Empirical Analysis of Market Risk and Its Determining Factors

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There has been an increased interest in applying market risk to security analysis since Sharpe and Lintner developed the one-parameter model respectively by extending the mean-variance model. The risk of a firm conventionally has been measured with the variability of a distribution of possible returns or of possible fluctuations of security price for individual common stocks. But this quantification of risk involves the total risk which can be divided into market risk and unsystematic risk.

The unsystematic risk which is called diversifiable risk is the one that can be eliminated by holding diversified portfolio, and market risk which is called systematic risk or non-market risk usually denoted by beta is measured with the covariance between general market returns and returns of individual securities during a certain holding period.

The purpose of the study is to find out how certain factors of a firm affect market risk and to analyze these variables statistically with empirical models. Four hypotheses are to be tested concerning the effect of important variables of a firm on systematic risk; 1) Financial leverage increases market risk of a firm and therefore it affects the price of security of the firm negatively, 2) Size of a firm is an essential variable to determine market risk and contributes the firm's stability and reduces the risk, 3) The effect of leverage on market risk is expected to vary according to size of a firm. A large firm affords to have greater debt ratio than a smaller one because leverage does not increase the risk in a large firm as much as in a small firm and 4) Market risk varies among industries because of basic characteristics of each industry and the industry-difference explains a substantial proportion of beta risk.

I. The Empirical Models and Data

Three different models are presented to test the hypotheses em-

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pirically; a model with two independent main variables (size and leverage of a firm), a model with an interaction variables and two main variables, and a model with industry-difference variables.

The Model with Two Independent Variables

In this model, market risk is the dependent variable and size and leverage of a firm are employed as independent ones as follows.

$$\beta_{it}=b_0+b_1L_{it}+b_2S_{it}+e_{it}\cdots\cdots(1)$$

L_{it} : leverage of firm i
S_{it} : size of firm i
B_{it} : market risk of firm i

We wish to find some solutions or clues concerning the hypotheses about leverage and size of a firm.

Interaction Model

The effect of leverages on systematic risk in different firms may not be the same regardless of sizes of firms in one industry. To explore such possibility, interaction variable between leverage and size is added to the empirical model.

$$\beta_{it}=b_0+b_1L_{it}+b_2S_{it}+b_3L_{it}S_{it}+e_{it}\cdots\cdots(2)$$

where $L_{it}S_{it}$ represents interaction term between leverage and size of firm i. This model expect to give an answer to the hypothesis that the effect of leverage on market risk varies according to size of firm.

Inter-Industries Model

The size and leverage variables above may not influence systematic risk in the same manner for all industries. The degree of impact or direction of influence on the risk are to be different. This can be examined by comparing magnitudes of coefficients of these independent variables among industries. But there might be some difference of market risk inherent in each industry not because of fundamental variables but because of unique characteristics of each industry. To detect these differences of the risk among industries, dummy variables are employed as follows.

$$\beta_{it}=b_0+b_1L_{it}+b_2S_{it}+\text{ dummy variables }+e_{it}\cdots\cdots(3)$$

Since eight different industries are included in the sample, seven dummy variables are in the model (3).

Sample and Data

Eight different industries are selected to conduct the empirical study. The industries (with the number of firms in each industry) are oil (23), drug (18), chemical (41), machinery (31), food manufacturing (22), electronics (27), food retail (21) and steel industry (25). A total of 208 firms' securities are sampled for the study. The criteria of sampling individual securities are that they are listed on the New York Stock Exchange and that the firms whose securities are on the list have been in existence since 1958.

Time-series data are required to measure systematic risk and so annual data from 1961 to 1970 are utilized.[1] The other variables (size and leverage) are obtained from annual data of 1970. In other words, we use time-series data to develop the dependent variable and point data for size and leverage variables.

II. Definitions of Variables

Dependent Variable

Covariance between market returns and individual security returns is measured and used as systematic risk. For the market return, the author employs the Moody's Industrial Average Index. The change of market index plus average yield of 125 securities during a certain holding period is defined as the market return, and the return of an individual stock consists of the dividend and capital gain (price change) during a given holding period.

Independent Variables

Financial leverage is defined as ratio to total assets. Debt (current and long-term liability) and total assets are measured by book value rather than market value. Size of a firm is measured by the book value of its tangible assets which represent tangible fixed properties and other current assets. Goodwill, patents and other intangible assets are excluded. Because size of a firm is a scale variable, the author uses a log scale of size to reduce wide variation of size from company to company.[2]

1 The question whether annual data rather than weekly or quarterly data is appropriate for calculation of beta or not is answered by many studies including Jensen's who showed mathematically that the expected value of the estmate of systematic risk is independent of the length of time over which the sample returns are calculated.

