these results are less convincing than the results that support market efficiency because the results rejecting efficiency generally occur with the sample of all bonds. Finally, we have not accounted for transaction costs; these are un-

Table III

Efficiency Tests

This table reports the market efficiency test results from a sample of 59 firms (136 bonds) filing under Chapter 11 between 1980 and 1990. The first test asks whether the average cumulative abnormal return (ACAR) is significantly different from zero. The second is the price-unbiasedness test; this asks if the actual rate of return cross-sectionally regressed on the expected rate of return falls along a 45° line. The returns for both tests are measured from the bankruptcy announcement month through emergence, or the last trading month, whichever comes first.

ACAR Tests: Market Model Adjustment						
		Market Model Parameters[a]			Partially Adjusted	Fully Adjusted
Panel	Sample	Alpha†	Beta	ACAR	Z-statistic[b]	Z-statistic[c]
A	All bonds (N = 136)	$(1-\beta)0.0075$	Benchmark	0.093	1.130	1.015
B	"One" bond per firm (N = 59)	$(1-\beta)0.0075$	Benchmark	0.123	1.116	1.000
C	All bonds (N = 136)	$(1-\beta)$Trate	Benchmark	0.100	1.225	−0.864
D	"One" bond per firm (N = 59)	$(1-\beta)$Trate	Benchmark	0.125	1.031	1.009

Table III—*Continued*

Price-unbiasedness Tests: Market Model Adjustment[d]
Model: $r_\iota = a + br'_\iota + e'^{e}_\iota$

		Market Model Parameters		Model Parameter Estimates			
Panel	Sample	Alpha†	Beta	Intercept	Slope	F-value	R^2
E	All bonds (N = 136)	$(1-\beta)$0.0075	Benchmark	0.053 (0.296)	1.007 (0.049)	0.807* (0.448)	0.76
F	"One" bond per firm (N = 59)	$(1-\beta)$0.0075	Benchmark	0.000 (0.705)	1.039 (0.150)	0.569 (0.569)	0.46
G	All bonds (N = 136)	$(1-\beta)$Trate	Benchmark	0.970 (0.334)	0.763 (0.054)	5.879* (0.004)	0.59
H	"One" bond per firm (N = 59)	$(1-\beta)$Trate	Benchmark	−0.421 (0.611)	1.178 (0.127)	2.724*** (0.074)	0.60

See Table II for footnote explanations.

† Trate is the yield to maturity (expressed in monthly terms) for a two-year Treasury security prevalent at the time each firm filed for bankruptcy; 0.0075 is the (approximate) average three-month Treasury Bill rate during the 1980s.

Table IV

Efficiency Tests

This table reports the market efficiency test results from a sample of 59 firms (136 bonds) filing under Chapter 11 between 1980 and 1990. The first test asks whether the average cumulative abnormal return (ACAR) is significantly different from zero. The second is the price-unbiasedness test; this asks if the actual rate of return cross-sectionally regressed on the expected rate of return falls along a 45° line. The returns for both tests are measured from the bankruptcy announcement month through the 12th month in bankruptcy, emergence, or the last trading month, whichever comes first.

ACAR Tests: Market Model Adjustment

Panel	Sample	Market Model Parameters[a] Alpha†	Beta	ACAR	Partially Adjusted Z-statistic[b]	Fully Adjusted Z-statistic[c]
A	All bonds (N = 136)	Zero	Benchmark	0.078	3.863*	3.281*
B	"One" bond per firm (N = 59)	Zero	Benchmark	0.090	1.550	1.443
C	All bonds (N = 136)	$(1-\beta)$Trate	Benchmark	0.035	1.018	−0.971
D	"One" bond per firm (N = 59)	$(1-\beta)$Trate	Benchmark	0.046	−0.089	−0.445

Table IV—*Continued*

Price-Unbiasedness Tests: Market Model Adjustment[d]
Model: $r_\iota = a + br'_\iota + e'^{e}_\iota$

		Market Model Parameters		Model Parameter Estimates			
Panel	Sample	Alpha†	Beta	Intercept	Slope	F-value	R^2
E	All bonds (N = 136)	Zero	Benchmark	−0.047 (0.339)	1.069 (0.055)	3.448** (0.035)	0.74
F	"One" bond per firm (N = 59)	Zero	Benchmark	−0.306 (0.823)	1.127 (0.162)	1.124 (0.332)	0.46
G	All bonds (N = 136)	$(1 - \beta)$Trate	Benchmark	0.985 (0.386)	0.789 (0.058)	3.838** (0.024)	0.58
H	"One" bond per firm (N = 59)	$(1 - \beta)$Trate	Benchmark	−0.774 (0.699)	1.188 (0.127)	2.363 (0.103)	0.61

See Table II for footnote explanations.

