A Reexamination of Firm Size, Book-to-Market, and Earnings Price in the Cross-Section of Expected Stock Returns

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Abstract

This paper reexamines the explanatory power of beta, firm size, book-to-market equity, and the earnings-price ratio for average stock returns, correcting two currently controversial biases: selection bias in COMPUSTAT and the errors-in-variables (EIV) bias. After filling in the missing data on COMPUSTAT with the Moody's sample, I do not find any significantly different results for book-to-market equity from using the COMPUSTAT sample only. After correcting for the EIV bias, I find stronger support for the beta pricing theory than previous studies. Regardless of the presence of firm size, book-to-market equity, and earnings-price ratios, betas have significant explanatory power for average stock returns. In particular, firm size is barely significant using monthly returns, but no longer significant using quarterly returns. However, book-to-market equity still has significant explanatory power for average stock returns, even though the EIV bias is corrected.

I. Introduction

The primary implication of the capital asset pricing model by Sharpe (1964), Lintner (1965), and Black (1972) is the mean-variance efficiency of the market portfolio. Put differently, there exists a positive linear relation between ex ante expected returns and market betas, and variables other than beta should not have power in explaining the cross-section of expected returns.

Contrary to the predictions of the CAPM model, previous empirical studies have found that idiosyncratic factors have significant explanatory power for average stock returns, while beta has little power. The most prominent idiosyncratic factors are firm size, book-to-market equity (B/V), and earnings-price (E/P) ratio. Banz (1981), Reinganum (1981), and Keim (1983) find that small (large) firms have greater (smaller) returns than those predicted by the CAPM model.[1] Jegadeesh

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[1]Berk (1995) argues that since firm size-related variables always explain any unmeasured risk, previous findings regarding the size effect should be interpreted as evidence of model misspecifications rather than an *anomaly*.

(1992) argues that beta does not explain the cross-sectional differences in average returns when the test portfolios are constructed so that the correlations between beta and firm size are small. Since Fama and French (1992), (1993), (1996), book-to-market equity has emerged as another strong contradiction to the CAPM model. Rosenberg, Reid, and Lanstein (1985), Chan, Hamao, and Lakonishok (1991), Fama and French (1992), Davis (1994), and Kothari and Shanken (1995) report that firms with greater book-to-market equity earn greater risk-adjusted returns. That is, there is a significant positive relation between book-to-market equity and beta risk-adjusted returns. Basu (1977), (1983) and Reinganum (1981) report that excess returns on common stocks are a monotone increasing function of their E/P ratios.[2]

Most empirical tests that have found those contradictions to the CAPM model, however, involve an errors-in-variables (EIV) problem, since true betas are unobservable and, thus, estimated betas are used as a proxy for the unobservable betas. Handa, Kothari, and Wasley (1989) and Kim (1995) show that the EIV problem induces an underestimation of the price of beta risk and an overestimation of the other cross-sectional regression (CSR) coefficients associated with idiosyncratic variables that are observed without error such as firm size, book-to-market equity, and E/P. A greater correlation between the estimated betas and the idiosyncratic variables causes more downward bias in the price of beta risk estimate and more exaggeration of the explanatory power of the idiosyncratic variable.

Several estimation methods have been developed to correct the EIV problem. Litzenberger and Ramaswamy (1979), Shanken (1992), and Kim (1995) suggest consistent estimation methods within the two-pass test methodology, and Gibbons (1982), and McElroy and Burmeister (1988) jointly estimate asset risk factors and their associated risk prices. In particular, Kim suggests a correction method for the EIV problem that arises in Fama and MacBeth's (1973) two-pass test methodology, and provides direct correction factors for the least squares CSR coefficients in certain circumstances. Kim's correction is most useful when all available *individual* assets (without forming portfolios) are used in the CSR estimation, since his estimators for the CSR coefficients are N-consistent (i.e., consistent when the time-series sample size, T, is fixed and the number of assets, N, is allowed to increase without bound). Kim's correction, therefore, provides a justification for the use of individual assets in asset pricing tests, which has been restricted due to the EIV problem.[3] In fact, use of individual assets has several advantages. First, it ensures the full utilization of information about the cross-sectional behavior of individual stocks, which might otherwise be lost in forming portfolios. Second, it avoids the data-snooping bias (Lo and MacKinlay (1990)). Third, most importantly, it avoids arbitrariness. According to the portfolio formation method and/or the number of portfolios used in the CSR estimation, the estimation results for risk premia are different (see, for example, Fama and French (1992), Jegadeesh (1992), and Kothari, Shanken, and Sloan (1995)).

[2]Fama and French (1992), however, show that the relation between E/P ratio and average return seems to be absorbed by the combination of firm size and book-to-market equity.

[3]The CSR estimation using individual assets is first performed by Litzenberger and Ramaswamy (1979).

Another problem involved with measuring the ability of the accounting variables such as book-to-market and earnings-price to predict returns is a selection bias induced by the manner in which COMPUSTAT includes firms in expanding its existing database. Kothari, Shanken, and Sloan (1995) argue that the potential source of the bias is in the COMPUSTAT "back-filling-in" procedure. In the practice of back-filling the missing data by COMPUSTAT, firms with relatively poor earnings (inducing low stock returns and high B/V) prior to the addition, but with good earnings and high stock returns on the year of the addition, are more likely to be added to the COMPUSTAT database. However, firms with consistently poor earnings are much less likely to be added. Firms that failed to report financial statements due to problems such as thin trading and financial distress, but recovered from the problems later, might retroactively report financial statements for the unreported period. In this case, COMPUSTAT might include data for the firms. However, COMPUSTAT might not include data for firms if they still suffer from the problems. This selection procedure tends to include firms with high B/V and subsequently high returns, but tends to exclude firms with high B/V and subsequently low returns. Kothari, Shanken, and Sloan, and Breen and Korajczyk (1994) argue that this might induce a (positive) upward bias in the CSR coefficient of the B/V variable and provide some indirect evidence that a portion of the significant explanatory power of book-to-market equity to average stock returns might be due to the selection bias.

The purpose of this paper is to reexamine whether firm size, B/V, and E/P still have significant explanatory power to average stock returns after correcting two possible biases: the EIV bias and the selection bias in COMPUSTAT for B/V and E/P. After correcting the EIV bias, Kim (1995) reports that betas have an economically and statistically significant positive relation with average stock returns, regardless of the presence of firm size, and that while the EIV correction leads to a diminished role of firm size, firm size remains a significant force in explaining average stock returns. However, Kim estimates risk premia assuming that all assets (portfolios or individual assets) have the *same* length of beta estimation period of five years. This assumption would be valid for the case of the estimation by portfolios because all portfolios have no missing return observations over the whole period. However, it could induce a selection bias in the case of the estimation by individual stocks because individual stocks having observations less than the predetermined beta estimation period of five years are excluded in the CSR estimation. In this paper, I allow the beta estimation period to be different across individual assets to avoid the selection bias, and estimate risk premia by using all individual stocks whose return observations are available for at least two years (three years) for the month-by-month (quarter-by-quarter) CSR estimation.

To investigate the effect of the selection bias in COMPUSTAT on book-to-market equity, Chan, Jegadeesh, and Lakonishok (1995) collect the missing book equity data on COMPUSTAT for the top 20% (by market capitalization) of NYSE and AMEX domestic primary companies. However, small (or large B/V) firms have more missing data and the selection bias caused by the COMPUSTAT practice of back-filling missing data is likely to be more serious for small firms. For this paper, I collected most of B/V and E/P data missing on COMPUSTAT for firms (except investment companies) from Moody's Industrial, Transportation, Utility, and Bank Manuals that also had stock return data in the Center for Research in Securities Prices (CRSP) database. This is the first paper that performs a direct test for Kothari, Shanken, and Sloan's (1995) selection bias hypothesis on COMPUSTAT.

I find that the selection bias in COMPUSTAT has no significant impact on the estimation for book-to-market equity. As expected, when the EIV bias is corrected, betas have a significant positive relation with average stock returns, regardless of the presence of firm size, book-to-market equity, and/or E/P in the model, and the explanatory power of the idiosyncratic variables to average stock returns decreases substantially. Remarkably, firm size is marginally significant in explaining average stock returns when monthly returns are used, but insignificant when quarterly returns are used. These results support market betas more strongly than does Kim (1995). E/P is also insignificant when betas are included. However, book-to-market equity still has significant explanatory power to average stock returns, even though the EIV bias is corrected.

The rest of the paper is organized as follows: Section II describes data and discusses the selection bias in COMPUSTAT. Section III describes the EIV correction procedure. Section IV presents empirical results, and Section V concludes.

II. The Selection Bias in COMPUSTAT

A. Data

All NYSE and AMEX firms listed on the CRSP monthly return file for at least two years during the period July 1958 to December 1993 and for at least one month after June 1963 were selected, and their stock return and firm size data (number of shares outstanding times price per share) were used. A total of 5,597 firms was thus obtained. In order to match return data with book value of common equity data from 1963 to 1993, annual returns of year y on these firms are calculated using monthly returns from July of year y through June of year $y + 1$ as long as at least one month's return data are available. Excluding investment companies (SIC codes of 6722, 6723, 6726), I find 74,000 firm-year return observations from 5,328 firms.[4] The one-month Treasury bill returns are taken from Ibbotson (1994) as the riskless returns.

Book value of common equity (or book equity) and earnings data are obtained first from the COMPUSTAT Primary, Supplementary, Tertiary, Full Coverage, and Research files (current and backdata in all files). I use the same definitions for book equity and earnings as in Fama and French (1992). Book equity and earnings were measured at the fiscal year-end in calendar year $y - 1$, and market value of common equity was measured at the end of December of year $y - 1$ and matched with accounting data for book-to-market and earnings-price values. The market value of common equity (or market equity) on June of year y was used to measure firm size. The annual returns in year y of the firms on the CRSP were matched with accounting ratios based on their latest CUSIP numbers (eight characters) on the CRSP and the CUSIP numbers on COMPUSTAT (six characters of CNUM +

[4]When return data are not needed to be matched with the accounting data (for example, the CSR estimation of returns on beta and firm size), these investment companies are included. Then, 76,202 firm-year return observations are available.

the first two digits of CIC) as the matching key.[5] Since most of the available book equity observations also have earnings data available, I focus on matching return data and book equity data to clarify the sample selection methodologies.

Among the 74,000 firm-year return observations on the CRSP, 58,745 are matched with book equity data from COMPUSTAT and the remaining 15,255 are missing on COMPUSTAT. Among these 15,255 missing data, 10,404 book equity data were hand-collected from Moody's (Industrial, Transportation, Utility, and Bank) Manuals but the other 4,851 were still not recovered.[6] Therefore, 79.4% of all necessary book-to-market equity (B/V) data were obtained from COMPUSTAT, and 14.0% were recovered from Moody's Manuals; 6.6% of the book-to-market equity data are still missing.

The shortest matching gap between the stock return data and the accounting data occurs when the fiscal year-end month is December. In this case, the gap spreads between six months and 18 months. The longest matching gap occurs when the fiscal year-end month is January. The gap spreads between 17 months and 29 months.[7] Assuming that all accounting information is available to the public six months after the fiscal year-end month, a matching gap greater than 18 months is unrealistic. In this case, the stock return data are being matched with old accounting information, despite the fact that new accounting information for the next fiscal year-end has already been released and made available. This kind of unrealistic match could occur for all firms whose fiscal year-end month is not December. To examine the effect of this unrealistic match, I matched stock return data with the most recent accounting data, assuming that all accounting data are available six months after the release. In this case, the matching gap for all firms is between six months and 18 months. However, I have failed to find significantly different results from the previous matching procedure. Therefore, I maintain the previous matching procedure.

