Faculty Working Papers

SPECIFICATION ERRORS, RESIDUAL ANALYSIS AND CAPITAL ASSET PRICING

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Summary

Based upon the relationship between the single-index and the multi-index models of capital asset pricing, the possible specification errors of alternative asset pricing models are analyzed. The implications associated with the mis-specified models are also discussed. Empirical results show that the specification error associated with the asset pricing model can bias the CAR and the risk-return relationship test.

Presentation

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I. Introduction

The security market model of Sharpe (1964), Lintner (1965) and Mossin (1966) (SLM) has been the foundation for much of the research for the last decade. In that model, it is suggested that the return generating process of an asset is a function of the variations in a market index and is known as the capital asset pricing model (CAPM). Recently, it has been suggested that introducing additional factors into the single-index model could improve the power of the model. In particular, the introduction of firm-specific information may be important in the returns generating process. For example, King (1966) demonstrated the importance of industry factors in determining stock price behavior. Likewise, Cohen and Pogue (1967) have suggested that an industry factor (I_t) could be included in Sharpe's model to increase the explanatory power of that model. Beaver (1972) and Downes and Dyckman (1973) argue that certain types of accounting information are taken into account in security pricing and, thus, should be included in a model of capital asset pricing. Similarly, Rosenberg (1974) has shown that there exist some extra-market components in the covariance of the market model; Brennen (1970) has derived a multi-index model by introducing an excess dividend yield term to the asset pricing process.

Several approaches have been suggested to provide such a multi-factor model of the return generating process. Sharpe (1977) has given the SLM model a "Multi-Beta" interpretation. Similarly, Ross (1976, 1977) uses an arbitrage approach in the same spirit of Sharpe's multi-beta interpretation. Likewise, Rosenberg and McKibben (1973), Rosenberg and Guy (1976) and Lee and Zumwalt (1980) add additional explanatory variables to better explain factors affecting beta and residual variance. In sum, the rates of return generating process can be classified into single-factor and multi-factor models. The single-factor model is generally used to estimate the systematic risk and to test the efficient market hypothesis. Hence, the empirical results in terms of the single index CAPM may well be subject to the specification bias as demonstrated by Brenner (1977, 1979) and others.

The main purpose of this paper is to show that the specification error test procedure developed by Ramsey (1969) and Ramsey and Schmidt (1976) can be used to empirically determine whether or not a single index CAPM is empirically appropriate for capital asset pricing and other financial management decisions. In the second section, the relationship between the single-index and the multi-index model is explored. In the third section, two alternative methods used to test the specification bias are explored. In the fourth section 451 securities selected from New York Stock Exchange (NYSE) during the period of January 1965-December 1977 are used to do the empirical study. Possible implications of these empirical results are explored. Finally the results of this paper are summarized. Future research potentials related to the results of this paper will be indicated.

II. Single-Index vs. Multi-Index Model

Following Sharpe (1963), Lintner (1965), Mossin (1966) and Brenner (1977, 1979) and the others, alternative single factor model can be defined as

$$\text{[A]} \quad R_{jt} - R_{ft} = \alpha_j + \beta_j(R_{mt} - R_{ft}) + \varepsilon_{jt} \tag{1}$$

$$\text{[B]} \quad R_{jt} - R_{zt} = \alpha_j + \beta_j(R_{mt} - R_{zt}) + \varepsilon_{jt}$$

$$R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt} \tag{2}$$

where R_{jt} = rates of return on j^{th} security in period t

R_{mt} = market rates of return in period t

R_{ft} = risk-free rates in period t

R_{zt} = rates of return for zero beta factor in period t

Equations (1A) and (1B) are Sharpe-Lintner type and Black (1972) type of CAPM respectively. Equation (2) is the market model. Fama (1976) has investigated the relative advantages and disadvantages between the SLM model and the zero beta model in detail and has concluded that the zero beta model is not necessarily superior to the SLM type of CAPM. Based upon equation (1A), a multi-index model can be defined

$$(R_{jt} - R_{ft}) = \alpha_j' + \beta_j'(R_{mt} - R_{ft}) + C_1 z_{1t} +$$
$$+ C_2 z_{2t} + \ldots + C_k z_{kt} + \varepsilon_{jt}' \tag{3}$$

where z_1, z_2, ..., and z_k are other finance and accounting factors which should statistically be included in the rates of return generating process.[1] If these factors are omitted from the model, then equation (3) reduces to equation (2). Based upon the specification developed by Theil (1957, 1971) and Griliches (1957), the relationships between α_j and α_j', β_j and β_j' are defined as

$$\beta_j = \beta_j' + B_1C_1 + B_2C_2 + \ldots + B_nC_n \tag{4}$$

$$\alpha_j = \alpha_j' - (\sum_{i=1}^{n} B_iC_i)\bar{R}_m + (\sum_{i=1}^{n} C_i\bar{z}_i) \tag{5}$$

where B_1, B_2, ..., B_n are the auxiliary regression coefficients of regressing R_{mt} on z_{1t}, z_{2t}, ..., and z_{nt} respectively. If the auxiliary regression coefficients are not zero, then both β_j and α_j are not unbiased estimators of β_j' and α_j'; if the auxiliary regression coefficients are all zero, then β_j is an unbiased estimator for β_j', however, α_j is still not an unbiased estimator of α_j'. Therefore, it is of interest to empirically determine whether estimated C_1, C_2, ..., and C_n are statistically significantly different from zero or not.

If either a CAPM or market model is a misspecified model, then the beta coefficient cannot be used to estimate the cost of capital and the residuals estimates cannot be used to test the announcement effects of either accounting earnings or dividends announcement as done by Fama, Fisher, Jensen and Roll (1972) [FFJR], Ball and Brown (1968), Joy, Litzenberger and McNally (1977) and others. In addition, if the CAPM is misspecified, then the Jensen investment performance measure is no longer an appropriate measure for ranking alternative investment performance. In the following section, two alternative methods, which can statistically be used to test whether or not a linear equation is misspecified, are explored in detail.

III. Two Alternative Methods for Testing Misspecification Bias

Following Ramsey (1969) and Ramsey and Schmidt (1976), equation (3) is rewritten as

$$y = X\beta + Z\gamma + u, \qquad u \sim N(0,\sigma_{u}^{2}I) \tag{6}$$

where

$$y = \begin{bmatrix} R_{j1}-R_{f1} \\ R_{j2}-R_{f2} \\ \vdots \\ R_{jn}-R_{fn} \end{bmatrix} \qquad X = \begin{bmatrix} 1 & R_{m1}-R_{f1} \\ 1 & R_{m2}-R_{f2} \\ & \vdots \\ 1 & R_{mn}-R_{fn} \end{bmatrix} \qquad \text{and} \qquad Z = \begin{bmatrix} z_{11} & \cdots & z_{n1} \\ \vdots & & \vdots \\ z_{1k} & & z_{nk} \end{bmatrix}$$

Equation (6) is identical to equation (3), if equation (1A) instead of equation (3) is used to do capital asset pricing analysis, then the residuals of the CAPM will no longer have zero mean unless the variables as indicated in matrix Z are all zero. The CAPM of equation (1A) is rewritten in terms of y and x as

$$y_{jt} = \alpha_j + \beta_j x_t + \varepsilon_{jt} \tag{7}$$

Ramsey (1969) has shown that the square of the residuals of the misspecified model, ε_{jt}^2 will follow a non-central χ^2 distribution. To obtain the optimum residual vector, Ramsey has shown that Theil's (1965, 1968) best linear unbiased (BLUS) residuals analysis technique should be used to construct and to perform the suitable statistical test. Now, the procedure of estimating BLUS residals is described as follows.[2]

(i) To estimate the OLS residuals and define the idempotent matrix M

$$\hat{\ell} = y - \hat{y} = [I - X(X'X)^{-1}X']y = My \tag{8}$$

(ii) To rearrange the matrix X, let

$$X_0 = \begin{bmatrix} 1 & x_i \\ 1 & x_j \end{bmatrix}, \quad X_1 = X \text{ without } i^{th} \text{ and } j^{th} \text{ row}$$

where x_i and x_j are two elements associated with two smallest elements on the diagonal of M.