† Trate is the yield to maturity (expressed in monthly terms) for a two-year Treasury security prevalent at the time each firm filed for bankruptcy; 0.0075 is the (approximate) average three-month Treasury Bill rate during the 1980s.

Table V

Efficiency Tests

This table reports the market efficiency test results from a sample of 59 firms (136 bonds) filing under Chapter 11 between 1980 and 1990. The first test asks whether the average cumulative abnormal return (ACAR) is significantly different from zero. The second is the price-unbiasedness test; this asks if the actual rate of return cross-sectionally regressed on the expected rate of return falls along a 45° line. The returns for both tests are measured from the bankruptcy announcement month through emergence, or the last trading month, whichever comes first.

ACAR Tests: Market Adjustment

		Market Model Parameters[a]				
Panel	Sample	Alpha	Beta	ACAR	Partially Adjusted Z-statistic[b]	Fully Adjusted Z-statistic[c]
A	All bonds ($N = 136$)	Zero	Unity	0.086	0.006	−0.574
B	"One" bond per firm ($N = 59$)	Zero	Unity	0.078	−0.259	−0.135
C	All bonds ($N = 136$)	Zero	Unity	0.042	−0.420	−1.264
D	"One" bond per firm ($N = 59$)	Zero	Unity	0.003	−1.468	−1.015

Table V—*Continued*

Price-Unbiasedness Tests: Market Adjustment[d]
Model: $r_\iota = a + br'_\iota + e'_\iota$[e]

		Market Model Parameters		Model Parameter Estimates			
Panel	Sample	Alpha	Beta	Intercept	Slope	F-value	R^2
E	All bonds (N = 136)	Zero	Unity	−0.271 (0.319)	1.049 (0.052)	0.465 (0.629)	0.75
F	"One" bond per firm (N = 59)	Zero	Unity	−0.372 (0.706)	1.087 (0.141)	0.191 (0.826)	0.51
G	All bonds (N = 136)	Zero	Unity	−0.316 (0.358)	1.040 (0.053)	0.393 (0.676)	0.74
H	"One" bond per firm (N = 59)	Zero	Unity	− 0.600 (0.808)	1.098 (0.138)	0.293 (0.747)	0.53

See Table II for footnote explanations.

In Panels C, D, G, and H, the bond returns are calculated through emergence, the last trading month, or the 12th month in bankruptcy, whichever comes first.

likely to be small and any abnormal returns that appear to be available could easily be erased by these costs.

Appendix A: Bias in Cross-Sectional Parameter Estimates[44]

Dividing the data by σ'_{CARi}, the estimate of σ_{CARi}, appropriately corrects for heteroskedasticity. Letting $R_{Ti}/\sigma'_{CARi} = r_{Ti}$, $R'_{Ti}/\sigma'_{CARi} = r'_{Ti}$, and $e'_i = e_i/\sigma'_{CARi}$, then $r_{Ti} = r'_{Ti} + e'_i$; the error e'_i is mean zero with unit variance. In the price-unbiasedness equation, $r_i = a + br'_i + e'_i$, price-unbiasedness implies $a = 0, b = 1$. Because r'_i and e'_i are correlated, OLS *estimates* of b are biased down from unity and of a are biased up from zero. In this paper's tables, the reported F-tests compare OLS estimates to $a = 0, b = 1$ after these hypothesized values are adjusted for large-sample values of the biases. In finding the large-sample bias, two cases are important: (a) the researcher believes that benchmark parameter estimates are unbiased; (b) the researcher believes that benchmark parameter estimates are biased (in this paper's case, the estimates of αs, because the bonds considered are issued by firms that have gone into bankruptcy).

The bias in the OLS estimate of b is

$$\text{bias} = \{\Sigma_{i=1}^{N}[(r'_i - r')e'_i]\}/\{\Sigma_{i=1}^{N}(r'_i - r')^2\}, \tag{A1}$$

where r' is the sample mean of r'_i. If the researcher believes that the benchmark parameter estimates are unbiased, then benchmark estimates of both α and β are used in calculating abnormal returns in the window. The out-of-sample forecast for period t is $R'_{it} = a_i + b_i R_{Mit}$; the out-of-sample forecast error conditional on market movements is

$$AR_{it} = \alpha_i + \beta_i R_{Mit} + v_{it} - (a_i + b_i R_{Mit}) = u_{ai} + u_{bi} R_{Mit} + v_{it}, \tag{A2}$$