B. Examining the Selection Bias

1. Data Frequency of the Samples across Firm Size

The whole period is divided into two subperiods: the first subperiod is from July 1963 to June 1972 (equivalently, from 1962 to 1970 for the accounting data), and the second subperiod is from July 1972 to December 1993 (equivalently, from 1971 to 1992 for the accounting data). The reason that the whole period (366 months or 31 years) is divided into the two subperiods (108 vs. 258 months or

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[5]The reasons for discrepancies in matching the CUSIPs of the CRSP and COMPUSTAT files discussed by Chan, Jegadeesh, and Lakonishok (1995) are not considered in this paper. As long as the CUSIP numbers are different, I assume that they are different entities.

[6]Based on the company names obtained from the CRSP, I track down the missing data by hand in Moody's Manuals in a conservative manner. If the tracking down of name changes is infeasible and book equity data in the financial statements are incomplete or look suspicious mainly due to bankruptcy, mergers, acquisitions, and reorganizations, I do not recover the missing data. In addition, the accounting data of ADRs are not recovered from Moody's Manuals since they are recorded in foreign currency.

[7]COMPUSTAT stores data in the former calendar year cell when the fiscal year-end month is prior to or equal to May, and in the latter calendar year cell when the fiscal year-end month is after May. For example, if the fiscal year is April 1990–March 1991, data are stored in the 1990 cell. If the fiscal year is October 1990–September 1991, data are stored in the 1991 cell.

9 vs. 22 years) is that, in the early years, COMPUSTAT has much more missing data than in the later years. Since it is uncertain which years and which companies are contaminated by the COMPUSTAT practice of back-filling the missing data and retroactively reporting financial statements, the extent of the contamination could be determined by counting the missing data on COMPUSTAT for each year. If COMPUSTAT has a large amount of missing data in a specific year, it could be argued that COMPUSTAT did not expand its database in that year and, thus, the data set in that year might be less contaminated. The year-by-year missing percentage of COMPUSTAT is not reported in this paper, since it is very similar to that in Table 1 of Chan, Jegadeesh, and Lakonishok (1995), although they use a different selection criteria for their firms. Instead, the statistics of the two subperiods are reported in Table 1.[8]

Table 1 presents the number of firm-year observations of the CRSP, COMPUSTAT, and Moody's samples across 10 firm size portfolios over the two subperiods in Panels A and B and over the whole period in Panel C. The break-points for the size portfolios are based on the market equity values on June of year y of the firms whose annual return data are available on the CRSP. By using the same CRSP break-points, firms in each sample are assigned into one of the 10 size portfolios according to their first available market equity value within the following one-year period (from July of year y through June of year $y + 1$).[9] The number of NYSE/AMEX firm-annual returns on the CRSP in each portfolio is listed in Column 1, and the numbers of book-to-market data on COMPUSTAT and on Moody's Manuals are also listed in Columns 2 and 4, respectively. Column 3 lists the number of firm years on the CRSP but not on COMPUSTAT (CRSP−COMPUSTAT), Column 5 lists the combined number of book-to-market data from both COMPUSTAT and Moody's Manuals (COMPUSTAT+Moody's), and Column 6 indicates the number of firm years on the CRSP but neither on COMPUSTAT nor on Moody's Manuals (CRSP−COMPUSTAT−Moody's). Numbers in parentheses indicate the number of negative book equity values.

Table 1 also reports that COMPUSTAT has 46.0% missing B/V data in the first subperiod but only 10.9% in the second subperiod. Further, 62% (or 9,442 firm years) of the total missing observations on COMPUSTAT (15,255 firm years) are concentrated over the shorter first subperiod. Another remarkable difference between these two subperiods is the average annual returns of the CRSP−COMPUSTAT sample. The average returns of the sample are 18.93% in the first subperiod and only 6.75% in the second subperiod. If COMPUSTAT expanded its database indiscriminately over the years, the average returns of the two subperiods should not differ this much because the average returns of the whole CRSP sample in the two subperiods are very similar (15.87% vs. 15.52%). It could be argued, based on these findings, that the COMPUSTAT data set of the second subperiod is more seriously contaminated. The second subperiod, therefore, might be more relevant to testing for the selection bias hypothesis by Kothari, Shanken, and Sloan (1995) than the first subperiod. However, the first subperiod is also

[8]I arbitrarily chose 1970 as the cut-off year for the subperiods because the missing percentage drastically decreases after 1970. I also tried 1968 and 1969 as the cut-off year, but the results did not change qualitatively.

[9]The number of firm years in each portfolio of the CRSP sample is, therefore, not necessarily equal.

TABLE 1

Number of Firm-Year Observations on the CRSP, COMPUSTAT, and Moody's Samples from 1963 to 1993

Size Portfolio	(1) CRSP	(2) COMPUSTAT	(3) CRSP− COMPUSTAT (1) − (2)	(4) Moody's	(5) COMPUSTAT + Moody's (2) + (4)	(6) Missing (1) − (5)
Panel A. July 1963–June 1972 Period						
1	2009	895 (19)	1114	875 (35)	1770 (54)	239
2	2079	1007 (10)	1072	843 (19)	1850 (29)	220
3	2113	1049 (6)	1064	807 (7)	1856 (13)	257
4	2106	1057 (3)	1049	776 (3)	1833 (6)	273
5	2113	1072 (1)	1041	765 (2)	1837 (3)	276
6	2087	1086 (0)	1001	757 (1)	1843 (1)	244
7	2065	1120 (0)	1945	733 (1)	1853 (1)	212
8	2023	1166 (0)	857	712 (0)	1878 (0)	145
9	1974	1257 (0)	717	673 (0)	1930 (0)	44
10	1946	1364 (0)	582	574 (0)	1938 (0)	8
Total	20515	11073 (39)	9442	7515 (68)	18588 (107)	1927
Proportion	100%	54.0%	46.0%	36.6%	90.6%	9.4%
Ann. Ret. (%)	15.87	13.26	18.93	21.49	16.58	9.08
Panel B. July 1972–December 1993 Period						
1	5327	4391 (298)	936	614 (63)	5005 (361)	322
2	5458	4567 (153)	891	459 (16)	5026 (169)	432
3	5457	4582 (107)	875	385 (5)	4967 (112)	490
4	5453	4670 (83)	783	270 (4)	4940 (87)	513
5	5401	4749 (74)	652	240 (1)	4989 (75)	412
6	5373	4849 (61)	524	229 (2)	5078 (63)	295
7	5370	4917 (43)	453	194 (3)	5111 (46)	259
8	5266	4962 (22)	304	185 (0)	5147 (22)	119
9	5205	4982 (11)	223	172 (0)	5154 (11)	51
10	5175	5003 (2)	172	141 (0)	5144 (2)	31
Total	53485	47672 (854)	5813	2889 (94)	50561 (948)	2924
Proportion	100%	89.1%	10.9%	5.4%	94.5%	5.5%
Ann. Ret. (%)	15.52	16.59	6.75	6.70	16.02	6.96
Panel C. July 1963–December 1993 Period (Whole Period)						
1	7336	5286 (317)	2050	1489 (98)	6775 (415)	561
2	7537	5574 (163)	1963	1302 (35)	6876 (198)	661
3	7570	5631 (113)	1939	1192 (12)	6823 (125)	747
4	7559	5727 (86)	1832	1046 (7)	6773 (93)	786
5	7514	5821 (75)	1693	1005 (3)	6826 (78)	688
6	7460	5935 (61)	1525	986 (3)	6921 (64)	539
7	7435	6037 (43)	1398	927 (4)	6964 (47)	471
8	7289	6128 (22)	1161	897 (0)	7025 (22)	264
9	7179	6239 (11)	940	845 (0)	7084 (11)	95
10	7121	6367 (2)	754	715 (0)	7082 (2)	39
Total	74000	58745 (893)	15255	10404 (162)	69149 (1055)	4851
Proportion	100%	79.4%	20.6%	14.0%	93.4%	6.6%
Ann. Ret. (%)	15.62	15.96	14.29	17.38	16.17	7.81

The break-points for the size portfolios are based on the market equity values on June of year y of the firms whose annual returns (using monthly returns from July of year y through June of year $y+1$ as long as at least one monthly return is available) are available on CRSP. By using the CRSP break-points, firms are assigned into one of the 10 size portfolios according to their first available market equity value within the one-year period. Portfolio 1 (10) represents the smallest (largest) size portfolio. Column (1) indicates the total number of NYSE-AMEX firm-annual returns on CRSP. Columns (2) and (4) indicate the number of firm-year observations whose book equity data on December at the fiscal year-end in calendar year $y-1$ are available on COMPUSTAT and Moody's Manuals, respectively. Column (3) indicates the number of firm-year observations on CRSP but not on COMPUSTAT (CRSP−COMPUSTAT). Column (5) represents the total number of available book-to-market data from both COMPUSTAT and Moody's Manuals, and Column (6) indicates the number of unrecovered data (CRSP−COMPUSTAT−Moody's). Numbers in parentheses indicate the number of firms whose book equity values are negative.

relevant in investigating the true relationship between stock returns and book-to-market, since this period is also contaminated by another type of selection bias. The selection bias in the first subperiod occurred because COMPUSTAT simply did not include a substantial portion of data, especially the data for small firms. Therefore, the selection bias in the second subperiod occurred from the practice of back-filling the missing data and of retroactively reporting financial statements, while the selection bias in the first subperiod occurred because much of the relevant data are simply not included and, thus, the sample size is small.

As Kothari, Shanken, and Sloan (1995) conjecture, the missing data problem on COMPUSTAT is more severe for smaller firms in both subperiods and in the whole period. For example, in the whole period, the smallest portfolio has 27.9% missing data, while the largest portfolio has 10.6% missing data. I find a monotone pattern of the missing data with firm size: the smaller the firm size, the more the missing B/V data. In the first subperiod, almost 80% of the missing data is recovered from Moody's Manuals, while in the second subperiod, approximately 50% is recovered. Overall, 68.2% of the missing data on COMPUSTAT is recovered from Moody's Manuals, and the combined sample (COMPUSTAT+Moody's) accounts for 93.4% of the CRSP data. More than 90% of the B/V data are available in any size portfolio of the combined sample in the whole period. In particular, 92% of the CRSP return data are matched with book equity data in the smallest portfolio. The fact that most small firms' B/V data are available is important in examining the selection bias issue, since this issue is more relevant to small firms. The unrecovered B/V data account for 6.6% of the CRSP data. Although the pattern of the unrecovered data is not monotone over firm size, relatively smaller firms have more missing book equity data.

2. Tests for the Selection Bias Hypothesis

According to the selection bias hypothesis of Kothari, Shanken, and Sloan (1995), the missing data on COMPUSTAT, CRSP−COMPUSTAT, should have higher book-to-market and lower average return than the COMPUSTAT sample because firms having higher book-to-market but lower returns are less likely to be included in COMPUSTAT. Thus, the collected Moody's sample should have higher book-to-market and lower return since Moody's sample represents a large portion of the CRSP−COMPUSTAT sample. In addition, the Moody's sample should have more frequently negative earnings since firms with consistently poor earnings are also less likely to be included when the COMPUSTAT database was expanded.