(iii) To find the eigen values $\lambda_1, \lambda_2, \ldots, \lambda_{n-2}$ and eigen vector $\rho_1, \rho_2, \ldots, \rho_{n-2}$ of a new idempotent matrix M_{11}, i.e.,

$$M_{11} = I - X_1(X_1'X)^{-1}X_1' \tag{9}$$

(iv) To compute

$$A_1 = P\, D^{1/2}\, P' \tag{10}$$

where

$$D^{1/2} = \begin{bmatrix} \sqrt{\lambda_1} & & & \bigcirc \\ & \sqrt{\lambda_2} & & \\ & & \ddots & \\ \bigcirc & & & \sqrt{\lambda_{n-2}} \end{bmatrix}$$

P = a matrix whose columns are the eigen vectors of M_{11}

(v) To compute the BLUS residuals

$$\tilde{u} = A'y^*$$

where $A' = [A_0 \; A_1] = [-A_1(X_1X_0^{-1}) \; A_1]$

$y^{*\prime} = [y_i, y_\ell, y_1, \ldots, y_n]$

= rearrange y such that the i^{th} and the j^{th} elements are the first and the second elements.

To test whether a linear regression is misspecified or not, the BLUS residuals can be used to regress against some estimated regressors as

$$\tilde{u} = a_0 + a_1q_1 + a_2q_2 + a_3q_3 \tag{11}$$

where $q_1 = A'[(\hat{y}_t^*)^2]$

$q_2 = A'[(\hat{y}_t^*)^3]$

$q_3 = A'[(\hat{y}_t^*)^4]$

$\hat{y}^{*\prime} = [\hat{y}_j, \hat{y}_\ell, \hat{y}_1, \hat{y}_2, \ldots, \hat{y}_n]$

= rearrange $\hat{y}$ such that the i^{th} and j^{th} elements are the first and second elements.

Ramsey and Schmidt (1976) have simplified the testing procedure as follows:

$$\ell_t = a_0 + a_1q_{1t} + a_2q_{2t} + a_3q_{3t} + \tau_{jt} \tag{12}$$

$$y_t = \alpha + \beta x_t + \gamma_1q_{1t} + \gamma_2q_{2t} + \gamma_3q_{3t} + \tau_{jt} \tag{13}$$

where $q_1 = M[\hat{y}_t^2]$

$q_2 = M[\hat{y}_t^3]$

$q_3 = M[\hat{y}_t^4]$

$$M = I - X(X'X)^{-1}X$$

$$\hat{y}' = [\hat{y}_1, \hat{y}_2, \ldots, \hat{y}_n]$$

The F value associated with either equation (12) or equation (13) can be used to test the linear model as indicated in equation (7) is misspecified or not. In the following section, the methods discussed in this section will be used to test whether alternative CAPM or market model is misspecified or not.

IV. Misspecification of Alternative CAPM and Market Model

To test whether equation (1A) and equation (2) as defined in section II are misspecified or not, monthly stock price data during the period of January 1965-December 1977 from the NYSE are used to perform the test. Value weighted Fisher Index with dividend are used to calculate the market rates of return and monthly 90 day treasury bill rates are used as proxy of risk-free rates of return. First the OLS residuals of the CAPM as indicated in equation (1A) are estimated; secondly, q_1, q_2 and q_3 as indicated in equations (12) and (13) are estimated; thirdly, regress the estimated OLS residuals on $\hat{q}_1$, $\hat{q}_2$ and $\hat{q}_3$ and use the F value of this multiple regression to determine whether the CAPM for a particular firm is misspecified or not. The critical value of F statistic used to perform the null hypothesis test under 95% significant level is $F_{3,152} = 2.6$.

Using these procedures, 451 firms are classified into two groups, i.e., (i) those firms with misspecification errors and (ii) those firms without misspecification errors. The estimated beta coefficient $(\hat{\beta}_j)$, the estimated coefficient of determination ($\bar{R}_j^2$) and F statistics for first group and second group are listed in Appendix A. It is found that there exist 133 out of 451 firms with specification errors. Note that 133 firms with specification errors and 218 firms without sample errors are listed in the first half and second half of Appendix A respectively. To test whether a CAPM without intercept term will affect the degree of misspecification, the above-mentioned procedure is applied to a CAPM without an intercept term, it is interesting to note that the results obtained from a CAPM without intercept term are exactly identical to those obtained for a CAPM with an intercept term. From Appendix A, it also is found that the F values is not significantly correlated to the magnitude of $\bar{R}_j^2$. This conclusion is based upon the fact that the correlation coefficient between the estimated R_j^2 and the estimated is only .12. This finding is identical to that obtained by Ramsey and Zarembka (1971) in testing the possible misspecification errors for four alternative production function specifications.

Now, the degree of misspecification associated with the market model as indicated in equation (2) is examined. From the above-mentioned criteria, it is found that 137 out of 451 firms are with specification errors. The degree of misspecification for the market model is almost identical to those obtained from the CAPM's. To examine the possible impacts of specification errors on the magnitude of cumulative average residuals (CAR), the CAR's in terms of FFJR's (1969) technique are calculated for all 451 firms, 137 firms with specification errors and 314 firms without specification errors. The CAR for these three groups are $(.425)10^{-9}$, $(.518)10^{-9}$ and $(.385)10^{-9}$ respectively. These results show that the specification errors do indeed have some impacts on the estimated CAR.

To show the importance of skewness in asset pricing, Kraus and Litzenberger (1976), Lee (1977) and others have shown that the square term of R_{mt} is not a negligible term in testing the risk-return relationship. To test whether the squared excess market rates of return, $(R_{mt} - R_{ft})^2$ can be introduced to reduce the misspecification of the CAPM, two new equations as indicated in equations (14) and (15) are used to perform the misspecification test.

$$R_{jt} - R_{ft} = \alpha_j + \beta_j(R_{mt} - R_{ft}) + \gamma_j(R_{mt} - R_{ft})^2 + \varepsilon_{jt} \quad (14)$$

$$R_{jt} - R_{ft} = \beta_j(R_{mt} - R_{ft}) + \gamma_j(R_{mt} - R_{ft})^2 + \varepsilon_{jt} \quad (15)$$

From the F tests, it is found that out of 451 firms 164 and 146 have specification errors. These results indicate that the squared term of excess market rates of return has essentially increased the specification bias.

To test whether three regressors, q_1, q_2 and q_3 are enough to perform the misspecification test, the fourth term, q_4, is introduced to test how the different degree of polynomial can affect the empirical results of misspecification test, q_4 is introduced to equations similar to equations (12) and (13) for both the CAPM with and without the intercept terms. They are:

$$\ell_t = a_0 + a_1 q_{1t} + a_2 q_{2t} + a_3 q_{3t} + a_4 q_{4t} + \tau_{jt} \quad (16)$$

where $q_{4t} = M[\widehat{R_{jt}-R_{ft}}^{5}]$,

M is obtained from $(R_{mt}-R_{ft})$, and

$$[A]\quad R_{jt} - R_{ft} = \beta_j(R_{mt}-R_{ft}) + \gamma_1 q_{1t} + \gamma_2 q_{2t} + \gamma_3 q_{3t} + \tau_{jt}$$

$$(17)$$

$$[B]\quad R_{jt} - R_{ft} = \alpha_j + \beta_j(R_{mt}-R_{ft}) + \gamma_1 q_{1t} + \gamma_2 q_{2t} + \gamma_3 q_{3t} + \gamma_4 q_{4t} + \tau_{jt}$$

The empirical results associated with equations (16) and (17) indicate that the number of firms with misspecification errors has increased from 133 and 133 to 157 and 153 for the CAPM with intercept and the CAPM without intercept respectively if the fifth order polynomial, q_4, is used. This implies that Ramsey's (1969, p. 362) statement about the degree of polynomial may well be questionable.[3]

Brenner (1979), Brown and Warner (1979) have used a constrained CAPM to calculate residuals and to perform the cumulative average residual (CAR) tests. The constrained CAPM can be defined as

$$(R_{jt} - R_{ft}) = (R_{mt} - R_{ft}) + u_{jt} \qquad (18)$$

Equation (18) can be obtained by assuming $\alpha_j = 0$, $\beta_j = 1$ to equation (1A).

The estimated u_{jt} from equation (18) for 451 firms are used to do the misspecification test. It is found that out of 451 firms only 122 have misspecification errors. It is interesting to note that the simplest model has the smallest percentage of specification error. These findings are consistent with Brown and Warner's (1979) findings. In investigating the performance of alternative models, Brown and Warner have found that the model as indicated in equation (18) generally performs better than other models which have been investigated in this paper. Brenner (1979) have found that different models can generate different CAR results. However, he has not proposed a method to determine which model should be used as this paper does.