2 The definitions of the independent variables above represent the stock concept. In this empirical study, the stock concepts are employed. There are some problems subject to argument in the stock concepts of leverage and size, but there are generally more problems concerned with alternative flow concept. In the stock concept, we use total assets as the proper measurement of size. In the flow concept, gross sales during a given period are employed as the size of a firm, and these sizes of firms can be changed according to the business cycle. This flow concept of the size of a firm is different from that of the conventional idea that size of firm is stable over time. In measurement leverage, similar problems are encountered with the flow concept where some variation of financial coverage is usually taken as the leverage proxy.

III. Results of Empirical Test

1) *Leverage and Systematic Risk*

Leverage positively affects the magnitude of systematic risk of a firm in one industry. All the coefficients of leverage which are denoted as in Table (1), except in the food manufacturing and oil industries, how a relatively strong effect on systematic risk. In the drug, chemical machinery, and electronics industires, the t-value of the leverage variables are significant at alpha = .01. However in the oil, food manufacturing, food retail, and steel industries, the coefficients at alpha = .05 are not significant. Leverage is a significant variable in steel and food retail at alpha = .10.

Table (1)

The Effect of Size and Leverage

$$\beta_{it}=b_0+b_1L_{it}+b_2S_{it}$$

Industry	Sample size	Beta	b_0	b_1	b_2	R^2	F
Oil	23	.912	2.277	.064 (.108)	–.174 (2.624)	.256	3.45
Drug	18	.910	1.936	1.526 (2.216)	–.311 (2.216)	.470	6.61
Chemical	41	1.182	1.365	1.345 (3.382)	–.148 (4.216)	.433	13.92
Machinery	31	1,266	1,647	1.389 (2.492)	–.216 (2.587)	.244	4.52
Food Mfr.	22	1.129	1.980	.254 (.389	–.319 (2.531)	.263	3.39
Steel	25	1.259	.667	1.112 (1.371)	–.020 (.320)	.280	3.94
Elec.	27	1.380	.057	4.842 (4.907)	–.350 (2.191)	.525	13.25
Food Retail	21	1.061	1.325	1.209 (1.483)	–.140 (1.210)	.148	1.55
Total	208	1.146	1.020	1.931 (7.065)	–.135 (5.126)	.351	41.09

* t-values of coefficients of variables are shown in parentheses.

However, a glance at Table (1) tells us that risk is increasing linearly with leverage in each industry with significant statistical evidence. Even though an increase in leverage is associated with increased risk, the MM proposition are not necessarily supported.[3] In this study, we have been concerned with only one part of risk, systematic risk while MM's hypotheses are based on total risk. As shown in Table (1), systematic risk is significantly increased with

3 Miller and Modigliani declared that the total market value of the firm and its cost of capital are independent of its capital structure because employment of debt increases risk of a firm so that the advantage of using debt is exactly offset by the risk increase.

debt. In an industry, a leveraged firm is more vulnerable to the movement of the market conditon. A price change or dividend change can be caused by various factors, but the proportion of such changes caused by a market change as a whole is larger for a firm which has more debt than for a firm with less leverage.

If the expectation of economic conditions in the future is bullish, stocks of higher leveraged firms are more desirable, because the movement of the price of the stocks will be enlarged according to market conditions when we assume that leverage affects risk independently.

2) *Size of Firm and Systematic Risk*

We used total assets as the measure of the size of firm. The log-scale was adopted to reduce the variations of scale difference among firms. As shown in Table (1), the coefficients of size which are represented by are all negative. Except for the steel and food retail industry, the size variable is significant at alpha = .01. In the oil, drug, chemical, machinery, food manufacturing, and electronics industry, size of firm is a strong variable in explaining behavior of covariance between market return and an individual stock's reutrn. A negative effect implies that systematic risk is smaller in larger companies than in smaller firms. If a firm is large, the proportion of the risk which moves in the same direction as the market, is relatively small. The undiversifiable risk is a decreasing function of the size of a firm.

Two major reasons provide the justification for the decreasing effect of size on market risk. First, a large firm is not as subject to short-term fluctuations of the market as a small firm. If the economy is in a recession or depression, the risk of bankruptcy is smaller for a large firm than for a smaller firm. The sensitive movement of smaller firms to economic conditions causes the increasing risk. Second, ownership of a larger firm is generally more widespread than that of a smaller firm. The change of expectations of a firm owned by a small group of investors will have a tendency toward over-reaction to slight changes in the market. This over-reaction will cause the price to fluctuate widely and will cause large variation in the capital gains.