In order to test the selection bias hypothesis, I formed 10 equally-weighted decile size (B/V) portfolios by ranking the firms in each of the COMPUSTAT, Moody's, and combined (COMPUSTAT+Moody's) samples according to their market equity value in June of year y (book-to-market equity value in December of the fiscal year-end in calendar year $y-1$). Rankings are performed separately in each sample and in each period. If firms have a negative book equity value in a specific year, those firms are excluded in forming the size and B/V portfolios for that year and are assigned into B/V portfolio -1.

After constructing the portfolios, I calculated the time-series averages of monthly returns (in percent), beta, firm size (in million dollars), B/V, E/P(+), and

E/P dummy for each of the portfolios.[10] E/P(+) is defined as earnings divided by market equity if earnings are positive and zero otherwise, and E/P dummy is 1 if earnings are negative and 0 otherwise. Betas are estimated by regressing a portfolio's equally-weighted monthly time-series returns on the CRSP equally-weighted monthly market returns. The grand averages (the total sum of the variable divided by the total number of observations) are computed for each variable except for the beta variable. The grand average of the beta variable is the simple average of the beta estimates for the 10 portfolios. Table 2 presents the descriptive statistics of these variables from the COMPUSTAT, Moody's, and combined samples over the two subperiods (in Panels A and B, respectively) and the whole period (in Panel C). Table 3 also presents the time-series average monthly returns and betas of each of the decile size portfolios of the CRSP and the two missing samples: CRSP−COMPUSTAT and CRSP−COMPUSTAT−Moody's. These portfolios are formed using the same method as the COMPUSTAT and Moody's samples.

In the first subperiod (the pre-1970 period) of Panel A of Table 2, I find that the Moody's sample has greater average return and beta, smaller firm size, a little higher B/V value, and more frequent negative earnings (measured by the E/P dummy variable) than does the COMPUSTAT sample (Panel A of Table 2). The average return and beta of the COMPUSTAT sample are even lower than the CRSP and CRSP−COMPUSTAT samples (Table 3). These results are not consistent with the expectations from the selection bias hypothesis. Nonetheless, the results of the first subperiod are not necessarily interpreted as evidence against the COMPUSTAT selection bias hypothesis since the back-filling-in procedure was not common. As mentioned in the preceding section, in the early years, COMPUSTAT omitted a substantial portion of the NYSE/AMEX data. The results of the first subperiod, therefore, indicate that COMPUSTAT did not simply cover many small NYSE/AMEX firms in the early years that usually have high returns. The reason that the Moody's sample in this subperiod has greater return than the COMPUSTAT's is simply that it includes many small firms.

One piece of evidence that COMPUSTAT did not knowingly include financially troubled firms in expanding its database, is in Panel B of Table 2. In the second subperiod, the Moody's sample has more frequent negative earnings and smaller firm size relative to the COMPUSTAT sample than in the first subperiod. The firm size of the Moody's sample in the second subperiod is only about one-fifth of that of the COMPUSTAT sample, while in the first subperiod it is almost half. The average E/P dummy value of the Moody's sample is 0.24 in the second subperiod, indicating that 24% of all earnings reports are negative, while it is only 0.10 in the first subperiod. It could be argued, therefore, that much smaller firms having more frequent negative earnings and greater book-to-market values are not included in COMPUSTAT in the second subperiod (the post-1970 period).

In the second subperiod of Panel B of Tables 2 and 3, the COMPUSTAT sample has the higher monthly returns (1.36%) and lower risk ($\beta = 1.00$) than the

[10]Fama and French define earnings as income before extraordinary items plus income-statement deferred taxes minus preferred dividends. However, this definition cannot be used on the Moody's sample because the income statement on Moody's Manuals has only a "net earnings" item for most firms. Therefore, for earnings data obtained from Moody's Manuals, "net earnings" is used instead of using the Fama and French definition. Nonetheless, use of two different definitions of earnings for computing earnings price ratio does not make any significant difference in the cross-sectional spread.

TABLE 2

Time-Series Averages of the Characteristics of Portfolios: the COMPUSTAT and Moody's Samples from 1963 to 1993

	Sorted by Size (V)						Sorted by Book-to-Market (B/V)					
Portfolio	Return (%)	β	Size	B/V	E/P(+)	E/P Dummy	Return (%)	β	Size	B/V	E/P(+)	E/P Dummy
Panel A. July 1963–June 1972 Period (108 months)												
COMPUSTAT Sample (Number of firm years = 11,073)												
−1							3.53	1.45	14	−0.61	0.05	0.73
1	2.23	1.32	6	1.08	0.07	0.21	1.01	1.01	1019	0.17	0.03	0.07
2	1.62	1.26	14	0.88	0.08	0.14	0.97	0.98	635	0.29	0.04	0.04
3	1.57	1.20	27	0.83	0.08	0.09	1.04	0.94	367	0.38	0.05	0.03
4	1.24	1.06	44	0.89	0.08	0.05	1.15	0.89	418	0.47	0.06	0.05
5	1.24	1.04	69	0.82	0.08	0.04	1.14	0.88	392	0.55	0.07	0.02
6	0.94	0.90	107	0.69	0.07	0.02	1.21	0.91	366	0.64	0.07	0.03
7	0.93	0.79	182	0.66	0.07	0.01	1.27	0.93	294	0.75	0.08	0.04
8	0.84	0.76	309	0.59	0.06	0.01	1.34	0.92	217	0.91	0.09	0.04
9	0.71	0.61	574	0.58	0.06	0.00	1.65	1.01	154	1.18	0.09	0.08
10	0.60	0.54	2643	0.49	0.06	0.00	1.73	1.02	105	2.26	0.13	0.15
Grand Ave.	1.06	0.95	395	0.89	0.07	0.07	1.06	0.95	395	0.89	0.07	0.07
Moody's Sample (Number of firm years = 7,515)												
−1							2.92	1.55	16	−0.57	0.06	0.71
1	2.36	1.48	5	1.31	0.06	0.39	0.97	1.29	242	0.17	0.04	0.15
2	1.72	1.24	9	1.16	0.06	0.22	0.95	1.05	210	0.33	0.05	0.12
3	1.55	1.28	14	1.05	0.07	0.18	1.04	1.09	294	0.45	0.06	0.10
4	1.37	1.20	22	1.13	0.07	0.13	1.19	1.03	208	0.56	0.06	0.07
5	1.28	1.11	33	1.16	0.07	0.08	1.23	1.01	223	0.68	0.07	0.08
6	1.16	1.03	49	0.94	0.07	0.06	1.44	0.94	171	0.80	0.07	0.08
7	1.05	1.06	76	0.87	0.07	0.03	1.46	1.01	153	0.96	0.08	0.08
8	1.01	0.91	130	0.81	0.07	0.02	1.63	1.06	108	1.17	0.08	0.10
9	0.95	0.75	262	0.78	0.07	0.02	1.64	1.04	103	1.51	0.08	0.13
10	0.80	0.59	1170	0.71	0.07	0.01	1.81	1.11	79	3.35	0.09	0.22
Grand Ave.	1.73	1.07	176	1.00	0.07	0.10	1.73	1.06	176	1.00	0.07	0.10
t(C−M)[a]	(−12.6)	(−1.1)	(39.0)	(−6.6)	(1.5)	(−7.0)	(−12.6)	(−1.1)	(39.0)	(−6.6)	(1.5)	(−7.0)
COMPUSTAT+Moody's Samples (Number of firm years = 18,588)												
−1							3.23	1.45	14	−0.61	0.05	0.73
1	2.27	1.38	5	1.22	0.06	0.27	0.98	1.13	655	0.16	0.04	0.10
2	1.69	1.27	10	1.02	0.07	0.16	0.96	1.02	407	0.31	0.05	0.06
3	1.56	1.23	18	0.96	0.08	0.12	1.03	0.99	338	0.41	0.06	0.06
4	1.36	1.11	28	0.95	0.08	0.08	1.07	0.97	354	0.51	0.06	0.06
5	1.23	1.07	42	0.94	0.08	0.06	1.15	0.95	275	0.61	0.07	0.05
6	1.14	1.01	65	0.83	0.08	0.03	1.25	0.95	280	0.73	0.08	0.05
7	1.16	0.89	106	0.81	0.08	0.01	1.35	0.94	209	0.86	0.08	0.05
8	0.98	0.81	184	0.68	0.07	0.01	1.54	0.96	175	1.04	0.08	0.07
9	0.87	0.68	391	0.68	0.07	0.01	1.64	1.02	131	1.33	0.08	0.09
10	0.69	0.55	2025	0.56	0.06	0.00	1.75	1.07	81	2.74	0.11	0.18
Grand Ave.	1.33	1.00	306	0.93	0.07	0.08	1.33	1.00	306	0.93	0.07	0.08

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CRSP−COMPUSTAT sample (0.69% and 1.07, respectively). More importantly, the Moody's sample has much greater book-to-market value (2.01) and lower return (0.83% per month) than the COMPUSTAT sample (1.30 and 1.36% per month). This evidence is quite consistent with the selection bias hypothesis. Although the Moody's sample represents approximately half of the missing data on COMPUSTAT in the second subperiod (2,889 among 5,813 firm years), these results appear to be quite robust since the return and risk structure of the still-missing sample, CRSP−COMPUSTAT−Moody's, is similar to that of the CRSP−COMPUSTAT sample (see Table 3). In addition, the (grand) average monthly returns of the three samples, CRSP−COMPUSTAT, CRSP−COMPUSTAT−Moody's, and Moody's, are not noticeably different (0.69%, 0.57%, and 0.83%, respectively). It would be hard, therefore, to overturn the results of the second subperiod supporting the selection bias hypothesis even if the still-missing book equity data were all recov-

TABLE 2 (continued)

Time-Series Averages of the Characteristics of Portfolios: the COMPUSTAT and Moody's Samples from 1963 to 1993