The correlation coefficients between the estimated $\overline{R}_j^2$ and the estimated F value are .120, .119, .121, .015, .004, .016, .017 and .011 for models 1, 2, 3, 4, 5, 6, 7 and 8 respectively. These results imply that the coefficient of determination $(\overline{R}_j^2)$ statistic cannot directly be used to determine whether a model is misspecified or not in capital asset pricing analysis. To show how the misspecification error for each firm distributes over 8 different models, Appendix B indicates the related information in detail. The summary information of Appendix B is listed in Table 1. Table 1 indicates the frequency distribution of specification errors for each individual firm. It is found that there exist 204 firms with some specification errors in terms of at least one model, and it is also found that there exist 247 firms entirely free from any specification errors.

To investigate the possible impacts of misspecification on the risk-return relationship test. The risk-return relationship model as defined in equations (19)-(22) are used to do some empirical investigations.

$$\overline{z}_j = a + b\,\hat{\sigma}_j^2 + \varepsilon_j \tag{19}$$

$$\overline{z}_j = a + b\,\hat{\beta}_j + \varepsilon_j \tag{20}$$

$$\overline{z}_j = a + b\,\hat{\beta}_j + C\hat{S}_1 + \varepsilon_j \tag{21}$$

$$\overline{z}_j = a + b\,\hat{\beta}_j + C\hat{S}_2 + \varepsilon_j \tag{22}$$

where $\overline{z}_j$ is either $\overline{R}_j$ or $(\overline{R}_j - \overline{R}_m)$; σ_j^2 is the total variance of j^{th} security; $\hat{\beta}_j$ is the beta coefficient estimated either from the CAPM or the market model. S_1 is the estimated residual variance from either the CAPM or the market model; S_2 is the estimated residual variance obtained from either

Table 1

Frequency Distribution of Specification for 451 Firms

Frequency	Number of Firms
8	86
7	10
6	13
5	10
4	45
3	9
2	19
1	12
0	247
Total	451

the CAPM or the market model with $\hat{q}_1$, $\hat{q}_2$, $\hat{q}_3$ and (or) q_4 terms. Results associated with equation (19)-(22) are presented in Tables 2-5. There exist eight different models in each table. Now the models are defined.

Model 1: the CAPM with intercept term. q_1, q_2 and q_3 are used to test the specification errors. There exist 133 firms with specification errors in this model.

Model 2: the market model. q_1, q_2, and q_3 are used to test the specification errors. There exist 137 firms with specification errors in this model.

Model 3: same as model 1 except that the intercept term is not included in the CAPM. There exist 133 firms with specification errors in this model.

Model 4: Model 1 with $(R_{mjt}-R_{ft})^2$ term. There exist 164 firms with specification errors in this model.

Model 5: Model 3 with $(R_{mt}-R_{ft})^2$. There exist 156 firms with specification errors.

Model 6: Model 1 using q_1, q_2, q_3, and q_4 to test the specification errors. There exist 157 firms with specification errors in this model.

Model 7: Model 3 using q_1, q_2, q_3 and q_4 to test the specification errors. There exist 153 firms with specification errors.

Model 8: The CAPM with zero intercept and unity slope coefficient [see equation (18)]. There exist 122 firms with specification errors.

Table 2 indicates that the slope coefficients of equation (19) are relatively stable among both groups and models; Tables 3-5 indicate that the slope coefficients are not stable among three different groups. In

Table 2. $\bar{z}_j = a + b\ \sigma_j^2$

	All Firms		Firms With Errors		Firms Without Errors	
	a	b	a	b	a	b
Model 1	-.0040	.5263	-.0038	.5364	-.0041	.5238
	(-9.6150)	(13.0153)	(-3.9113)	(5.3941)	(-9.0885)	(12.1948)
Model 2	.0006	.5253	.0008	.5325	.0004	.5261
	(1.3714)	(13.0119)	(.8641)	(5.4132)	(.9882)	(12.1642)
Model 3	-.0040	.5297	-.0038	.5397	-.0041	.5272
	(-9.6143)	(13.0144)	(-3.9106)	(5.3933)	(-9.0881)	(12.1943)
Model 4	-.0040	.5297	-.0045	.5637	-.0037	.5126
	(-9.6143)	(13.0144)	(-5.6565)	(6.6858)	(-7.7456)	(-7.7456)
Model 5	-.0039	.5297	-.0044	.5718	-.0038	.5140
	(-9.6143)	(13.0144)	(-5.1524)	(6.4320)	(-8.2410)	(11.6315)
Model 6	-.0060	.5253	-.0000	.5588	.0009	.5129
	(-1.3714)	(13.0119)	(-.0025)	(6.9023)	(1.8097)	(11.1646)
Model 7	-.0040	.5263	-.0047	.5718	-.0036	.5058
	(-9.6150)	(13.0153)	(-5.9432)	(7.0427)	(-7.5076)	(10.9776)
Model 8	-.0040	.5263	-.0033	.4665	-.0042	.5385
	(-9.6150)	(13.0153)	(-3.3112)	(4.3271)	(-9.0742)	(12.4375)

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t values appear in parentheses beneath coefficient.

Table 3. $\bar{z}_j = a + b\ \beta_j$

	All Firms		Firms With Errors		Firms Without Errors	
	a	b	a	b	a	b
Model 1	-.0081 (-10.3201)	.0079 (11.5330)	-.0069 (-4.1884)	.0067 (4.8827)	-.0087 (-9.7904)	.0086 (10.7748)
Model 2	-.0035 (-4.4335)	.0079 (11.4224)	-.0022 (-1.3441)	.0066 (4.9055)	-.0041 (-4.5665)	.0085 (10.5931)
Model 3	-.0081 (-10.2424)	.0079 (11.4478)	-.0068 (-4.1467)	.0067 (4.8371)	-.0087 (-9.7241)	.0085 (9.7241)
Model 4	-.0081 (-10.5577)	.0080 (11.8057)	-.0086 (-6.2986)	.0081 (6.6525)	-.0079 (-8.4739)	.0080 (9.8054)
Model 5	-.0079 (11.3318)	.0079 (11.3318)	-.0081 (-5.6503)	.0078 (6.1713)	-.0079 (-8.4601)	.0079 (9.5866)
Model 6	-.0035 (-4.4466)	.0079 (11.4053)	-.0040 (-2.9514)	.0080 (6.7224)	-.0032 (-3.3411)	.0078 (9.2141)
Model 7	-.0082 (-10.4465)	.0080 (11.6720)	-.0089 (-6.7552)	.0082 (7.1476)	-.0078 (-8.1244)	.0079 (9.2339)
Model 8	—	—	—	—	—	—

t values appear in parentheses beneath coefficient.

Table 4. $\bar{z}_j = a + b\ \beta_j + CS_1$

	All Firms			Firms With Errors			Firms Without Errors		
	a	b	c	a	b	c	a	b	c
Model 1	-.0071	.0048	.4029	-.0065	.0042	.4173	-.0073	.0050	.3986
	(-9.215 1)	(5.7564)	(6.4703)	(-3.9982)	(2.5146)	(2.4794)	(-8.4070)	(5.1586)	(6.0477)
Model 2	-.0025	.0047	.3974	-.0018	.0044	.3821	-.0027	.0049	.4005
	(-3.2390)	(5.7437)	(6.4017)	(-1.1589)	(2.6445)	(2.2952)	(-3.1058)	(5.0501)	(6.0969)
Model 3	-.0070	.0048	.3964	-.0064	.0043	.3947	-.0073	.0049	.3956
	(-9.1407)	(5.7471)	(6.3720)	(-3.9653)	(2.5635)	(2.3428)	(-8.334)	(5.1207)	(6.0103)
Model 4	-.0072	.0050	.3842	-.0083	.0060	.3279	-.0065	.0043	.4117
	(-9.4841)	(6.0897)	(6.1910)	(-6.1476)	(4.227)	(2.5739)	(-7.0902)	(4.3284)	(5.8925)
Model 5	-.0069	.0046	.4075	-.0079	.0057	.3481	-.0064	.0040	.4354
	(-9.0305)	(5.5821)	(6.5490)	(-5.5051)	(3.7483)	(2.4874)	(-7.0453)	(4.0452)	(6.4253)
Model 6	-.0025	.0050	.3520	-.0036	.0062	.2618	-.0018	.0043	.3868
	(-3.2301)	(5.9071)	(5.4821)	(-2.6589)	(4.2257)	(1.9364)	(-1.9217)	(4.1303)	(5.3435)
Model 7	-.0071	.0048	.3995	-.0084	.0060	.3364	-.0064	.0042	.4185
	(-9.3425)	(5.8786)	(6.4257)	(-6.3988)	(4.1581)	(2.4898)	(-6.7952)	(4.1590)	(6.0047)
Model 8	--	--	--	--	--	--	--	--	--

t values appear in parentheses beneath coefficient.