where $u_{ai} = \alpha_i - a_i$ and $u_{bi} = \beta_i - b_i$, the error v_{it} is iid with variance σ_{vi}^2, the subscript t now refers to window rather than calendar time, and the asset i subscript on R_{Mit} shows that for any t in event time the R_{Mt} is likely different for assets i and j. The cumulative abnormal return is

$$CAR_{Ti} = \Sigma_{t=1}^{Ti} AR_{it} = \Sigma_{t=1}^{Ti}(u_{ai} + u_{bi} R_{Mit} + v_{it}) = T_i u_{ai} + T_i u_{bi} R_{Mi} + \Sigma_{t=1}^{Ti} v_{it} \tag{A3}$$

and the *CAR*'s variance is

$$\sigma_{CARi}^2 = (T_i)^2\left[\sigma_{uai}^2 + \sigma_{ubi}^2 (R_{Mi})^2 + 2\sigma_{uai,ubi}(R_{Mi}) + \sigma_{vi}^2/T_i\right], \tag{A4}$$

[44] This appendix briefly summarizes the discussion in Eberhart and Sweeney (1992).

where R_{Mi} is the sample mean of R_{Mit} over the window for asset i. Focus on the numerator of the slope's bias,

$$\Sigma_{i=1}^{N}(r_i' - r)e_i' = \Sigma_{i=1}^{N}(r_i')e_i' - \Sigma_{i=1}^{N} r'e_i'$$
$$= \Sigma_{i=1}^{N}(R_{Ti}'CAR_{Ti})/\sigma_{CARi}'^{2} - \{\Sigma_{i=1}^{N} r'CAR_{Ti}/\sigma_{CARi}']\}. \quad \text{(A5)}$$

As the T_i and B_i go to infinity, the plim of the numerator is

$$-\left[\Sigma_{i=1}^{N}(T_i)^2\sigma_{uai}^2 + (T_i)^2\sigma_{ubi}^2(R_{Mi})^2 + 2(T_i)^2\sigma_{uai,ubi}(R_{Mi})\right]/\sigma_{CARi}^2 + (1/N)$$
$$\cdot \Sigma_{i=1}^{N}\left[(T_i)^2\sigma_{uai}^2 + (T_i)^2\sigma_{ubi}^2(R_{Mi})^2 + 2(T_i)^2\sigma_{uai,ubi}(R_{Mi})\right]/\sigma_{CARi}^2$$
$$= -\Sigma_{i=1}^{N}[1 - 1/N]\left[\sigma_{uai}^2 + \sigma_{ubi}^2(R_{Mi})^2 + 2\sigma_{uai,ubi}(R_{Mi})\right]/\left[\sigma_{uai}^2\right.$$
$$\left. + \sigma_{ubi}^2(R_{Mi})^2 + 2\sigma_{uai,ubi}(R_{Mi}) + \sigma_{vi}^2/T_i\right]$$
$$= -\Sigma_{i=1}^{N}[1 - 1/N]\left[1 + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi})\right]/\left[1\right.$$
$$\left. + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi}) + B_i/T_i\right], \quad \text{(A6)}$$

where there is no event clustering, var$'(R_{MBi})$ and R_{MBi} are the sample variance and mean of the market rate of return over the *benchmark* period for i, B_i is the number of observations in the benchmark period for i, and the results use the well known formulas for parameter variances and covariances under OLS. The plim of the denominator of the bias is

$$\left\{\Sigma_{i=1}^{N}[1 - 1/N]\left[1 + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi})\right]/\left[1\right.\right.$$
$$\left.\left. + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi}) + B_i/T_i\right]\right\} + \left\{\Sigma_{i=1}^{N}[Er_i' - Er']^2\right\}, \quad \text{(A7)}$$

where $Er_i' = (\alpha_i + B_i R_{mi})T_i/\sigma_{CARi}$ and $Er' = (1/N)\Sigma_{i=1}^{N} Er_i'$.

The plim of the bias in this case is

$$\text{plim bias} = -\left\{\Sigma_{i=1}^{N}[1 - 1/N]\left[1 + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi})\right]/\left[1\right.\right.$$
$$\left.\left. + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi}) + B_i/T_i\right]\right\} / \left\{\Sigma_{i=1}^{N}[1 - 1/N]\left[1\right.\right.$$
$$\left. + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi})\right] / \left\{\Sigma_{i=1}^{N}\left[1\right.\right.$$
$$\left. + (R_{MBi} - R_{Mi})^2/\text{var}'(R_{MBi}) + B_i/T_i\right]$$
$$\left. + \Sigma_{i=1}^{N}[Er_i' - Er']^2\right\} \geq -1. \quad \text{(A8)}$$