	Sorted by Size (V)						Sorted by Book-to-Market (B/V)					
Portfolio	Return (%)	β	Size	B/V	E/P(+)	E/P Dummy	Return (%)	β	Size	B/V	E/P(+)	E/P Dummy
Panel B. July 1972–December 1993 Period (258 months)												
COMPUSTAT Sample (Number of firm years = 47,672)												
−1							1.82	1.48	114	−1.76	0.04	0.71
1	2.10	1.28	7	2.13	0.10	0.41	0.87	0.98	1554	0.26	0.09	0.10
2	1.41	1.17	18	1.77	0.14	0.24	1.06	1.00	1242	0.49	0.08	0.07
3	1.33	1.11	34	1.47	0.14	0.19	1.05	0.98	1000	0.65	0.09	0.08
4	1.35	1.08	58	1.43	0.12	0.15	1.15	0.96	889	0.81	0.09	0.09
5	1.27	1.05	99	1.27	0.12	0.13	1.07	0.92	825	0.96	0.10	0.09
6	1.28	1.03	172	1.17	0.11	0.09	1.35	0.91	756	1.11	0.11	0.10
7	1.36	0.93	314	1.13	0.11	0.08	1.41	0.94	694	1.30	0.12	0.12
8	1.24	0.87	580	0.97	0.12	0.07	1.61	0.98	577	1.53	0.13	0.16
9	1.19	0.80	1202	1.02	0.10	0.06	1.83	1.06	409	1.95	0.13	0.24
10	1.05	0.67	5429	0.80	0.09	0.03	1.90	1.23	197	2.69	0.14	0.34
Grand Ave.	1.36	1.00	765	1.30	0.12	0.15	1.36	1.00	765	1.30	0.12	0.15
Moody's Sample (Number of firm years = 2,889)												
−1							1.91	1.45	29	−3.04	0.14	0.76
1	1.82	1.46	2	2.94	0.09	0.60	0.15	1.19	293	0.33	0.10	0.33
2	1.20	1.36	6	2.61	0.10	0.46	0.06	1.06	354	0.68	0.09	0.26
3	0.95	1.22	11	2.60	0.13	0.34	0.13	0.94	341	0.93	0.09	0.21
4	0.73	1.12	16	2.53	0.13	0.29	0.91	0.99	293	1.20	0.10	0.20
5	0.39	1.14	27	2.39	0.10	0.25	0.45	1.12	253	1.50	0.11	0.19
6	0.51	1.20	42	2.35	0.13	0.20	1.10	0.96	172	1.85	0.13	0.15
7	0.72	1.11	75	2.26	0.14	0.16	0.58	1.02	101	2.34	0.12	0.26
8	0.57	0.83	135	2.19	0.14	0.18	0.81	1.09	92	2.74	0.14	0.28
9	0.50	0.79	267	1.39	0.10	0.06	1.26	1.21	66	3.40	0.12	0.31
10	0.96	0.69	1197	1.02	0.10	0.12	1.60	1.34	56	4.54	0.15	0.48
Grand Ave.	0.83	1.10	165	2.01	0.14	0.24	0.83	1.10	165	2.01	0.14	0.24
t(C−M)[a]	(6.0)	(−1.1)	(103.0)	(−15.4)	(−3.3)	(−11.9)	(6.0)	(−1.1)	(103.0)	(−15.4)	(−3.3)	(−11.9)
COMPUSTAT+Moody's Samples (Number of firm years = 50,561)												
−1							1.70	1.49	159	−1.91	0.06	0.72
1	2.04	1.29	6	2.24	0.09	0.43	0.85	0.99	1502	0.26	0.08	0.11
2	1.38	1.18	17	1.84	0.11	0.26	1.06	1.01	1205	0.48	0.08	0.07
3	1.29	1.11	32	1.53	0.12	0.21	1.14	0.98	981	0.67	0.09	0.09
4	1.32	1.09	55	1.49	0.12	0.17	1.24	0.96	873	0.82	0.10	0.09
5	1.27	1.07	93	1.29	0.14	0.13	1.12	0.93	813	0.96	0.11	0.09
6	1.27	1.03	164	1.20	0.11	0.09	1.48	0.93	748	1.13	0.12	0.11
7	1.34	0.94	298	1.16	0.12	0.08	1.46	0.94	670	1.31	0.12	0.12
8	1.22	0.87	557	0.98	0.11	0.07	1.55	1.00	571	1.58	0.14	0.17
9	1.21	0.81	1155	1.02	0.10	0.05	1.74	1.08	369	2.00	0.14	0.25
10	1.06	0.67	5278	0.82	0.09	0.03	1.82	1.23	183	2.83	0.15	0.35
Grand Ave.	1.33	1.01	731	1.34	0.12	0.16	1.33	1.01	731	1.34	0.12	0.16

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ered. Nevertheless, the evidence consistent with the selection bias hypothesis has minimal impact when the COMPUSTAT and Moody's samples are aggregated. Since the COMPUSTAT sample dominates the Moody's sample (47,672 vs. 2,889 observations), the aggregated results of the COMPUSTAT+Moody's sample are not significantly different from the results of the COMPUSTAT sample only.

In the whole period statistics in Panel C of Table 2, the Moody's sample has higher return and slightly higher book-to-market values than the COMPUSTAT sample (1.48% vs. 1.30% and 1.28 vs. 1.22, respectively), which does not support the selection bias hypothesis. The characteristics of the combined sample over the whole period are quite similar to those of the COMPUSTAT sample alone. More importantly, in testing the impact of selection bias on the cross-sectional relation between average returns and book-to-market, a similar monotone positive relationship between the two variables is maintained even after the Moody's sample

TABLE 2 (continued)

Time-Series Averages of the Characteristics of Portfolios: the COMPUSTAT and Moody's Samples from 1963 to 1993

	Sorted by Size (V)						Sorted by Book-to-Market (B/V)					
Portfolio	Return (%)	β	Size	B/V	E/P(+)	E/P Dummy	Return (%)	β	Size	B/V	E/P(+)	E/P Dummy
Panel C. July 1963–December 1993 (Whole Period = 366 months)												
COMPUSTAT Sample (Number of firm years = 58,745)												
−1							2.54	1.47	86	−1.48	0.04	0.70
1	2.14	1.29	7	1.82	0.09	0.35	0.91	0.99	1396	0.23	0.07	0.09
2	1.47	1.20	17	1.51	0.12	0.21	1.03	1.00	1063	0.43	0.07	0.06
3	1.40	1.13	32	1.28	0.12	0.16	1.05	0.97	813	0.57	0.08	0.07
4	1.32	1.08	54	1.27	0.11	0.12	1.15	0.94	750	0.71	0.08	0.08
5	1.26	1.05	90	1.14	0.11	0.10	1.09	0.91	697	0.84	0.09	0.07
6	1.18	0.99	153	1.03	0.10	0.07	1.31	0.91	641	0.97	0.10	0.08
7	1.23	0.89	275	0.99	0.10	0.06	1.37	0.94	576	1.14	0.11	0.09
8	1.12	0.84	500	0.86	0.10	0.05	1.53	0.97	471	1.35	0.12	0.13
9	1.05	0.75	1017	0.89	0.09	0.04	1.78	1.05	334	1.72	0.12	0.19
10	0.92	0.64	4607	0.71	0.08	0.02	1.85	1.17	170	2.56	0.14	0.29
Grand Ave.	1.30	0.99	695	1.22	0.11	0.13	1.30	0.98	695	1.22	0.11	0.13
Moody's Sample (Number of firm years = 10,404)												
−1							2.27	1.48	24	−2.22	0.11	0.75
1	1.98	1.46	3	2.46	0.08	0.54	0.39	1.22	299	0.28	0.08	0.28
2	1.35	1.33	7	2.18	0.09	0.39	0.32	1.06	347	0.58	0.08	0.22
3	1.13	1.24	12	2.14	0.11	0.29	0.40	0.98	355	0.79	0.08	0.18
4	0.92	1.14	18	2.12	0.11	0.24	0.99	1.00	301	1.01	0.09	0.16
5	0.65	1.13	29	2.03	0.09	0.20	0.68	1.09	265	1.26	0.10	0.16
6	0.70	1.16	44	1.93	0.11	0.16	1.20	0.96	172	1.54	0.11	0.13
7	0.82	1.09	82	1.85	0.12	0.12	0.84	1.02	116	1.93	0.11	0.21
8	0.70	0.85	157	1.78	0.12	0.13	1.05	1.08	97	2.28	0.12	0.23
9	0.63	0.78	350	1.21	0.09	0.05	1.37	1.17	77	2.84	0.11	0.26
10	0.91	0.66	1443	0.93	0.09	0.09	1.66	1.28	63	4.19	0.13	0.40
Grand Ave.	1.48	1.09	173	1.28	0.09	0.14	1.48	1.09	173	1.28	0.09	0.14
t(C−M)[a]	(−4.3)	(−1.1)	(119.0)	(−3.2)	(6.5)	(−2.7)	(−4.3)	(−1.1)	(119.0)	(−3.2)	(6.5)	(−2.7)
COMPUSTAT+Moody's Samples (Number of firm years = 69,149)												
−1							2.24	1.48	80	−1.53	0.06	0.73
1	2.11	1.32	6	1.94	0.08	0.38	0.89	1.03	1259	0.23	0.07	0.11
2	1.47	1.21	15	1.60	0.10	0.23	1.03	1.01	973	0.43	0.07	0.07
3	1.37	1.15	28	1.36	0.11	0.18	1.11	0.99	797	0.59	0.08	0.08
4	1.33	1.10	47	1.33	0.11	0.14	1.19	0.96	734	0.73	0.09	0.08
5	1.26	1.07	78	1.19	0.12	0.11	1.13	0.93	654	0.86	0.10	0.08
6	1.23	1.03	135	1.09	0.10	0.07	1.41	0.93	610	1.01	0.11	0.09
7	1.29	0.93	243	1.06	0.11	0.06	1.43	0.94	534	1.18	0.11	0.10
8	1.15	0.85	451	0.89	0.10	0.05	1.55	0.99	454	1.42	0.12	0.14
9	1.11	0.77	944	0.92	0.09	0.04	1.71	1.06	299	1.83	0.12	0.20
10	0.95	0.64	4341	0.74	0.08	0.02	1.80	1.18	153	2.75	0.14	0.30
Grand Ave.	1.33	1.01	609	1.24	0.11	0.13	1.33	1.01	609	1.24	0.11	0.13

Rankings for portfolios are separately performed in each sample and in each period. Size (B/V) portfolio 1 represents the smallest market equity (book-to-market equity), and portfolio 10 represents the largest market equity (or book-to-market equity). B/V portfolio −1 contains firms with negative B/V value. Firms with negative B/V value are excluded in calculating the average values. If earnings are positive, E(+)/P is the ratio of total earnings to market equity and E/P dummy is 0. If earnings are negative, E(+)/P is 0 and E/P dummy is 1.

[a]This indicates t-statistic for the difference in the grand averages between the COMPUSTAT sample and the Moody's sample in each variable.

is added. These results are verified by Chan, Jegadeesh, and Lakonishok (1995), even though they test the selection bias hypothesis using a small portion of the missing data. They collected the missing data of the NYSE/AMEX domestic primary firms in the top 20% by market capitalization. In order to overcome the selection bias, however, we should focus on small firms rather than large firms since small firms may be more contaminated by the practice of back-filling missing data. Notice from Table 1 that the collected data of the 20% largest firms account for only 1.5% of the total collected Moody's sample.