Table 5. $\bar{z}_j = a + b\ \beta_j + CS_2$

	All Firms			Firms With Errors			Firms Without Errors		
	a	b	c	a	b	c	a	b	c
Model 1	-.0071 (-9.2774)	.0049 (5.9518)	.3921 (6.2835)	-.0065 (-4.0172)	.0045 (2.6539)	.4011 (2.2914)	-.0072 (-8.4245)	.0050 (5.2127)	.3928 (5.9273
Model 2	-.0025 (-3.2385)	.0048 (5.8082)	.3995 (6.4242)	-.0018 (-1.1329)	.0043 (2.6066)	.4117 (2.3648)	-.0027 (-3.0849)	.0049 (5.0291)	.4020 (6.0889
Model 3	-.0070 (-9.1343)	.0047 (5.7356)	.4079 (6.5420)	-.0063 (-3.9217)	.0041 (2.4180)	.4543 (2.5818)	-.0072 (-8.3135)	.0049 (5.0715)	.4023 (6.0973
Model 4	-.0071 (-9.4518)	.0049 (5.9620)	.4062 (6.4331)	-.0083 (-6.1495)	.0059 (4.1474)	.3647 (2.6477)	-.0064 (-7.0587)	.0042 (4.1985)	.4279 (6.1024
Model 5	-.0069 (-9.0453)	.0046 (5.5918)	.4187 (6.5982)	-.0078 (-5.5157)	.0057 (3.7456)	.3721 (2.4534)	-.0064 (-7.0475)	.0039 (3.9938)	.4452 (6.5126
Model 6	-.0025 (-3.2045)	.0050 (5.8879)	.3671 (5.6536)	-.0036 (-2.6322)	.0061 (4.1467)	.2993 (2.0600)	-.0018 (-1.9217)	.0043 (4.1303)	.3868 (5.3435
Model 7	-.0071 (-9.4028)	.0049 (6.0017)	.4033 (6.4193)	-.0084 (-6.4411)	.0061 (4.2302)	.3545 (2.4542)	-.0064 (-6.8066)	.0043 (4.1876)	.4178 (5.9671
Model 8	--	--	--	--	--	--	--	--	--

t values appear in parentheses beneath coefficient.

addition, Tables 3-4 also indicate that the slope coefficients are stable among different models for overall group and group without specification errors, however, the slopes are not stable among different models within the group with specification errors. These findings have provided additional support to the argument that the CAPM and the market model cannot be applied to do capital asset pricing for some firms. Levy (1978) have theoretically explored this argument by allowing only limited number of securities in the portfolio.

Some important statistics used in Tables 2-5, are listed in Table 6. In Table 6, average rates of return, average excess rates of return, average beta coefficients, average S_1 and average S_3 are presented in accordance with overall firms, firms with errors and firms without errors. In addition, each average statistic is also listed in terms of different models. Results from Table 6 show that basic return and risk statistic measures are generally different among different groups.

To investigate the degree of stability for the beta coefficients associated with a misspecified CAPM, the random coefficient method suggested by Theil (1971) and Fabozzi and Francis (1978) is used to test whether a beta coefficient associated with the misspecified CAPM for an individual firm is a random coefficient estimator or not. It is found that there exist 111 out of 133 beta coefficients, which are estimated from misspecified CAPM's, of fixed coefficient beta estimates.[4]

V. Summary and Concluding Remarks

Based upon the relationship between the single-index and the multi-index models of capital asset pricing, the possible specification errors

Table 6. Average $\bar{z}$, $\bar{\beta}_j$, $\bar{S}_1$ and $\bar{S}_3$

	$\bar{z}$	$\bar{\beta}_j$	$\bar{S}_1$	$\bar{S}_3$
Model 1				
All firms	.00055 $(\bar{R}_j-\bar{R}_f)$	1.0861	.00611	.00603
Firms with errors	.00080 $(\bar{R}_j-\bar{R}_f)$	1.1368	.00584	.00557
Firms without errors	.00045 $(\bar{R}_j-\bar{R}_f)$	1.0648	.00622	.00622
Model 2				
All firms	.0051 $(\bar{R}_j)$	1.0871	.0061	.0059
Firms with errors	.0054 $(\bar{R}_j)$	1.1343	.0059	.0055
Firms without errors	.0050 $(\bar{R}_j)$	1.0664	.0062	.0062
Model 3				
All firms	.00055 $(\bar{R}_j-\bar{R}_f)$	1.0860	.00611	.0060
Firms with errors	.00080 $(\bar{R}_j-\bar{R}_f)$	1.1367	.00584	.00551
Firms without errors	.00045 $(\bar{R}_j-\bar{R}_f)$	1.0648	.00623	.00620
Model 4				
All firms	.00055 $(\bar{R}_j-\bar{R}_f)$	1.0818	.00610	.0060
Firms with errors	.00005 $(\bar{R}_j-\bar{R}_f)$	1.0711	.00567	.00533
Firms without errors	.00084 $(\bar{R}_j-\bar{R}_f)$	1.0880	.00634	.00632
Model 5				
All firms	.00055 $(\bar{R}_j-\bar{R}_f)$	1.0826	.0061	.0060
Firms with errors	.00033 $(\bar{R}_j-\bar{R}_f)$	1.0806	.00575	.00539
Firms without errors	.00067 $(\bar{R}_j-\bar{R}_f)$	1.0836	.00629	.00626
Model 6				
All firms	.0051 $(\bar{R}_j)$	1.0919	.0061	.0059
Firms with errors	.0047 $(\bar{R}_j)$	1.0938	.00574	.00532
Firms without errors	.0053 $(\bar{R}_j)$	1.0909	.00631	.00626
Model 7				
All firms	.00055 $(\bar{R}_j-\bar{R}_f)$	1.0842	.0061	.0059
Firms with errors	.00006 $(\bar{R}_j-\bar{R}_f)$	1.0890	.0057	.0053
Firms without errors	.00081 $(\bar{R}_j-\bar{R}_f)$	1.0818	.00629	.00627
Model 8				
All firms	.00055 $(\bar{R}_j-\bar{R}_f)$	1.0000	.00611	.00603
Firms with errors	.00053 $(\bar{R}_j-\bar{R}_f)$	1.0000	.00562	.00535
Firms without errors	.00056 $(\bar{R}_j-\bar{R}_f)$	1.0000	.00635	.00631

of alternative asset pricing model are analyzed. The implications associated with the misspecified models are also discussed. 451 firms from the NYSE during the period January 1965-December 1977 are used to do empirical study. It is found that the specification error associated with asset pricing model can bias the CAR and the risk-return relationship test. Therefore, the method proposed in this paper could be used to determine whether a CAPM can statistically be used to estimate the cost of capital or to forecast the rates of return of a firm (or portfolio) or not. The main sources of misspecification for a firm (or portfolio) in employing either the CAPM or market model will be investigated in detail in the future research.

Footnotes

[1]It should be noted that the statistical relationship is not always identical to mathematical relationship. The time-series statistical relationship can be regarded as a rate of return generating process.

[2]The BLUS residuals can be used to substitute for the OLS residuals as inputs of Goldfeld and Quandt's (1965) technique in testing the existence of heteroscedasticity to improve the power of test. See Harvey and Phillips (1974) for detail.

[3]Professor Ramsey (1969, p. 362) has said "... How many vector q_j are needed will depend upon the particular circumstances so that no general rule can be specified. The author has found, however, that using q_1, q_2 and q_3 has been sufficient."

[4]These results are obtained in terms of model 1 as defined in equation (1A).