3) *The Interaction Variable and Systematic Risk*

The variables do not always influence risk independently. Sometimes, if not always, two or more variables will work together on dependent variable. Leverage of firms in the same industry will not increase the undiversifiable risk in the same magnitude regardless of the size of firm. It is a reasonable proposition that the risk from debt is smaller in a firm which has large assets than in a small firm.

Risk caused by leverage can be different from company to company according to other conditions of the firm.

In the empirical model of which result is presented in Table (1), we assumed that variables affect the dependent variable by themselves, and the magnitude and direction of influence of the main variables were uniform for all firms in an industry regardless of the other conditions under which firms are operating. We dropped this assumption and accepted the possibility that interactions among variables are important factors in explaining the relationship between independent variables and the dependent variable in the second empirical model. Because we have two variables, there is only one interaction variable. The result based on this model is presented in Table (2).

Table (2)

Effects of Size and Leverage and Interactions on Market Risk

$$\beta_{it}=b_0+b_1L_{it}+b_2S_{it}+b_3L_{it}S_{it}$$

Industry	b_0	b_1	b_2	b_3	R^2	F
Oil	.2307	.133 (.081)	−.178 (1.650)	.009 (.045)	.287	2.18
Drug	−3.553	13.566 (2.624)	.731 (1.585)	−2.317 (2.346)	.619	7:56
Chemical	1.256	1.633 (1.696)	−.124 (1.519	−.062 (.330)	.425	9.10
Machinery	1.042	2.640 (2.167)	−.084 (.588)	−.273 (1.153)	.380	3.47
Food Mfr.	4.809	−3.230 (.943)	−.661 (1.625)	−.604 (.885)	.294	2.47
Steel	2.868	3.901 (1.003)	−.390 (1.223)	.950 (1.317)	.386	2.22
Elec.	−1.357	7.664 (3.174)	.213 (.455)	−1.073 (1.278)	.556	9.61
Food Retail	−4.314	14.302 (3.863)	.982 (3.020)	−2.591 (3.590)	.515	6.02
Total	2.208	4.715 (7.911)	.133 (2.312)	−.616 (5.180)	.423	40.47

The effects of size and leverage do not show as strongly as in the previous test using only the main variables. Leverage still maintains its significance, but the coefficient of the size variable is changed considerably. The effects of the main variables are significant unless we consider interaction variables and main variables together. For instance, the leverage effect as a separate factor is significant, but in the interaction model it does not show itself as a strong variable because the power of leverage is shared with the interaction variables for explanation of the dependent variables. As shown in Table (2), the importance of the main variables is weakened and some of the explanatory power is transferred to the interaction variable. When we consider only the main variables, the validity of the previous discussions holds. This is because the correlation between leverage and interaction is relatively high, but not high enough to conclude that there is the multi-collinearity between these two variables.

The coefficients of the interaction between leverage and size of firm are denoted by b_3 in Table (2). Positive coefficients are shown in oil and steel industries, but their t-values are not significant at alpha=.05. However, the other industries show a negative effect of the interaction term on systematic risk, and among them in the drug, food retail, machinery, and electronics industries, the interaction variables are significant. This implies that the amount or degree of the leverage effect on market risk depends partly on size of firm. The influence of the product of size and leverage reduces the risk. Leverage as a separate factor increases risk, but when combined with size, reduces risk. This means that if the firm is considerable in size and employs some amount of debt, the risk of the firm is less than the firm with smaller assets. It can also be said that a larger firm can stabilize the risk from leverage by the influence of the interaction between leverage and size of firm. This does not mean that the firm with larger assets can employ more debt to reduce the fluctuation of market price, because increasing risk from the leverage factor is larger than the reducing power of the interaction terms. Besides the leverage and size influence on market risk of the firms by themselves, the interaction of leverage and size reduces the coveriance between the return of a firm and market return. The result from all firms in the sample shows that the t-value of the coefficient of leverage is 5.18, which is significant at the level of alpha=.01. The regression result below is the outcome of the interaction model by utilizing the total sample of 208 common stocks:

$$\beta_{it}=2.02+\underset{(7.91)}{4.72L_{it}}+\underset{(2.31)}{.13S_{it}}-\underset{(5.18)}{.62L_{it}S_{it}} \quad R^2=.42$$

where $L_{it}S_{it}$ is the interaction variable. The explanatory power for determination of the market risk of a firm is increased since the coefficient of determination is increased from .35 to .42 by adding the interaction variable.