TABLE 3

Monthly Average Returns and Betas of Size Portfolios: the CRSP, CRSP–COMPUSTAT, and CRSP–COMPUSTAT–Moody's Samples

	CRSP		CRSP–COMPUSTAT		CRSP–COMPUSTAT–Moody's	
Portfolio	Return (%)	β	Return (%)	β	Return (%)	β
Panel A. July 1963–June 1972 Period (108 months)						
1	2.40	1.37	2.31	1.42	1.64	1.21
2	1.66	1.28	1.49	1.25	1.13	1.23
3	1.45	1.22	1.32	1.21	1.26	1.17
4	1.29	1.13	1.21	1.19	0.57	1.19
5	1.16	1.09	1.21	1.12	1.09	1.13
6	1.18	1.01	1.09	1.08	0.85	1.11
7	1.15	0.92	1.04	1.02	1.04	1.07
8	0.93	0.83	0.88	0.93	1.10	0.95
9	0.92	0.70	1.02	0.80	0.65	0.81
10	0.69	0.56	0.79	0.62	0.88	0.68
Grand Ave.	1.28	1.01	1.53	1.07	0.77	1.09
Firm Years	20,515		9,442		1,927	
Panel B. July 1972–December 1993 Period (258 months)						
1	1.97	1.30	1.26	1.32	0.79	1.33
2	1.31	1.20	0.35	1.28	0.25	1.09
3	1.20	1.12	0.76	1.21	1.13	1.25
4	1.29	1.10	0.86	1.08	1.16	1.08
5	1.18	1.08	0.62	1.13	0.92	1.14
6	1.24	1.03	0.53	1.14	0.28	1.15
7	1.34	0.96	0.65	1.05	0.77	1.14
8	1.20	0.88	1.06	1.00	1.42	1.02
9	1.22	0.81	0.80	0.87	0.77	0.95
10	1.03	0.68	1.08	0.72	0.96	0.82
Grand Ave.	1.28	1.02	0.69	1.07	0.57	1.10
Firm Years	53,485		5,813		2,924	
Panel C. July 1963–December 1993 (366 months)						
1	2.09	1.32	1.57	1.35	1.04	1.30
2	1.41	1.22	0.68	1.27	0.51	1.13
3	1.34	1.15	0.93	1.21	1.17	1.23
4	1.29	1.11	0.96	1.11	0.99	1.11
5	1.18	1.08	0.80	1.13	0.97	1.14
6	1.22	1.03	0.70	1.12	0.45	1.14
7	1.28	0.95	0.77	1.04	0.85	1.12
8	1.17	0.86	1.01	0.98	1.32	1.00
9	1.10	0.78	0.86	0.85	0.73	0.91
10	0.95	0.64	1.00	0.69	0.94	0.78
Grand Ave.	1.28	1.01	1.21	1.08	0.65	1.10
Firm Years	74,000		15,255		4,851	

3. The CRSP–COMPUSTAT–Moody's Sample: Unrecovered Data

It might be argued that the return and risk structure of the (uncollected) CRSP–COMPUSTAT–Moody's sample could be systematically different from that of the Moody's (collected) sample so that the previous results of Table 2 might be significantly affected if these still-missing data were all collected. However, according to Table 3, this does not seem to be the case. The betas of the CRSP–COMPUSTAT–Moody's sample have a roughly decreasing pattern over firm size in each period. This pattern is similar to the CRSP–COMPUSTAT sample. In the first subperiod, the CRSP–COMPUSTAT–Moody's sample has lower returns than the Moody's or CRSP–COMPUSTAT sample, and it has a different cross-sectional spread of returns across firm size. It could be argued, therefore, that, in this period, only firms having relatively higher returns might be collected from Moody's Manuals, and so the Moody's sample could be biased and have different book-to-market values. However, since the Moody's sample accounts for almost 80% of the total missing data, the current cross-sectional relation between average returns and book-to-market values may be barely changed even if all the still missing CRSP–COMPUSTAT–Moody's data were recovered.

Unlike the first subperiod, the second subperiod, which is more important to the inferences for the selection bias hypothesis, has a similar return profile and risk structure in the CRSP–COMPUSTAT and CRSP–COMPUSTAT–Moody's samples. It could be hard to argue, therefore, that the Moody's sample in this period is biased and that the characteristics of the uncollected book-to-market data and the Moody's data are significantly different. Overall, the uncollected sample accounts for only 6.6% of the whole CRSP sample or 7.0% of all available data (COMPUSTAT+Moody's). Even if the still-missing data are recovered and added to the existing sample, it would not be expected that the overall results of Table 2 are changed.

C. Summary

The selection bias hypothesis on COMPUSTAT of Kothari, Shanken, and Sloan (1995) is supported in the post-1970 period when the practice of back-filling data was more common. Nonetheless, the overall results are not significantly changed when the Moody's sample representing almost all of the missing data on COMPUSTAT is aggregated with the COMPUSTAT sample. The cross-sectional relations among average returns, betas, firm size, and book-to-market in the COMPUSTAT sample only are still quite similarly maintained even after the recovered missing data are added. It could be argued, therefore, that the COMPUSTAT selection bias is not so severe that the monotone positive relationship between average returns and book-to-market is significantly affected. These arguments are confirmed in the CSR tests reported in Section IV.

III. Risk Premia Estimation and a Correction for the Errors-in-Variables Problem

A. A Cross-Sectional Regression Model

In order to estimate risk premia, I use the two-pass methodology of Fama and MacBeth (1973). For each month, t, from July 1963 to December 1993, I estimate the CSR coefficient $\Gamma_t = (\gamma_{0t}, \gamma_{1t}, \Gamma_{2t})$ of the following model,

$$R_t = \gamma_{0t} + \beta_t \gamma_{1t} + B_{t-1}\Gamma_{2t} + \epsilon_t, \tag{1}$$

where $R_t = (R_{1t}, \ldots, R_{Nt})'$ is the $(N \times 1)$ vector of returns in excess of the riskless return (N is the number of assets) for a time period, $\beta_t = (\beta_{1t}, \ldots, \beta_{Nt})'$ is the true market beta vector, B_{t-1} $(N \times K)$ is a set of K idiosyncratic explanatory variables measured without error at time $t-1$, and $\epsilon_t = (\epsilon_{1t}, \ldots, \epsilon_{Nt})'$ is the idiosyncratic error vector with mean vector 0 and covariance matrix Σ_ϵ. I assume that the idiosyncratic error terms are intertemporally homoskedastic.[11] Since the true market beta, β_t, is unobservable, I substitute for β_t its estimate, $\hat{\beta}_{t-1}$. This estimate is obtained from the OLS time-series regression (i.e., the market model) using observations available up to $t-1$. For the month-by-month CSR estimation, available monthly return observations for at least two of the previous five years are used, and for the quarter-by-quarter CSR estimation, available quarterly return observations for at least three of the previous 15 years (60 quarterly observations) are used. In this study, I include the following idiosyncratic explanatory variables: firm size (in logarithm), book-to-market (in logarithm), E/P(+), and E/P dummy. These idiosyncratic explanatory variables are matched with the returns for July of year y to June of year $y+1$.

The sample means of the resulting time-series of estimated coefficients, $\hat{\gamma}_{0t}$, $\hat{\gamma}_{1t}$, and $\hat{\Gamma}_{2t}$, are used as the ultimate estimates of risk premia, γ_0, γ_1, and Γ_2, respectively. The sample variances of those time-series estimates are used to calculate the standard errors of the final estimates. The time-series sample mean of $\hat{\gamma}_{1t}$, $\bar{\hat{\gamma}}_1$, is used for testing whether the price of beta risk (γ_1) is positive and significantly different from zero. The time-series sample mean of $\hat{\Gamma}_{2t}$, $\bar{\hat{\Gamma}}_2$, is used for testing whether the idiosyncratic variables are priced. The CAPM implies that γ_0 and Γ_2 should be zero.

B. A Correction for the Errors-in-Variables Problem in the CSR Estimation

In the CSR model of equation (1), the beta variable is measured with error, because the beta variable estimated by the least squares (LS), $\hat{\beta}_{t-1}$, is used as an explanatory variable instead of the true beta. Meanwhile, the other explanatory variables are assumed to be measured without error. The traditional least squares CSR estimation is T-consistent (consistent as long as the time-series sample size in estimating betas, T, is large) but not N-consistent (biased when the cross-sectional sample size, N, becomes large for fixed T). Therefore, when the traditional least squares estimation is employed to estimate risk premia, the EIV problem is inevitable since T is usually fixed because of the nonstationarity of betas. In order to correct the EIV bias of the traditional least squares estimator for risk premia under the condition that T is fixed, an N-consistent estimation is crucial. This paper employs Kim's (1995) N-consistent estimation method, and assumes that the beta estimation period is not necessarily the same across assets, while Kim assumes that the beta estimation period is the same for all assets, for instance, five years. The assumption of different beta estimation periods is more appropriate for the CSR estimation using *individual* assets, because the time periods for which return observations are available are different across assets.[12]

[11] Miller and Scholes (1972), Brown (1977), Belkaoui (1977), Bey and Pinches (1980), and Barone-Adesi and Talwar (1983) report some evidence of intertemporal heteroskedasticity of the idiosyncratic error terms. However, Kim (1995) reports that the EIV-corrected estimation results for risk premia with the assumption of homoskedasticity are similar to those obtained with the assumption of heteroskedasticity.

[12] When the CSR estimation is performed for portfolios whose composition changes over time, the assumption of the same beta estimation period can be maintained.

The relationship between the true betas and the estimated betas is

$$\hat{\beta}_{t-1} = \beta_t + \xi_{t-1}, \tag{2}$$

where $\xi_{t-1} = (\xi_{1t-1}, \ldots, \xi_{Nt-1})'$ is the measurement error vector of the estimated betas with mean vector 0 and covariance matrix Σ_ξ. The measurement error of asset i's estimated beta is represented with past idiosyncratic errors prior to each CSR,

$$\xi_{it-1} = \sum_{s \in S^i} \epsilon_{is} \left(R_{ms} - \bar{R}_m\right) \Big/ \sum_{s \in S^i} \left(R_{ms} - \bar{R}_m\right)^2, \tag{3}$$

where S^i indicates an information set containing return observations used to estimate $\hat{\beta}_{it-1}$ up to $t-1$, R_{ms} is the market portfolio return at time s ($< t$), and $\bar{R}_m$ is the sample mean of R_{ms}. The set of return observations, S^i, is not necessarily the same across assets.

Since the predictive beta ($\hat{\beta}_{t-1}$) in the two-pass methodology is used, one can maintain from equation (3) that, conditional on the market return, the idiosyncratic error term, ϵ_{it}, and the measurement error term, ξ_{it-1}, are independent, i.e., $E(\epsilon_t \xi_{t-1} | R_m) \equiv \Sigma_{\epsilon\xi} = 0$. Moreover, based on equation (3), one can obtain additional information about the relationship between the idiosyncratic error variance and the measurement error variance, which is necessary to obtain the maximum likelihood estimate (MLE) of $\Theta = (\gamma_{0t}, \gamma_{1t}, \Gamma_{2t}, \beta_t)$. That is, conditional on the market return, the ratio of the idiosyncratic error variance, $\text{var}(\epsilon_{it})$, to the measurement error variance, $\text{var}(\xi_{it-1})$, of an asset i ($i = 1, \ldots, N$) equals

$$\delta_{it} = \text{var}(\epsilon_{it}) / \text{var}(\xi_{it-1}) = \sum_{s \in S^i} (R_{ms} - \bar{R}_m)^2. \tag{4}$$

Since the number of return observations available for estimating betas can be different across assets, the ratio δ_{it} is not necessarily the same for all assets. If all assets have the same beta estimation period (five years), then $\delta_{it} = \delta_t = T\hat{\sigma}_m^2$ for all assets, as long as the disturbance terms of the market model (ϵ_t) are intertemporally homoskedastic, where T is the sample size used to estimate betas in the market model and $\hat{\sigma}_m^2$ is the sample variance obtained by using T market return observations.[13]