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Appendix A. $\overline{R}^2$, F and β for Model 1

$$[\overline{R}_{jt} - R_{ft} = \alpha_j + \beta_j (R_{mt} - R_{ft}) + \varepsilon_j]$$

	TS	$\overline{R}^2$	F	β		TS	$\overline{R}^2$	F	β
1	ABT	.3300	6.0226	.9729	46	DM	-.0032	3.8759	0.2179
2	AIN	.3487	2.8058	1.7179	47	DI	.3832	4.5606	1.2092
3	AN	.3795	4.6491	1.2564	48	DQU	.2865	4.3361	0.5878
4	AL	.2214	2.8303	0.8062	49	EPI	.4048	3.2127	1.1730
5	ALS	.4340	3.2895	1.4662	50	ES	.3088	3.1130	1.2885
6	ASU	.2242	3.3796	1.4882	51	ETN	.4517	4.4714	1.3179
7	AH	.2550	2.9017	1.1830	52	EMR	.5335	3.2367	1.1438
8	AA	.2436	5.1573	0.8976	53	EQT	.3436	2.9871	0.6411
9	AB	.4905	3.3761	1.9103	54	FMC	.5263	3.1959	1.5309
10	ABA	.1868	7.1091	1.2097	55	FJQ	.2688	4.8632	1.6645
11	ADC	.2833	7.9670	1.1098	56	FOE	.4582	4.8642	1.4906
12	AIC	.2732	3.2747	1.5291	57	FBD	.2169	4.2608	1.7406
13	ARV	.2435	2.8420	1.1540	58	FIR	.3113	3.5540	0.8930
14	ATE	.2744	5.0519	0.7357	59	FO	.4930	3.2033	1.4635
15	AV	.4590	3.8569	2.3956	60	FTR	.3849	3.0143	1.1771
16	BYK	.0797	2.9905	0.5868	61	GD	.2129	5.0036	1.2483
17	BX	.3937	2.6522	1.1878	62	GIS	.4434	5.4318	1.0651
18	BOR	.4716	5.5248	1.1661	63	GM	.4415	8.1937	0.9199
19	BMY	.4665	6.0327	1.616	64	GPT	.3011	4.7340	1.2774
20	BC	.3617	2.9154	1.8780	65	GTE	.5318	2.7275	1.0377
21	BY	.2093	7.5855	1.0064	66	GT	.3995	3.0523	1.0106
22	BVA	.2984	6.1403	1.2979	67	G	.3062	5.5128	0.8926
23	BUR	.3269	3.6547	1.0785	68	HPG	.2191	3.5341	0.8050
24	CIT	.3315	4.7411	0.9541	69	HAL	.2833	4.6339	1.0010
25	CZ	.2995	5.9026	1.0036	70	HNZ	.3707	3.0362	1.0072
26	CSR	.2903	3.4549	0.8753	71	HLT	.3396	2.7305	1.6516
27	CO	.3151	12.4958	0.9197	72	IPL	.3072	3.7197	0.8687
28	CCN	.1755	2.7940	1.6050	73	IR	.4345	3.9220	1.1685
29	C	.3427	4.5275	1.4330	74	IGL	.1454	3.1392	0.9622
30	CMZ	.2554	5.0135	1.2309	75	ITT	.5322	3.6583	1.3639
31	CS	.1855	3.0320	0.6908	76	IWG	.2529	4.9746	0.6981
32	CLU	.2334	4.8309	1.0565	77	JOY	.2542	4.0672	1.2269
33	KO	.5215	3.7634	1.0865	78	LG	.2067	4.4039	0.5842
34	CL	.3257	5.1178	1.0507	79	LOF	.3904	4.2230	1.1274
35	CK	.3135	3.4164	1.3143	80	LCE	.2446	7.4033	1.0717
36	CG	.2406	2.9265	0.6162	81	LAT	.4407	3.2775	1.4771
37	CSP	.2892	3.5869	1.2754	82	MZ	.4009	4.9206	1.3032
38	ED	.1738	3.1605	0.7946	83	MHT	.3484	2.6350	1.7101
39	CLL	.2216	3.4934	0.8348	84	MNC	.3566	6.7834	1.2544
40	CR	.2539	4.1360	1.0857	85	MYG	.2936	5.6917	0.8995
41	CUC	.1373	5.4190	0.7368	86	MCR	.2704	2.8528	1.2607
42	CYL	.2035	4.2287	0.9079	87	MP	.1819	7.6578	0.9645
43	D	.4758	4.5139	1.7602	88	MES	.2725	2.8939	1.3096
44	DE	.2491	4.4700	0.9931	89	MRK	.3392	4.0632	0.8601
45	DTE	.2595	4.3080	0.7498	90	MPH	.3258	2.6266	1.0213

	TS	$\bar{R}^2$	F	β		TS	$\bar{R}^2$	F	β
91	NCR	.3285	4.3739	1.2414	141	APC	.2708	1.2906	1.2098
92	NAB	.2930	3.0854	0.8721	142	AGM	.0662	1.1479	0.4019
93	DR	.2953	3.3274	0.8133	143	AMX	.2489	2.4810	0.8666
94	NG	.3684	3.9176	1.2691	144	AMR	.3500	0.3086	1.6889
95	NFK	.2896	5.0394	0.7148	145	AMB	.3387	0.8543	0.7427
96	NNG	.2769	4.8522	0.8423	146	ABC	.2990	1.2887	1.3588
97	NOC	.2023	3.6729	1.0856	147	AC	.2463	0.1798	0.6030
98	OLN	.4572	2.9958	1.3676	148	ACY	.3991	1.8774	1.0183
99	OM	.4650	6.3963	1.7986	149	AEP	.3419	0.5203	0.8340
100	PLT	.2587	3.1601	0.5752	150	AHP	.3794	1.3046	0.9547
101	PAC	.1717	2.8278	0.4549	151	AMO	.1311	1.6429	1.0264
102	PN	.3509	2.8519	1.9505	152	ANR	.2686	0.0994	0.6361
103	PSM	.3324	2.6051	1.0905	153	AST	.2997	1.1888	1.3001
104	PDG	.3120	6.3980	1.3999	154	ASC	.2950	2.1227	1.0009
105	PEP	.4842	9.3808	1.1955	155	T	.3899	1.1230	0.6164
106	PET	.2805	2.9355	0.8704	156	AP	.2438	0.3896	1.2630
107	PUL	.2532	3.4928	1.6352	157	ASR	.1820	0.3975	0.6757
108	RVS	.3623	6.3295	1.2016	158	AD	.3404	0.4962	1.0121
109	ROK	.2611	2.7169	0.7887	159	ARH	.3705	1.0623	1.1674
110	RCC	.3582	3.3980	1.4311	160	AYL	.4252	1.8460	1.3453
111	SJO	.3304	3.4361	1.0405	161	ADM	.1207	0.8492	0.7863
112	SLB	.2398	4.1454	0.9838	162	ARR	.1463	2.0209	1.0194
113	SPP	.2833	3.4336	0.9974	163	AS	.3304	0.8199	0.9275
114	SCI	.2595	4.2871	1.1282	164	ACK	.3380	1.2662	1.1266
115	S	.4305	2.9805	0.9266	165	AR	.3371	2.8216	1.3081
116	SUO	.3264	9.9433	1.0101	166	ASH	.3405	0.2355	1.0525
117	SMC	.4087	5.7704	1.3621	167	DG	.3475	2.5912	1.1804
118	SCG	.3895	6.7729	1.1229	168	ARC	.2289	1.9206	0.9099
119	SR	.3541	5.2859	1.0327	169	AZ	.1498	1.5311	1.3351
120	SN	.2312	2.7828	0.6696	170	BGE	.2778	1.5174	0.6621
121	STX	.4519	3.3618	1.1251	171	BCX	.4215	1.2631	1.5954
122	SW	.2479	3.5091	1.2196	172	BHY	.2188	2.5681	1.0143
123	SUN	.2177	3.3345	0.6881	173	BHW	.4144	0.1043	1.5563
124	SOC	.3008	3.3199	1.1499	174	BNL	.3794	0.5963	1.2928
125	TAN	.3992	3.1971	2.2098	175	BE	.0880	1.4125	1.1272
126	TA	.4831	4.1870	1.5714	176	BS	.3670	2.1576	1.1021
127	UK	.5073	2.6495	1.0912	177	BDK	.4361	2.3535	1.2752
128	USG	.3376	3.3825	1.0566	178	BLI	.3174	1.0888	1.0906
129	USI	.3235	2.6428	1.5128	179	BA	.2871	1.3288	1.4007
130	WLA	.4484	6.4619	1.0869	180	BN	.3104	1.0972	0.8295
131	WX	.3048	5.7165	1.0248	181	BSE	.2119	0.7597	0.6528
132	Z	.3607	3.0075	1.1298	182	BNF	.2914	0.4993	1.7981
133	ZE	.3882	3.6857	1.4131	183	BGG	.3762	1.9157	0.9674
134	ACF	.3441	0.1939	1.1625	184	BF	.3692	0.6627	1.4468
135	AMT	.2119	0.8466	0.8675	185	BFC	.2279	1.9328	1.0369
136	ALL	.1865	2.2153	1.3918	186	BGH	.2993	1.4910	1.1664
137	AGG	.1421	0.6275	0.2317	187	CBS	.3771	2.1497	1.0929
138	AG	.2507	0.8206	0.9319	188	CPC	.3510	0.9051	0.8189
139	AYP	.3073	1.2535	0.8345	189	CDE	.2301	0.2313	1.9725
140	ACD	.3756	1.3985	1.1312	190	CMN	.2242	0.1095	1.5070