4) *Industry-Difference Effect on Market Risk*

Is there any relationship between industry-difference and systematic risk? It is true that there is a difference in the magnitude of beta among industries. Oil (β =.912), drug (β =.910), and food retail (β=1.06) industries have relatively lower market risk, while electronics (β =1.38) and machinery (β =1.26) have a higher risk as shown in Table (1)

Industry variable means only "the fact of industry-difference" by eliminating other variables in that industry. As mentioned above, there are differences of beta, but this might be caused by other fundamental or interactional variables rather than industrial difference factors. Introduction of dummy variables will show only "difference of industry" as a variable, but not the difference of the other fundamental variables.

Seven dummy variables are used to find the industry effect on the market risk. The following is the result of the regression analysis with industry-difference factors.

$$\beta_{it} = 1.56 + .81L_{it} - .13S_{it} - .28X_1 - .03X_2 - .04X_3 - .05X_4 + .12X_5$$
$$(5.47) \quad (3.79) \quad (1.70) \quad (.24) \quad (.27) \quad (.33) \quad (.83)$$
$$-.19X_6 - .07X_7$$
$$(1.06) \quad (.45)$$

x_1 : 1 if it is drug industry
0 otherwise
x_2 : 1 if it is chemical industry
0 otherwise
x_3 : 1 if it is machinery industry
0 otherwise
x_4 : 1 if it is food manufacturing industry
0 otherwise
x_5 : 1 if it is steel industry
0 otherwise
x_6 : 1 if it is electronics industry
0 otherwise
x_7 : 1 if it is food retail industry
0 otherwise

The coefficient of x_3 (drug industry) shows significant t-value at alpha=.10 while the other six dummies show a relationship too weak to admit that industry-difference is significant for determination of covariance between market movement and individual return behavior.[4]

If we conduct K independent t-tests (our case includes seven independent t-tests), the probability of falsely rejecting at least one of the null hypotheses is very high if K is a large number. Therefore analysis of variance protects us from this error by considering the importance of the dummy variables as a whole. The result of the analysis of variance is presented in Table (3).

4 The author also tested the significance of the industry-difference variables with a smaller number of industries, and the result of the test was similar to that of all the industries together.

Table (3) tells us that while the effect of the main variable is significant at alpha=.01, that of industry-difference is not significant at all even at alpha=.10, since F=1.12 is below the necessary F=1.72 with $v_1=7$ and $v_2=198$. (v_1 is the degree of freedom used for the measures of seven dummy variables and v_2 is the degree of freedom available for error term.)

The result of the empirical test shown in Table (3) was not expected from the beginning. Intuitive judgment suggests that there might be a considerable difference of beta-risk inherent in certain industries. The results of the study in this paper suggest that the difference does not come from the industry-difference itself, but rather from different combinations of fundamental variables and different effcets of each variable (main variables and interaction term) on the systematic risk of each industry.

Table (3)

Analysis of Variance of Industry-Difference on Market Risk

Source of Variance	df	Sum of Square	Mean Square	F-Ratio
main Variables	2	12.36	6.18	27.14
Industry-Difference	7	7.92	.26	1.12
Error	198	44.78	.23	
Total	207	59.06		

IV. Conclusion

The hypothesis that leverage increases systematic risk of a firm is indirectly related to the argument between the MM and traditional views as to whether the value of a firm is independent of capital structure or not. The empirical study in this paper has been concentrated on the part of risk – systematic risk. Since we did not study unsystematic risk, we are prevented from reaching conclusions on this issue from our research. But the conclusion is that the systematic risk increases with the increasing leverage of a firm if the unsystematic risk is stable. This conclusion seems very clear since all the industries show the same result even though the strength or importance of leverage is different from industry to industry.

There is a decreasing effect of the size of a firm on systematic risk. This hypothesis is supported by our research since the t-value of the coefficient is significant at alpha=.10. As a matter of fact, the size variable is the most significant variable in almost every industry and also in the aggregated model. In the step-wise regression analysis, size of firm in particular appears to be the best single variable in predicting behavior of the market risk of individual firms. The reasons for this result could lie in the diversified characteristics of large firms and the stable expectation of individual investors on the price change of stocks of larger firms.

There are interaction effects among the main variables; leverage and size of firm. The interaction term appeared as a strong independent variable in the empirical study. The t-value of the result indicates that interactions are inevitable variables in explaining the behavior of market risk of a company.

The hypothesis that industry-difference would affect systematic risk is statistically rejected. There is a difference in the beta-coefficient which measures systematic risk, but the difference is not caused by the mere fact that they are in different industries, rather it is caused by the structure of fundamental variables and the difference of the effect of the fundamental variables in different industries. The strength or magnitude is different from industry to industry, but the variation of risk can be explained by other fundamental variables, not by industry-difference.

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