To obtain the N-consistent MLE of the risk premia conditional on δ_{it}, I minimize the quadratic function (or maximize the likelihood function), $L = \eta_t' \Omega^{-1} \eta_t$, with respect to β_t, γ_{0t}, γ_{1t}, and Γ_{2t}, where Ω is the covariance matrix of $\eta_t = (\epsilon_t, \xi_{t-1})$. I substitute for γ_{0t} its MLE, $\hat{\gamma}_{0t} = \tilde{R} - \tilde{\hat{\beta}} \gamma_{1t} - \tilde{B} \Gamma_{2t}$ in the likelihood function L, where $\tilde{R}$ and $\tilde{\hat{\beta}}$ are the cross-sectional weighted averages of the variables R_t and $\hat{\beta}_{t-1}$, respectively, and $\tilde{B}$ is also the $(1 \times K)$ cross-sectional weighted

[13]When the disturbance term of the market model is conditional heteroskedastic, the ratio δ_{it} is also different across assets, even though the beta estimation period is the same for all assets.

average vector of the variable B_{t-1}.[14] Then I set the derivatives of L with respect to γ_{1t}, and Γ_{2t} to zero; that is,

$$(5)\quad \frac{\partial L}{\partial \gamma_{1t}} = \hat{\epsilon}_t{}'D\left(\gamma_{1t}^2 I_N + D\right)^{-1}\hat{\Sigma}_\epsilon^{-1}\hat{\beta}_{t-1} + \gamma_{1t}\,\hat{\epsilon}_t{}'D\left(\gamma_{1t}^2 I_N + D\right)^{-2}\hat{\Sigma}_\epsilon^{-1}\hat{\epsilon}_t = 0$$

$$(6)\quad \frac{\partial L}{\partial \Gamma_{2t}} = \hat{\epsilon}_t{}'D\left(\gamma_{1t}^2 I_N + D\right)^{-1}\hat{\Sigma}_\epsilon^{-1}B_{t-1} = 0,$$

where $\hat{\epsilon}_t = R_t^* - \hat{\beta}_{t-1}^*\gamma_{1t} - B_{t-1}^*\Gamma_{2t}$, and $D = \mathrm{diag}(\delta_{1t}, \delta_{2t}, \ldots, \delta Nt)$. R_t^*, $\hat{\beta}_{t-1}^*$, and B_{t-1}^* are the weighted mean-adjusted values of the corresponding variables.[15] In the case that the ratios δ_{it} are the same for all assets, Kim (1995) provides the closed form MLE of the gammas from equations (5) and (6). However, since the ratios are not the same in this paper, the MLEs, $\hat{\gamma}_{1t}$, and $\hat{\Gamma}_{2t}$, are obtained by solving the nonlinear equations (5) and (6).

According to the shape of the idiosyncratic error variance $\hat{\Sigma}_\epsilon$, one obtains the GLS, weighted least squares (WLS), or OLS version of the MLE. Kim (1995) justifies the use of WLS version estimates, especially when individual assets are used. Therefore, the CSR coefficients will be estimated using the WLS version of the MLE and the traditional WLS estimation throughout the paper.

IV. Empirical Results

A. Explanatory Power of Market Betas and Firm Size

1. Estimation Results

Table 4 presents the estimation results for the intercept, γ_0, the price of beta risk, γ_1, and the coefficient associated with firm size, γ_2, during the period of July 1963 to December 1993 using monthly returns (Panel A) and quarterly returns (Panel B). Regardless of the availability of the B/V and E/P data, all 5,597 individual firms (including investment companies) are used whose return data are available for at least 24 months up to 60 months (12 quarters up to 60 quarters) for the month-by-month (quarter-by-quarter) CSR estimation. In fact, use of at least 24 months up to 60 months return observations is the most popular *ad hoc* choice in estimating betas for testing asset pricing models. In order to examine different aspects of statistical significance of the explanatory power of the variables, I also report the time-series averages of the adjusted R^2s and a coefficient of partial determination of each explanatory variable. The coefficient of partial determination measures the *marginal* contribution of one explanatory variable in reducing the variation of the dependent variable, when all other explanatory variables are already included in the model.

After correcting the EIV problem, the estimate of the price of beta risk, $\bar{\hat{\gamma}}_1$, is 0.935% per month, with a t-statistic of 2.40. This estimate indicates that betas have economically and statistically significant explanatory power for average stock

[14]The cross-sectional weighted average of a variable x is $\tilde{x} = \sum_{i=1}^N \sum_{j=1}^N w_{ij}x_i \,/\, \sum_{i=1}^N \sum_{j=1}^N w_{ij}$, where w_{ij} is the (i,j)-th element of $\hat{\Sigma}_\epsilon^{-1}$.

[15]The weighted mean-adjusted value of a variable x is $x^* = x - \tilde{x}$.

TABLE 4

Time-Series Averages (in Percent) of the CSR Coefficient Estimates Using All Individual Stocks: July 1963 to December 1993

$$R_{it} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{it-1} + \gamma_{2t} \log V_{it-1} + \epsilon_{it}, \quad i = 1, \ldots, N$$

EIV-Corrected MLE				Uncorrected WLS			
Intercept	β	log(V)	$\overline{\text{Adj}}\ R^2$	Intercept	β	log(V)	$\overline{\text{Adj}}\ R^2$
Panel A. Using Monthly Returns							
−0.011	0.935		5.39	0.428	0.379		4.21
(−0.06)	(2.40)			(2.97)	(1.51)		
0.376	0.818	−0.058	6.66	1.030	0.203	−0.101	5.71
(1.37)	(2.02)	(−1.55)		(4.31)	(0.86)	(−2.70)	
	[5.24]	[1.50]			[3.68]	[1.62]	
				1.197		−0.109	
				(3.14)		(−2.49)	2.20
Panel B. Using Quarterly Returns							
−0.188	3.228		7.83	1.092	1.494		5.34
(−0.28)	(2.16)			(2.97)	(1.65)		
0.667	2.989	−0.152	9.58	2.752	1.086	−0.298	7.49
(0.74)	(2.01)	(−1.22)		(3.17)	(1.35)	(−2.23)	
	[6.33]	[1.91]			[4.13]	[2.35]	
				3.850		−0.374	
				(2.56)		(−2.20)	3.62

The CSR coefficients are estimated by using all *individual* stocks traded on the NYSE and AMEX, regardless of the availability of the book equity and earnings data. Numbers in parentheses represent *t*-statistics, and numbers in brackets represent the coefficient of partial determination. Betas of individual stocks for month *t* are estimated with the equal-weighted CRSP market returns by using at least 24 monthly (12 quarterly) returns of the previous five years (15 years) up to month (quarter) $t-1$ for the month-by-month (quarter-by-quarter) CSR estimation.

returns. Important to the validity of the CAPM, the estimate of the intercept, $\bar{\hat{\gamma}}_0$, is -0.011% per month, with *t*-statistic of -0.06, which is not significant. However, without correcting the EIV problem, one could be misled into rejecting the CAPM; that is, the traditional least squares estimate of the price of beta risk, $\bar{\hat{\gamma}}_1^{LS}$, is 0.379% per month, with *t*-statistic of 1.51, and the estimate of the intercept is 0.428% per month, with *t*-statistic of 2.97.

When the size variable is included in the model, the EIV-corrected estimate of the price of beta risk is still significant; 0.818% per month, with a *t*-statistic of 2.02. More impressively, the estimate of the coefficient associated with firm size, $\bar{\hat{\gamma}}_2$, is barely statistically significant at the traditional significance level; -0.058% per month, with a *t*-statistic of -1.55. The marginal contribution of the beta variable to explain the cross-sectional behavior of stock returns (measured by the coefficient of partial determination) is 5.24%, while that of the size variable is only 1.50%. This indicates that market betas make almost 3.5 times greater marginal contribution in explaining stock returns than firm size does. Without correcting the EIV problem, one could be again misled into rejecting betas and supporting firm size. That is, the traditional least squares estimate of the price of beta risk is 0.203% per month, with *t*-statistic of 0.86, and the estimate of the coefficient on the firm size variable is -0.101% per month, with a *t*-statistic of -2.70.

For the quarter-by-quarter CSR estimation, the equal-weighted sample means of all individual stocks' buy-and-hold returns are used as the market portfolio proxy as in Handa, Kothari, and Wasley (1989).[16] The statistical significance of the estimation results is similar to the results using monthly returns except for the case of firm size. The statistical significance of the estimate of the coefficient associated with firm size decreases. When the EIV bias is corrected, the estimate of the coefficient on the firm size variable, $\bar{\hat{\gamma}}_2$, is no longer significant at any traditional significance level; that is, -0.152% per quarter, with a t-statistic of -1.22.[17]

The above results show that firm size is sensitive to the return measurement intervals. The reasons are twofold; the first is that the estimate of the systematic risk is sensitive to the choice of the return measurement intervals (see Levhari and Levy (1977), Handa, Kothari, and Wasley (1989), (1993), and Kothari, Shanken, and Sloan (1995)), and the second is that the buy-and-hold returns on small firms are smoothed out as the investment horizon becomes longer. Since small firms are more likely to have big swings in returns (i.e., large positive returns and subsequent large negative returns or vice versa) than are large firms, the buy-and-hold mean returns (or geometric mean returns) on small firms would drastically decrease, while the buy-and-hold mean returns on large firms would remain relatively unchanged, as the investment horizon becomes longer. Figure 1 shows the cross-sectional spread of the buy-and-hold monthly mean returns across firm size when the length of holding period (or investment horizon) is monthly, quarterly, semi-annual, and annual, respectively. As the holding period increases, the difference between the buy-and-hold monthly mean returns on the smallest and on the largest decile size portfolios decreases.[18] For example, the buy-and-hold monthly mean return on the smallest portfolio decreases from 2.11% to 1.39% when the holding period increases from one month to one year, while that of the largest portfolio decreases only from 0.95% to 0.84%. Therefore, as the return measurement interval increases, the cross-sectional spread of betas increases, while the cross-sectional spread of buy-and-hold mean returns decreases. This induces the greater explanatory power of betas for average stock returns and reduces the explanatory power of the firm size variable.

The results in this paper are more supportive of the CAPM than those found in Kim (1995). In particular, the effect of firm size is much weaker in this paper. The main reason for the weaker effect is that the tests are performed under the different testing environments. The testing period is similar (July 1963 to December 1990 vs. July 1963 to December 1993). However, Kim uses non-financial firms only, while this paper uses all firms. Moreover, different firm selection criteria for the CSR tests are applied. In Kim (1995), firms having at least 60 monthly return

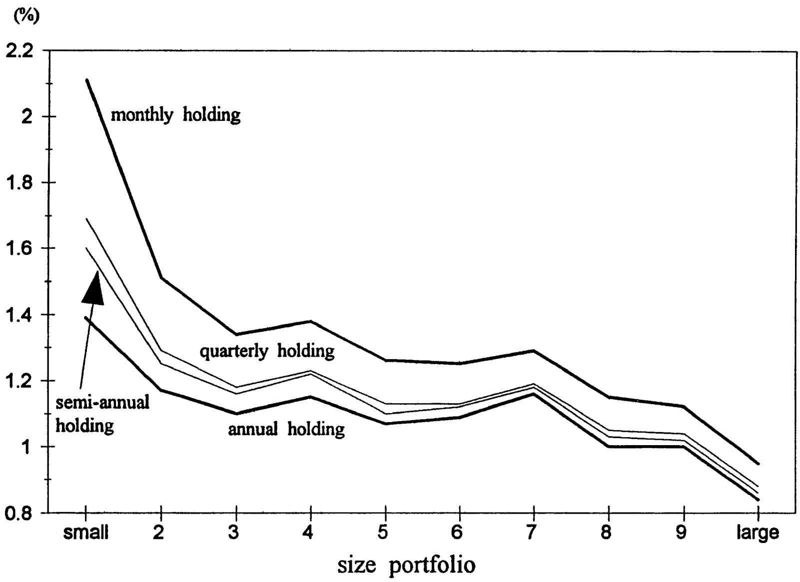
[16]The compounding of the CRSP monthly market returns for investment horizons longer than one month would violate the buy-and-hold strategy (see Roll (1983) and Blume and Stambaugh (1983)).