	TS	$\bar{R}^2$	F	β		TS	$\bar{R}^2$	F	β
191	CPB	.2866	0.7911	0.7817	241	FMO	.2354	0.3038	0.8320
192	CP	.3330	1.2858	0.9626	242	FDS	.4199	0.6560	1.1200
193	CPL	.2468	0.8566	0.8508	243	FPL	.2843	1.1216	0.9080
194	CRS	.2886	1.2176	1.0704	244	FDP	.2526	0.6160	0.9102
195	CRR	.3108	0.8099	1.3136	245	FFS	.1659	1.1909	0.8238
196	CAT	.4589	1.2236	1.1212	246	FWC	.2651	0.1578	1.4794
197	CNH	.2158	2.2813	0.5832	247	FT	.2686	0.8811	1.0555
198	CER	.2813	1.8353	0.7248	248	GMT	.4009	0.4278	1.1741
199	CIP	.2495	1.8105	0.7261	249	GSK	.2796	0.6122	1.0263
200	CHA	.3835	1.2734	1.3728	250	GDC	.3534	1.1223	1.2532
201	CGG	.3286	1.8087	1.0669	251	GBS	.2148	1.5703	0.6478
202	CIN	.2195	2.1888	0.6229	252	GK	.3363	1.2458	1.2474
203	CNV	.4375	2.1152	1.9991	253	GE	.5497	1.3556	1.1776
204	CKL	.4551	0.5914	1.5023	254	GF	.3715	1.9873	0.9336
205	CVX	.2529	0.9763	0.5613	255	GH	.2232	1.3444	1.4198
206	COT	.2775	0.3581	1.4093	256	GRL	.3251	1.0083	1.7099
207	CPS	.2359	1.0528	1.6737	257	GPU	.3802	1.2556	0.8335
208	COC	.2869	1.0252	0.8057	258	GSX	.4187	1.1078	1.3997
209	CWE	.3610	1.2016	0.7929	259	GY	.3807	1.8397	1.2573
210	COG	.3300	1.5709	1.7933	260	GSO	.2219	2.3304	1.2984
211	CFD	.3649	1.1256	1.0247	261	GET	.1831	2.0947	0.8613
212	CNG	.1966	1.7705	0.5350	262	GS	.3240	0.9142	0.9817
213	CMS	.2716	1.7275	0.8041	263	GR	.3078	1.2553	1.1734
214	CCX	.1749	1.0254	1.1943	264	GLD	.3102	1.0426	1.1748
215	CCC	.2351	1.3590	0.6776	265	GRA	.3211	0.3453	0.9899
216	GWD	.2426	1.9393	0.7648	266	GNN	.2153	0.6157	0.9812
217	ZB	.4128	1.4052	1.1309	267	GQ	.1461	0.3831	0.9762
218	CW	.2355	1.6403	1.4778	268	GO	.4025	0.8271	0.8716
219	CH	.3958	1.9755	1.4862	269	GTU	.2956	2.0739	0.9621
220	DAY	.3316	0.9273	1.1987	270	HMW	.2237	1.0457	1.3604
221	DPL	.2769	1.4040	0.7240	271	HML	.3506	0.1702	1.3546
222	DEL	.2514	1.5168	0.7940	272	HSM	.2216	2.4631	0.9673
223	DEW	.3356	0.4324	0.7574	273	HAY	.3477	1.4073	1.1273
224	DTL	.2005	1.5209	1.8302	274	HPC	.3191	0.1922	1.0818
225	DSO	.2745	0.6834	1.4105	275	HSY	.2239	1.0619	0.7915
226	DN	.4215	0.7019	0.9294	276	HLY	.1087	0.7438	0.7041
227	DIA	.3730	2.0302	1.1850	277	HM	-.0013	1.3965	0.1814
228	DOW	.4763	2.5038	1.0751	278	HH	.4356	1.9838	1.2910
229	EMI	.2119	0.5369	1.1668	279	HFC	.4392	2.1086	1.3004
230	EAL	.3017	0.4413	1.8458	280	HOU	.2793	1.6536	0.8882
231	EOS	.3455	1.5658	1.1909	281	IU	.4162	1.5842	1.2812
232	ELG	.2793	1.3119	0.7900	282	IDA	.2157	1.5669	0.5660
233	ET	.4485	0.8501	1.4026	283	IPC	.2471	0.7306	0.7489
234	EDE	.1757	2.2678	0.4953	284	N	.3398	0.3436	0.9294
235	ENS	.2648	2.5956	0.8498	285	IAD	.3079	2.3297	0.8663
236	ESM	.2528	0.4958	0.9340	286	INR	.4348	1.4622	1.3474
237	EVY	.2985	1.5349	1.8330	287	IC	.2103	0.5048	0.8577
238	XLD	.3652	1.2634	1.1396	288	ISS	.4471	2.4827	1.3525
239	XON	.3068	0.7760	0.6567	289	IK	.3193	2.2315	0.9573
240	FEN	.2072	0.7675	1.3539	290	IBM	.4874	0.4189	0.9136

	TS	$\bar{R}^2$	F	β
291	HR	.2593	1.7958	0.8804
292	IM	.0960	2.5461	1.0319
293	IP	.4641	0.5771	1.1381
294	IPW	.2744	2.1106	0.5590
295	IOP	.3873	0.4963	0.7644
296	JWL	.3428	1.4559	1.1894
297	JM	.3432	1.9420	1.0164
298	JNJ	.2650	2.2294	0.7963
299	KLU	.3539	0.7886	1.4904
300	KSU	.3319	2.1857	1.2203
301	KN	.1829	1.5601	0.8354
302	KES	.1811	2.0535	0.7833
303	KMB	.3541	0.6670	0.9651
304	KOP	.3364	0.5555	1.1471
305	KRA	.3581	2.1146	0.8715
306	KR	.2786	1.3840	0.9516
307	LEH	.1844	1.9308	1.6240
308	LIO	.1357	0.9883	1.3805
309	LK	.1961	0.9827	1.4432
310	LIL	.3085	2.2569	0.7572
311	LOU	.1988	2.0123	0.6182
312	LUC	.2351	0.2894	1.3261
313	MRO	.2602	1.5657	0.9368
314	MF	.3472	0.6887	1.2194
315	ML	.4058	0.8425	1.2363
316	MA	.3665	0.5408	1.2708
317	MGR	.3793	0.5406	1.1692
318	MST	.2021	0.6430	0.9754
319	MCC	.2771	0.6999	1.0595
320	MSU	.3348	2.4659	0.9894
321	MLR	.2661	0.2456	1.0443
322	MMM	.5033	0.6638	1.1068
323	MPL	.3046	0.4312	0.7361
324	MOB	.3176	0.8670	0.8402
325	MOH	.3539	1.0832	1.3956
326	MTC	.4011	1.0580	1.1366
327	MDK	.2991	1.8553	0.6641
328	MTP	.2560	1.2582	0.6352
329	MMR	.2867	1.9827	1.6882
330	MOT	.3295	0.2486	1.4265
331	MUN	.2825	1.1312	1.0517
332	NL	.4179	2.1107	1.1836
333	NVF	.1666	0.3095	1.1942
334	NAL	.4131	1.7141	1.9880
335	NAC	.3158	0.1020	1.1972
336	NTL	.2657	0.1916	1.2146
337	NAS	.3216	0.8862	1.0755
338	NS	.3196	1.0547	0.8491
339	NOM	.1514	0.8053	1.4362
340	NES	.2797	2.3023	0.7308
341	NGE	.3448	0.7361	0.7349
342	NEM	.3304	2.0834	1.0116
343	NMK	.2583	1.1810	0.6197
344	NPH	.3857	1.6099	1.4991
345	NSP	.2737	2.0366	1.6725
346	NWA	.3934	0.2547	1.6725
347	NWT	.4067	1.5045	1.6409
348	OEC	.2636	1.9465	0.6644
349	OGE	.2212	0.2446	0.7946
350	OI	.3695	2.3626	0.9838
351	PPG	.3943	1.5597	1.0442
352	PCG	.2828	0.0644	0.6968
353	PTC	.1011	0.2461	0.6894
354	PEL	.2975	1.6578	0.8834
355	JEC	.4812	1.4988	1.2222
356	PPL	.2956	1.7141	0.6444
357	PGL	.2027	1.5862	0.5245
358	PFE	.3860	2.3990	1.1040
359	PD	.3003	0.3505	1.0289
360	MO	.2562	1.0637	0.9177
361	P	.2937	2.5069	1.0848
362	PVH	.3863	1.0718	1.7000
363	PBI	.2869	1.0021	1.1596
364	PFG	.1805	0.7369	0.7716
365	PCO	.2696	2.0463	1.2432
366	POM	.2320	2.2304	0.6081
367	PG	.3767	0.9725	0.7256
368	PSR	.2301	0.9288	0.7015
369	PIN	.3264	0.7758	0.8923
370	PEG	.3225	0.8179	0.8092
371	PU	.2376	1.9640	0.9490
372	OAT	.2561	2.0178	0.9592
373	KSF	.3719	0.4033	1.4119
374	RTN	.2747	0.2055	1.3317
375	REP	.1687	0.4862	1.7524
376	RS	.3259	2.1219	0.9324
377	RUB	.1273	0.2212	1.1498
378	REX	.2843	1.0943	0.9713
379	RJR	.2185	0.6518	0.6646
380	RLM	.3595	1.2884	1.4059
381	RXM	.3560	1.7493	1.0291
382	RGS	.2937	1.0488	0.7683
383	RHR	.1298	1.8803	0.8830
384	RON	.2478	1.6107	1.2930
385	ROP	.4377	0.2427	1.5574
386	RD	.3298	2.329	0.8377
387	SA	.2631	1.3874	0.6988
388	FN	.4045	0.9746	1.0900
389	SRT	.3474	0.5057	1.0680
390	SDO	.2826	1.9306	0.7479