where the inequality holds since $[Er_i' - Er']^2 \geq 0$ for all i. Thus, $0 \leq \text{plim}\, b' \leq 1$. The properties of plim b' depend crucially on the ratios B_i/T_i. As all ratios B_i/T_i go to infinity, plim bias goes to zero and plim b' to $b = 1$. As all the ratios B_i/T_i go to zero, plim bias goes to $-(N-1)/\{(N-1) + \Sigma_{i=1}^{N}[Er_i' - Er']^2\} \geq -1$, and plim b' goes to $1 - (N-1)/\{(N-1) + \Sigma_{i=1}^{N}[Er_i' - Er']^2\} \geq 0$; using *av* for the average value of $[Er_i' - Er']^2$, in large samples *av* is constant as N rises, and the plim bias of $-1/\{1 +$

$Nav/(N - 1)\}$ goes to $-1/(1 + av)$ as N grows large.[45] In this latter case, plim b' goes to $av/(1 + av)$, which sets a lower bound on plim b'.

This discussion assumes that benchmark estimates of α_i are used to form market-model adjusted returns in the event window. As the text discusses, using benchmark estimates of α_i is unwise in a study, such as this paper, that uses selection criteria that are likely to result in choosing assets with biased estimates of α; the prices of bonds of companies that ultimately go into bankruptcy are likely to show ex post negative trends in the benchmark period that on average give downward biased estimated αs. Tables discussed in the text show results under two (basic) assumptions, that the window $\alpha_i = 0$ and that the window $\alpha_i = (1 - \beta_i)^* r_{fi}$, where r_{fi} is a risk-free rate chosen to correspond to the period of firm i's bankruptcy.[46] As before, if all B_i are large relative to T_i, and N is large, the plim bias is zero; if all T_i are large relative to B_i, and N is large, then plim $b' = av/(1 + av)$. It appears that the large-sample bias is much the same under the various assumptions that might be made.

Appendix B: Standard Errors of Abnormal Returns

The text presents the standard error estimates when benchmark αs and βs are used to compute abnormal returns. Listed below are the standard error calculations for the other methods of computing abnormal returns. The Z-statistic calculation follows the same procedure as outlined in the text.[47]

Alpha = 0, *Beta* = *Benchmark*
Partial Adjustment for Parameter Estimation Error: $\mathrm{SE}_{it} = s_{ARit} = [s^2_{ubi}(R_{Mit})^2 + s^2_{vi}]^{1/2}$.
Full Adjustment for Parameter Estimation Error: $\mathrm{SE}'_{i,Ti} = s_{CARi,Ti} = [(Ti)^2 s^2_{ubi}(R_{Mi})^2 + Tis^2_{vi}]^{1/2}$.

Alpha = (1 − *Beta*)*0.0075, *Beta* = *Benchmark*
Partial Adjustment for Parameter Estimation Error: $\mathrm{SE}_{it} = s_{ARit} = [s^2_{ubi}(0.0075 - R_{Mit})^2 + s^2_{vi}]^{1/2}$.
Full Adjustment for Parameter Estimation Error: $\mathrm{SE}'_{i,Ti} = s_{CARi,Ti} = [(Ti)^2$
$\mathrm{s}^2_{\mathrm{ubi}}(0.0075 - \mathrm{R}_{\mathrm{Mi}})^2 + \mathrm{Tis}^2_{vi}]^{1/2}$.

Alpha = (1 − *Beta*)**Trate*, *Beta* = *Benchmark*
Partial Adjustment for Parameter Estimation Error: $\mathrm{SE}_{it} = s_{ARit} = [s^2_{ubi}(\mathrm{Trate} - R_{Mit})^2 + s^2_{vi}]^{1/2}$.
Full Adjustment for Parameter Estimation Error: $\mathrm{SE}'_{i,Ti}$
$= \mathrm{s}_{\mathrm{CARi,Ti}} = [(\mathrm{Ti})^2 \mathrm{s}^2_{\mathrm{ubi}}(\mathrm{Trate} - \mathrm{R}_{\mathrm{Mi}})^2 + \mathrm{Tis}^2_{vi}]^{1/2}$.

[45] In the empirical tests, r_i' and r' are used as estimates of Er_i' and Er'.

[46] The risk-free rate is approximated by Trate and 0.0075 (as explained in the text).

[47] In all cases, s^2_{vi} is the market model residual variance from the benchmark period (as also used in the text).

Alpha = 0, *Beta* = 1
"Partial Adjustment for Parameter Estimation Error": $\mathrm{SE}_{it} = s_{ARit} = s_{vi}$.
"Full Adjustment for Parameter Estimation Error": $\mathrm{SE}_{i,Ti} = s_{CARi,Ti} = [Tis_{vi}^2]^{1/2}$.

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