[17]I find that when monthly returns are used, the estimate of the coefficient on the firm size variable is sometimes slightly significant according to the sample used. For example, when only CRSP/COMPUSTAT firms are used, it is -0.061% per month, with a t-statistic of -1.67, which is significant at the 10% significance level. Using quarterly returns and correcting the EIV problem, however, the estimate of γ_2 is never significant for any sets of the sample considered.

[18]The decile size portfolios are formed as in Table 1. The buy-and-hold monthly mean return is computed as $R_p(h) = (1/T)\sum_{t=1}^{T}[(1+R_{pt}(h))^{1/h} - 1]$ for portfolio p and investment horizon h, where $R_{pt}(h)$ is the equal-weighted average of the buy-and-hold returns for h months on individual stocks in the portfolio.

FIGURE 1

Buy-and-Hold Monthly Mean Returns



observations are included and their betas are estimated using the same 60 months for all assets, while, in this paper, firms having at least 24 monthly return observations are included and their betas are estimated using at least 24 available up to 60 months return observations. These selection criteria increase the CSR sample size (N) (1,407 vs. 2,077, on average) and decrease the beta estimation period (T) (60 months vs. 54.19 months, on average) in this paper. In particular, as Kim points out, the EIV correction is negatively sensitive to the ratio δ_{it} or, equivalently, to T.[19] In other words, the magnitude of the EIV correction increases as T decreases. Thus, the magnitude of the EIV correction in this paper is slightly greater than in Kim.

2. Residual Returns

Residual returns would be a good diagnostic check for the CSR tests. Table 5 shows the time-series averages of the raw returns and EIV-corrected and uncorrected average residual returns on each of 20 vitile size portfolios. The residual returns on individual firms are first obtained from $\hat{\epsilon}_{it} = R_{it} - \hat{\gamma}_{0t} - \hat{\gamma}_{1t}\hat{\beta}_{it-1}$ by estimating the CSR model with the beta variable alone using monthly and quarterly returns through the MLE and the WLS estimation. Then, the residual returns are assigned into one of the vitile portfolios according to their market equity values in June of each year. The equal-weighted residual returns and time-series averages on the portfolios ($\bar{\hat{\epsilon}}_i$) are calculated.

[19]The EIV correction methods of Litzenberger and Ramaswamy (1979) and Shanken (1992) are also negatively sensitive to the presumed beta estimation period, T.

TABLE 5

Residual Returns (in Percent)

Size Portfolio	Monthly: Actual Return	Monthly: EIV-Corrected Residual Return		Monthly: Uncorrected Residual Return		Quarterly: Actual Return	Quarterly: EIV-Corrected Residual Return		Quarterly: Uncorrected Residual Return	
1	2.60	0.76	(2.50)	1.12	(3.60)	7.78	1.26	(1.63)	3.00	(2.84)
2	1.78	0.18	(1.19)	0.34	(2.03)	5.60	0.09	(0.21)	0.98	(1.96)
3	1.53	−0.01	(−0.04)	0.13	(0.90)	4.89	−0.26	(−0.73)	0.42	(0.91)
4	1.40	−0.10	(−1.00)	−0.02	(−0.15)	4.63	−0.38	(−1.67)	0.09	(0.23)
5	1.39	−0.10	(−1.14)	−0.02	(−0.17)	4.52	−0.26	(−1.19)	0.08	(0.29)
6	1.29	−0.14	(−1.77)	−0.09	(−1.18)	4.24	−0.40	(−1.51)	−0.13	(−0.56)
7	1.41	−0.01	(−0.08)	0.03	(0.51)	4.29	−0.21	(−1.04)	−0.08	(−0.43)
8	1.30	−0.12	(−1.84)	−0.08	(−1.18)	4.32	−0.20	(−1.07)	−0.06	(−0.28)
9	1.35	0.00	(−0.07)	0.01	(0.23)	4.21	0.05	(0.29)	0.04	(0.23)
10	1.21	−0.13	(−1.75)	−0.12	(−1.90)	4.02	−0.16	(−0.85)	−0.20	(−1.03)
11	1.27	−0.08	(−1.36)	−0.08	(−1.27)	3.95	−0.19	(−1.02)	−0.27	(−1.35)
12	1.22	−0.11	(−1.82)	−0.12	(−1.89)	4.06	−0.10	(−0.50)	−0.17	(−0.77)
13	1.34	0.06	(0.80)	0.02	(0.28)	4.16	0.42	(1.53)	0.11	(0.43)
14	1.21	−0.05	(−0.73)	−0.10	(−1.45)	3.82	0.07	(0.43)	−0.24	(−1.07)
15	1.20	0.00	(−0.02)	−0.08	(−0.98)	3.54	−0.02	(−0.08)	−0.42	(−1.68)
16	1.13	−0.05	(−0.66)	−0.14	(−1.53)	3.52	0.04	(0.16)	−0.42	(−1.31)
17	1.15	0.03	(−0.12)	−0.11	(−1.19)	3.57	0.25	(1.10)	−0.27	(−0.94)
18	1.10	0.05	(0.19)	−0.13	(−1.32)	3.29	0.23	(0.91)	−0.46	(−1.40)
19	0.97	−0.09	(−0.91)	−0.24	(−2.26)	2.94	0.02	(0.07)	−0.74	(−2.09)
20	0.90	−0.08	(−0.73)	−0.28	(−2.17)	2.72	0.08	(0.24)	−0.82	(−2.05)
P1−P20	1.70[a]	0.84	(2.12)	1.40	(3.45)	5.06[a]	1.18	(1.27)	3.82	(2.84)
Pairwise t-Test Rejection Rate										
at 5%	0.289	0.126		0.216		0.211	0.068		0.147	
at 1%	0.132	0.089		0.126		0.105	0.016		0.084	
Hotelling T^2 Test										
p-Value	0.001	0.005		0.002		0.022	0.123		0.035	

The residual returns estimated by the EIV-corrected MLE and the uncorrected WLS estimation are assigned into one of the 20 size portfolios according to their market equity values in June of each year. The equal-weighted residual returns on the portfolios are calculated. Numbers in parentheses indicate t-values of the average residual returns. "P1−P20" indicates the difference between the average returns on the smallest portfolio (Portfolio 1) and on the largest portfolio (Portfolio 20). The Hotelling T^2 p-val is the p-value for the joint hypotheses that P1−P2, P2−P3, ..., P19−P20 are all zeros.
[a]This difference is significant at the 1% level.

When monthly returns are used, it is hard to argue that firm size disappears even after the EIV bias is corrected, since the EIV-corrected average residual return on the smallest portfolio (P1) is still significantly different from that on the largest portfolio (P20) and the Hotelling T^2 test (see also Chan, Chen, and Hsieh (1985)) rejects the joint null hypotheses that the differences in the average residual returns between P1 and P2, P2 and P3, ..., P19 and P20 are all zero. This evidence is not inconsistent with the results of Table 4 where the coefficient on the size variable is marginally statistically significant. Nevertheless, the EIV-corrected average residual returns are almost flat across firm size except for the smallest portfolio, while the uncorrected average residual returns still have a roughly monotone negative relationship with firm size.

However, when quarterly returns are used, the EIV-corrected residual returns show that firm size is much weakened. Although the quarterly residual return on the smallest portfolio is higher than on the largest portfolio, the difference in the average residual returns between P1 and P20 is statistically insignificant; its

t-statistic is 1.27. Furthermore, the rejection rates of all possible pairwise t tests for the null hypothesis that the difference between average residual returns on any two portfolios are zero are only 6.8% and 1.6% at the 5% and 1% significance levels, respectively, which are slightly greater than the nominal significance levels. The Hotelling T^2 test also does not reject the joint null hypotheses; its p-value is 0.123.

B. Book-to-Market Equity and Earnings-Price Ratios

1. Estimation Results

Table 6 presents the results of the CSR model when the accounting variables, B/V and E/P, are added to the previous model using monthly (in Panel A) and quarterly (in Panel B) returns on all individual firms of the CRSP, COMPUSTAT, and Moody's Manuals whose book-to-market equity and earnings-price ratio data are available.[20] With the correction of the EIV bias, betas still have economically and statistically significant explanatory power, although the firm size, B/V, and E/P variables are included in the model. When the firm size and B/V variables are included in the model, the estimate of the price of beta risk is 0.875%, with t-statistic of 2.10, for monthly CSR, and 2.952%, with t-statistic of 2.01, for quarterly CSR. Moreover, the marginal contribution of the beta variable to explain stock returns is dominant over that of other explanatory variables. In the monthly (quarterly) CSR estimation, the coefficients of partial determination of the beta, firm size, and B/V variables are 4.71, 1.27, and 0.43% (5.54, 1.41, and 0.57%), respectively.

The positive earnings-price (E(+)/P) variable shows a slightly significant explanatory role to average stock returns when monthly returns are used. However, when quarterly returns are used, the average coefficient on the E(+)/P variable is insignificant, whether or not the EIV bias is corrected. Fama and French (1992) report that when book-to-market equity is included in the model, the average coefficient on the earnings-price variables is insignificant due to the positive correlation between the E/P and B/V variables. Without book-to-market equity in the model, the explanatory power of the E/P variables becomes statistically insignificant when the beta variable is included in the model and quarterly returns are used.

Unlike firm size and earnings-price, book-to-market equity still has significant explanatory power for average stock returns, even though the EIV bias is corrected. When the beta and B/V variables are included in the model, the EIV-corrected average coefficients on the B/V variable are 0.197% per month, with a

[20]Apart from the issue of the EIV problem, when ratio-type variables such as B/V and E/P are included in the model, the CSR estimation using *individual* stocks rather than portfolios is more appropriate as it avoids an aggregation problem. For example, aggregating book-to-market equity ratios of individual firms into portfolios, we have to decide a proper measure of book-to-market equity for portfolios. A possible proxy is either the average of book-to-market equity ratios of individual firms in the portfolio or the ratio of the total aggregated book equity to the total aggregated market equity of all individual firms in the portfolio. It is hard to say which proxy has a better economic justification. In order to avoid this aggregation problem and reduce the effects of measurement errors of beta estimates, Fama and French (1992) use the "allocation-β" procedure in which the post-ranking beta of a portfolio is allocated to each stock contained in the portfolio, and *individual stock's* returns are then cross-sectionally regressed on the allocated betas. Davis (1994) and Breen and Korajczyk (1994) also use this allocation-β procedure. However, simulation results show that the allocation-β procedure does not alleviate the EIV bias at all, and the amount of the bias is quite similar to the regular least squares estimation using the portfolios. The simulation results are available upon request.