	TS	$\bar{R}^2$	F	β		TS	$\bar{R}^2$	F	β
391	SGP	.2854	1.4522	0.9334	422	TR	.2949	0.2275	1.3581
392	SCO	.3247	1.9307	1.3233	423	TU	.3168	1.5005	1.0348
393	VO	.3702	1.3612	0.9476	424	TWA	.3828	1.6027	2.1477
394	SVE	.2963	1.7680	1.7817	425	TF	.3130	1.4155	1.7581
395	SIM	.1593	2.2643	0.7959	426	UGI	.2798	2.1640	0.8474
396	SIH	.1620	0.1614	1.5256	427	UV	.2805	0.6971	1.5302
397	SOO	.1877	2.3928	0.7889	428	UNR	.1679	0.4359	1.0424
398	SCE	.3423	0.2706	0.8724	429	UCC	.3758	1.5784	1.1562
399	SO	.3172	1.1303	0.8261	430	UCL	.2874	2.1614	0.8798
400	NRG	.2040	1.7879	0.7818	431	R	.4445	1.3236	1.3134
401	SX	.4199	1.8039	1.0131	432	UPK	.0418	1.9066	0.6685
402	SPS	.2958	0.4160	0.7339	433	UBO	.2679	2.2658	0.8315
403	SY	.3278	0.9837	1.2978	434	UTX	.2364	0.5570	1.0363
404	SQD	.3929	1.3801	1.8880	435	UVV	.2098	1.5122	0.7153
405	SB	.3607	1.2743	0.8131	436	UTP	.3490	0.2664	0.7073
406	SD	.3396	0.2451	0.8633	437	VEL	.3242	0.4024	0.9650
407	SOH	.0995	0.8173	0.8174	438	YMC	.3243	2.0334	1.0441
408	SCX	.1396	0.3790	0.8174	439	WAG	.3913	0.5033	1.1367
409	STF	.3681	0.2221	1.0809	440	WMC	.2990	0.7085	1.2292
410	SBI	.1951	0.3302	0.9657	441	WD	.2250	0.6786	1.7152
411	STY	.2798	1.5767	0.9555	442	WGL	.0787	2.2567	0.4208
412	STN	.2668	1.2198	1.1067	443	WWP	.2024	0.5533	0.4292
413	SBC	.2470	1.6119	1.1150	444	WKT	.3020	1.2527	1.1139
414	SNL	.2748	1.7075	1.4892	445	WAL	.3689	0.2800	1.8103
415	SMB	.4650	2.0418	1.4029	446	WPI	.2128	1.6991	1.2139
416	SSC	.1168	1.3985	1.0869	447	W	.3150	0.2670	1.0466
417	SYB	.4044	0.8696	1.3522	448	WHX	.3026	0.6597	1.4918
418	TRW	.3889	1.6752	1.2606	449	WPC	.2230	0.5441	0.5749
419	TXU	.2154	0.3218	0.7088	450	WPS	.1794	1.4444	0.4247
420	TXT	.4636	1.1653	1.5345	451	WWY	.1804	0.2239	0.6119
421	TED	.2949	0.2275	1.3581					

Remarks: TS = stock symbols of firms

$\bar{R}^2$ = adjusted coefficient of determination

F = F value for equation (12)

β = beta coefficient of firms

Appendix B. Firms With Misspecification Errors for 8 Models

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
ACF									
ABT	/	/	/	/	/	/	/	/	8
AMT									
ALL									
AIN	/	/	/	/	/	/	/		7
AGG				/	/	/	/		4
AN	/	/	/	/	/	/	/	/	8
AL	/	/	/					/	4
AG									
AYP									
ACD									
ALS	/	/	/	/	/	/	/	/	8
ASU	/	/	/					/	4
AH	/	/	/	/	/			/	6
APC					/	/	/		3
AA	/	/	/	/	/	/	/	/	8
AGM									
AMX				/	/				2
AB	/	/	/	/	/	/	/	/	8
AMR									
ABA	/	/	/	/	/	/	/	/	8
AMB									
ABC					/	/	/		3
AC									
ACY					/	/	/		3
ADC	/	/	/	/	/	/	/	/	8
AEP				/	/				2
AHP				/	/	/	/		4
AIC	/	/	/	/		/	/	/	7
AMO				/	/	/			3
ANR									
AST				/	/	/	/		4
ASC									
T									
AP									
ASR									
AD									
ARH									
AYL									
ADM									
ARR				/	/	/	/		4
AS									
ACK									
ARV	/	/	/					/	4
AR									
ASH									
DG	/								1

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
ATE	/	/	/	/		/	/	/	7
ARC									
AZ									
AV	/	/	/	/	/	/	/	/	8
BGE									
BYK	/	/	/	/	/	/	/	/	8
BCX									
BHY	/								1
BHW									
BX	/	/	/					/	4
BNL									
BE									
BS									
BDK									
BLI									
BA									
BN									
BOR	/	/	/	/	/	/	/	/	8
BSE				/					1
BNF									
BGG				/	/				2
BMY	/	/	/	/	/	/	/	/	8
BC	/	/	/						3
BY	/	/	/	/	/	/	/	/	8
BF									
BFC									
BVA	/	/	/	/	/	/	/	/	8
BUR	/	/	/	/	/	/	/	/	8
BGH									
CBS									
CIT	/	/	/			/	/	/	6
CPC									
CDE									
CMN									
CPB									
CP									
CPL				/	/				2
CRS									
CRR									
CAT									
CZ	/	/	/	/	/	/	/	/	8
CSR	/	/	/	/	/	/	/	/	8
CNH				/	/	/	/		4
CER				/	/	/	/		4
CIP				/	/	/	/		4
CHA									
CO	/	/	/	/	/	/	/	/	8
CGG									
CCN	/	/	/					/	4