TABLE 6

Time-Series Averages (in Percent) of the CSR Coefficient Estimates for Market Beta, Book-to-Market Equity, and E/P Using All Individual Firms on CRSP, COMPUSTAT, and Moody's Manuals: July 1963 to December 1993

EIV-Corrected MLE							Uncorrected WLS						
Intercept	β	log(*V*)	log(B/V)	E(+)/P	E/P Dummy	Adj R^2	Intercept	β	log(*V*)	log(B/V)	E(+)/P	E/P Dummy	Adj R^2
Panel A. Using Monthly Return													
−0.027	0.977		0.197			5.93	0.500	0.319		0.222			4.57
(−0.13)	(2.40)		(3.52)				(3.35)	(1.29)		(3.81)			
	[5.52]		[0.70]					[3.84]		[0.74]			
0.221	0.875	−0.031	0.160			7.08	1.025	0.153	−0.089	0.134			5.85
(0.77)	(2.10)	(−0.84)	(3.51)				(4.24)	(0.67)	(−2.40)	(2.97)			
	[4.71]	[1.27]	[0.43]					[3.11]	[1.41]	[0.45]			
−0.099	1.062			0.206	−0.139	5.86	0.450	0.350			0.251	0.128	4.36
(−0.44)	(2.54)			(1.92)	(−0.92)		(3.00)	(1.45)			(2.18)	(0.73)	
	[5.35]			[0.10]	[0.43]			[3.65]			[0.10]	[0.52]	
0.414	0.883	−0.070		0.187	−0.227	7.02	1.190	0.149	−0.121		0.199	−0.055	5.76
(1.38)	(2.06)	(−1.83)		(1.79)	(−1.77)		(4.79)	(0.65)	(−3.23)		(1.89)	(−0.40)	
	[4.77]	[1.41]		[0.11]	[0.31]			[3.14]	[1.53]		[0.11]	[0.34]	
						0.83	0.748			0.264			0.83
							(3.07)			(3.98)			
						2.95	1.174		−0.089	0.152			2.95
							(2.93)		(−1.95)	(2.70)			
									[2.20]	[0.69]			
Panel B. Using Quarterly Return													
−0.036	3.016		0.633			8.60	1.290	1.292		0.734			6.13
(−0.05)	(2.03)		(3.23)				(2.43)	(1.47)		(3.49)			
	[7.36]		[1.09]					[4.90]		[1.21]			
0.377	2.952	−0.085	0.505			9.87	2.745	0.948	−0.266	0.459			7.82
(0.41)	(2.01)	(−0.72)	(3.35)				(3.11)	(1.24)	(−2.03)	(2.98)			
	[5.54]	[1.41]	[0.57]					[3.41]	[1.89]	[0.62]			
−0.215	3.262			0.326	−0.225	8.40	1.189	1.394			0.471	0.475	5.96
(−0.29)	(2.18)			(1.04)	(−0.40)		(2.23)	(1.63)			(1.14)	(0.68)	
	[6.93]			[0.10]	[0.77]			[4.53]			[0.11]	[1.02]	
1.025	2.904	−0.206		0.221	−0.534	10.10	3.349	0.852	−0.364		0.311	−0.125	7.92
(1.07)	(1.96)	(−1.68)		(0.61)	(−1.13)		(3.74)	(1.12)	(−2.77)		(0.75)	(−0.23)	
	[5.54]	[1.76]		[0.11]	[0.58]			[3.42]	[2.17]		[0.12]	[0.67]	
							2.310			0.850			1.38
							(2.67)			(3.47)			
							3.852		−0.342	0.441			4.71
							(2.47)		(−1.95)	(2.38)			
									[3.45]	[0.89]			

The CSR coefficients are estimated by using all *individual* stocks obtained from the CRSP, COMPUSTAT, and Moody's Manuals. Numbers in parentheses represent *t*-statistics, and numbers in brackets represent the coefficient of partial determination.

t-statistic of 3.52, using monthly returns, and 0.633% per quarter, with a *t*-statistic of 3.23, using quarterly returns. These results show that book-to-market is robust to the EIV-correction and the return measurement intervals whose effects have been remarkable on firm size. The reason that book-to-market is robust to the EIV correction is partly because the correlation between the beta variable and the B/V variable is weaker than the correlation between the beta variable and the firm size variable.[21] Notice that Kim (1995) shows that the EIV correction effect on an idiosyncratic variable is greater when the beta variable is more closely correlated with the idiosyncratic variable.[22]

[21]The time-series average of the correlation coefficient between the beta and firm size variables is −0.338 (the largest is −0.564, and the smallest is −0.049), and that between the beta and B/V variables is −0.020 (the largest is 0.471, and the smallest is −0.348).

[22]Davis (1994) examines the relationship between book-to-market equity and stock returns over the pre-COMPUSTAT period from July 1940 to June 1963 in which COMPUSTAT data are not available.

2. The Effect of the Selection Bias in COMPUSTAT on the CSR Estimation

To further investigate the impact of the selection bias in COMPUSTAT on book-to-market, the monthly CSR models are reestimated using the COMPUSTAT sample and the COMPUSTAT+Moody's sample by dividing the whole period into the two subperiods as in Section II. The CSR estimation results in Table 7 confirm the preliminary results in Section II. As argued in the previous section, since COMPUSTAT did not cover a substantial portion of small firms in the early years and the collected Moody's sample represents the missing data, the Moody's sample would have greater returns and higher B/V values than the COMPUSTAT sample. Therefore, if the Moody's sample were added, firm size and book-to-market would be expected to be strengthened. Panel A of Table 7 shows that the results over the first subperiod from July 1963 to June 1972 are consistent with the expectation and with the preliminary investigation in the previous section.

TABLE 7

Time-Series Averages (in Percent) of the Monthly CSR Coefficient Estimates for Market Beta, Book-to-Market Equity, and Firm Size Using Individual Firms from the COMPUSTAT and COMPUSTAT+Moody's Samples

$$R_{it} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{it-1} + \gamma_{2t}\log V_{it-1} + \gamma_{3t}\log(B/V)_{it-1} + \epsilon_{it}, \quad i = 1, \ldots, N$$

COMPUSTAT only					COMPUSTAT+Moody's				
Intercept	β	log(V)	log(B/V)	Adj R^2	Intercept	β	log(V)	log(B/V)	Adj R^2
Panel A. July 1963–June 1972 Period									
1.572		−0.186		2.92	1.567		−0.190		2.86
(2.20)		(−2.23)			(2.17)		(−2.82)		
−0.613	1.681		0.137	8.18	−0.459	1.563		0.176	6.92
(−0.83)	(2.50)		(1.43)		(−1.47)	(2.36)		(1.94)	
−0.034	1.491	−0.095	0.040	9.76	0.215	1.336	−0.112	0.097	8.33
(−0.08)	(2.27)	(−1.52)	(0.51)		(0.49)	(2.07)	(−1.73)	(1.06)	
0.666			0.239	0.96	0.833			0.275	0.77
(1.70)			(2.32)		(2.02)			(2.82)	
Panel B. July 1972–December 1993 Period									
1.098		−0.085		1.89	1.043		−0.075		1.92
(2.48)		(−1.70)			(2.32)		(−1.48)		
0.144	0.763		0.222	5.55	0.155	0.731		0.206	5.52
(0.55)	(1.53)		(3.14)		(0.61)	(1.44)		(2.96)	
0.326	0.680	−0.021	0.191	6.59	0.224	0.682	0.003	0.186	6.56
(0.93)	(1.31)	(−0.48)	(3.26)		(0.62)	(1.30)	(−0.11)	(3.04)	
0.734			0.270	0.87	0.712			0.259	0.85
(2.44)			(3.17)		(2.38)			(3.06)	

Numbers in parentheses represent t-statistics.

The second subperiod from July 1972 to December 1993 is a more interesting period for examining the selection bias hypothesis of Kothari, Shanken, and Sloan (1995) since the COMPUSTAT data set would be more seriously contaminated by

He randomly collects necessary B/V data of 100 individual firms from Moody's Industry Manual to construct a selection bias-free data set. He finds that book-to-market is significant in this period in explaining average stock returns. With correcting for the EIV bias, however, I find that book-to-market is not significant over this period when the beta variable is included in the model. I am grateful to James Davis for allowing use of his data set.

the practice of back-filling missing data in this period. Since the Moody's sample would represent the knowingly unchosen data by COMPUSTAT, book-to-market should be weakened after the Moody's sample is added if the selection bias hypothesis holds. The results over the second subperiod (Panel B of Table 7) support the selection bias hypothesis. For example, when the beta and B/V variables are in the model, the EIV-corrected coefficient on the B/V variable is 0.222% (*t*-statistic of 3.14). After the Moody's sample is added, it decreases to 0.206% (*t*-statistic of 3.04). The results from the uncorrected estimation remain qualitatively the same. The above results support Kothari, Shanken, and Sloan's arguments that Fama and French's (1992) results on book-to-market are exaggerated by the selection bias. However, the strong significance of book-to-market is still maintained. The Moody's sample has a minimal adverse impact on book-to-market. These CSR results confirm the preliminary testing results that the selection bias in COMPUSTAT does not have as serious an impact on the estimation for book-to-market as Kothari, Shanken, and Sloan argue.

V. Conclusions

This paper has investigated the COMPUSTAT selection bias issue raised by Kothari, Shanken, and Sloan (1995) arguing that the selection bias may induce an upward bias for the book-to-market equity of Fama and French (1992). To do this, I collected most of the missing data for book value of common equity and earnings in COMPUSTAT from Moody's Manuals. This paper also has reexamined the explanatory power of beta, firm size, book-to-market equity, and earnings-price ratios for average stock returns, correcting the EIV bias.

The selection bias hypothesis on COMPUSTAT of Kothari, Shanken, and Sloan (1995) is supported in the post-1970 period when the practice of back-filling of data was more common. However, when the Moody's sample representing almost all of the missing data on COMPUSTAT is aggregated with the COMPUSTAT sample, the overall results do not change significantly. The cross-sectional relationships among average returns, betas, firm size, and book-to-market in the aggregated sample are quite similar to those of the COMPUSTAT sample only. Therefore, the COMPUSTAT selection bias is not so severe that the monotone positive relationship between average returns and book-to-market is significantly affected.

This paper finds stronger support for the beta pricing theory than does Kim (1995). After correcting the EIV problem, market betas have economically and statistically significant force, regardless of the presence or absence of firm size, book-to-market equity, and earnings-price ratio. Moreover, the intercept estimate is insignificant when market betas are alone in the model. Firm size is barely significant using monthly returns, but no longer significant in explaining average stock returns using quarterly returns. The results in this paper confirm that the weak relationship between market beta and average stock returns and the size-related anomaly are due to the failure to correct for the EIV bias. These results, however, should be interpreted with caution. The EIV-corrected results are conditional on the presumption of the length of the beta estimation period. In other words, the results are sensitive to the assumption of the extent of beta stationarity. This paper employs the most widely used ad hoc choice of five years. It would be necessary, therefore, to obtain the EIV-corrected results unconditional on the length of the beta estimation period or conditional on the precisely estimated beta shift-points.

Unlike firm size and earnings-price, book-to-market still has significant explanatory power to average stock returns. These results are robust to the EIV correction and the return measurement intervals. Therefore, book-to-market gives stronger evidence in support of the misspecification of the capital asset pricing model than does firm size.

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