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
C	/	/	/	/	/	/	/	/	8
CIN						/	/		2
CMZ	/	/	/	/	/	/	/	/	8
CS	/	/	/	/	/	/	/	/	8
CNV				/	/	/	/		4
CKL									
CVX				/	/	/	/		4
CLU	/	/	/	/	/	/	/	/	8
KO	/	/	/	/	/	/	/	/	8
CL	/	/	/	/	/	/	/	/	8
CK	/	/	/	/	/	/	/	/	8
COT									
CG	/	/	/					/	4
CPS									
COC									
CSP	/	/	/	/	/	/	/	/	8
CWE									
COG				/	/	/	/		4
ED	/	/	/	/	/	/	/	/	8
CFD									
CNG				/	/	/	/		4
CMS					/	/	/		3
CCX									
CCC									
CLL	/	/	/	/	/	/	/	/	8
CWD									
CR	/	/	/	/	/	/	/	/	8
ZB									
CUC	/	/	/	/	/	/	/	/	8
CW									
CH									
CYL	/	/	/	/	/	/	/	/	8
D	/	/	/	/	/	/	/	/	8
DAY				/	/	/	/		4
DPL				/					1
DE	/	/	/	/	/	/	/	/	8
DEL									
DEW									
DTL				/	/	/	/		4
DSO									
DTE	/	/	/	/	/	/	/	/	8
DN									
DIA									
DM	/	/	/	/	/	/	/	/	8
DOW						/	/		2
DI	/	/	/	/	/	/	/	/	8
DQU	/	/	/	/	/	/	/	/	8
EMI									
EPI	/	/	/					/	4

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
ES	/	/	/					/	4
EAL									
ETN	/	/	/	/	/	/	/	/	8
EOS									
ELG									
ET									
EMR	/	/	/					/	4
EDE				/	/	/	/		4
ENS	/			/	/	/	/		5
EQT	/	/	/	/					4
ESM									
EVY									
XLD									
XON									
FMC	/	/	/	/	/	/	/	/	8
FEN									
FJQ	/	/	/	/	/	/	/	/	8
FMO									
FDS									
FOE	/	/	/	/	/	/	/	/	8
FBD	/	/	/	/	/	/	/	/	8
FIR	/	/	/	/		/	/	/	7
FO	/	/	/	/	/	/	/	/	8
FPL									
FDP									
FFS				/	/	/	/		4
FWC									
FT				/	/	/	/		4
FTR	/	/	/	/	/	/	/	/	8
GMT									
GSK									
GDC									
GBS				/	/	/	/		4
GK									
GD	/	/	/	/	/	/	/	/	8
GE									
GF									
GH									
GRL									
GIS	/	/	/	/	/	/	/	/	8
GM	/	/	/	/	/	/	/	/	8
GPT	/	/	/	/	/	/	/	/	8
GPU				/	/	/	/		4
GSX									
GTE	/	/	/	/		/	/	/	7
GY				/	/				2
GCO				/	/				2
GET				/	/				2
GS									
GR									

Models / TS	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
GT	/	/	/	/				/	5
GLD									
GRA									
GNN									
G	/	/	/	/	/	/	/	/	8
GQ									
GO									
GTU									
HMW									
HPG	/	/	/			/	/	/	6
HAL	/	/	/	/	/	/	/	/	8
HML									
HSM	/								1
HAY				/	/				2
HNZ	/	/	/	/	/	/	/	/	8
HPC									
HSY									
HLT	/	/	/						3
HLY									
HM									
HH				/	/	/	/		4
HFC									
HOU				/	/	/	/		4
IU									
IDA									
IPC									
N									
IPL	/	/	/	/	/	/	/	/	8
IR	/	/	/			/	/	/	6
IAD									
INR									
IC									
ISS				/	/				2
IK									
IBM									
HR									
IGL	/	/	/	/	/	/	/	/	8
IM				/					1
IP									
ITT	/	/	/	/	/	/	/	/	8
IPW									
IWG	/	/	/	/	/	/	/	/	8
IOP									
JWL									
JM									
JNJ									
JOY	/	/	/			/	/	/	6
KLU									
KSU				/	/	/	/		4
KN									

Models / TS	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
KES									
KMB									
KOP									
KRA									
KR									
LG	/	/	/	/	/	/	/	/	8
LEH				/	/	/	/		4
LOF	/	/	/	/	/	/	/	/	8
LIO									
LK									
LCE	/	/	/	/	/	/	/	/	8
LIL				/					1
LOU									
LAT	/	/	/	/				/	5
LUC									
MZ	/	/	/	/	/	/	/	/	8
MHT	/	/	/	/	/	/	/		7
MRO									
MF									
ML									
MNC	/	/	/	/	/	/	/	/	8
MA									
MYG	/	/	/	/	/	/	/	/	8
MCR	/	/	/	/	/	/	/	/	8
MGR									
MP	/	/	/	/	/	/	/	/	8
MES	/	/	/	/	/	/		/	7
MST									
MRK	/	/	/	/	/	/	/	/	8
MCC									
MSU				/	/	/	/		4
MLR									
MMM									
MPL									
MOB									
MOH				/	/				2
MTC									
MDK						/	/		2
MTP									
MMR									
MOT									
MUN									
MPH	/	/	/	/	/	/	/	/	8
NCR	/	/	/			/	/	/	6
NL									
NVF									
NAB	/	/	/	/	/	/	/	/	8
NAL									
NAC									
NTL									
DR	/	/	/			/	/	/	6

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
NG	/	/	/	/	/	/	/	/	8
NAS									
NS									
NOM									
NES									
NGE									
NEM									
NMK									
NFK	/	/	/	/	/	/	/	/	8
NPH									
NNG	/	/	/	/	/	/	/	/	8
NSP									
NOC	/	/	/			/	/	/	6
NWA									
NWT									
OEC				/	/	/	/		4
OGE									
OLN	/	/	/	/				/	5
OM	/	/	/	/	/	/	/	/	8
OI				/	/				2
PPG									
PCG									
PLT	/	/	/	/	/	/	/	/	8
PAC	/	/	/	/	/	/	/		7
PTC									
PN	/	/	/			/	/		5
PEL									
JCP									
PPL									
PSM	/	/	/	/	/				5
PDG	/	/	/			/	/	/	6
PGL									
PEP	/	/	/	/	/	/	/	/	8
PET	/	/	/	/				/	5
PFE				/	/	/	/		4
PD									
MO									
P	/			/	/	/	/		5
PVH									
PBI									
PFG									
PCO									
POM					/	/	/		3
PG									
PSR									
PIN									
PEG				/	/	/	/		4
PUL	/	/	/	/	/	/	/	/	8
PU									
OAT				/	/				2

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
KSF									
RTN									
RVS	/	/	/	/	/	/	/	/	8
REP									
RS									
RVB									
REX									
RJR									
RLM									
RXM									
RGS				/					1
ROK	/	/	/					/	4
RHR									
RON				/	/	/	/		4
ROP									
RCC	/	/	/					/	4
RD									
SA									
SJO	/	/	/				/	/	5
FN									
SRT									
SDO				/	/	/	/		4
SGP				/	/	/	/		4
SLB	/	/	/	/	/	/	/	/	8
SPP	/	/	/				/	/	5
SCO						/	/		2
SCI	/	/	/	/	/	/	/	/	8
VO									
SVE									
S	/	/	/	/	/	/	/	/	8
SUO	/	/	/	/	/	/	/	/	8
SIM									
SMC	/	/	/	/	/	/	/	/	8
SIH									
SOO				/	/				2
SCG	/	/	/	/	/	/	/	/	8
SCE									
SO									
NRG									
SX									
SR	/	/	/			/	/	/	6
SPS									
SY									
SQD				/	/	/	/		4
SB									
SD									
SN	/	/	/						3
SOH					/				1
SCX									
STF									

Models TS	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
SBI									
STY				/	/	/	/		4
STN									
STX	/	/	/	/	/	/	/	/	8
SBC									
SW	/	/	/	/	/	/	/	/	8
SNL									
SUN	/	/	/	/	/			/	6
SMB									
SSC									
SOC	/	/	/	/	/			/	6
SYB									
TRW									
TAN	/	/	/	/	/	/	/		7
TXU									
TXT									
TED									
TR									
TU									
TWA									
TA	/	/	/	/	/	/	/	/	8
TF									
UGI				/	/	/	/		4
UV									
UNR									
UCC									
UK		/	/	/	/		/	/	6
UCL									
R						/			1
UPK						/			1
USG	/	/	/	/	/	/	/	/	8
USI	/	/	/		/	/	/		6
UBO				/	/				2
UTX						/			1·
UVV									
UTP									
VEL									
VMC				/	/				2
WAG									
WMC				/		/			2
WD									
WLA	/	/	/	/	/	/	/	/	8
WGL				/	/	/	/		4
WWP									
WKT				/	/	/	/		4
WAL									
WPI									
WX	/	/	/	/	/	/	/	/	8
W									

TS \ Models	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	
WHX									
WPC									
WPS									
Z	/	/	/	/	/	/		/	7
WWY									
ZE	/	/	/	/	/	/	/	/	8
Total	137	133	133	164	156	157	153	122	

Remarks: TS = Stock symbols of firms
/ = firm with specification errors