A MULTIPLE DISCRIMINANT INVESTIGATION INTO THE FINANCIAL CHARACTERISTICS OF COMPANIES HEAVILY INVESTED IN TOTAL QUALITY MANAGEMENT PROGRAMS COMPARED TO COMPANIES SELECTED AT RANDOM

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ABSTRACT

The Commerce Department's National Institute of Science And Technology (NIST) publishes an annual performance comparison of Baldrige Award winning companies with the Standard and Poor's 500 Stock Index. The winning companies have invested a great deal of human and financial capital in Total Quality Management (TQM) programs. Since the award was established in 1988, the TQM companies have always outperformed the index. The implication and the conclusions drawn by the NIST is that TQM programs have resulted in superior financial performance. The problem with their method is that only the winning company is compared with the index. The other nominees and contestants for the award are not only not considered, but their names are not even released to the public. A fair question is, do all companies that invest heavily in TQM programs outperform companies that may be selected at random?

The purpose of this study is to analyze empirically observed financial measures of risk and return to determine whether or not there are significant differences in a group of firms known to have invested heavily in TQM programs and a group of firms selected randomly, but from the same industries as the first group. Investors at the margin trade off financial measures of risk and return, and determine market value by buying and selling as a result of those measures, or forecasts of those measures. Analysis such as this have in the past identified differences in theory and practice. Multiple Discriminant Analysis (MDA) is used to compare sets of financial variables between the two groups of firms. The conclusions follow the results of the analysis.

INTRODUCTION

The concept of total quality management (TQM) has been of great interest to businesses, managers, and academicians for the past two decades. One of the leading advocates of TQM has suggested that while the twentieth century will be referred to as the century of productivity, the next century will be the century of quality (Stewart, 1999). Over the past fifteen years, issues concerning quality have been at the forefront of the American business scene and the TQM issue has taken on a new urgency as the twenty-first century approaches. Spencer (1994) writes that TQM is conceptualized, not as a new paradigm, but as a comprehensive

management practice that captures signals from established models of organization and exemplifies them by providing a methodology for use. When this practice is properly introduced, the TQM program is characterized by operational excellence. As might be expected, not all academicians, and not all managers, agree. Greising (1994), and Port, Cary, Kelly, and Forrest, (1992) write that returns from TQM programs depend in large part on the way they are implemented, and on the subject firms' abilities and performance before implementation. Chandresekhar and Jjoshi (1998) report that seventy percent of new TQM programs fail because of faulty implementation. Many scholars have simply questioned the concept of TQM as a legitimate body of knowledge (Ackoff, 1993; Becker, 1993; Bemowski, 1993; Jacob, 1993; and Wilkinson et al, 1993). Thus, a good deal has been written on the merits and the lack of merits of TQM programs, and that issue will not be addressed here.

The Commerce Department's National Institute of Science And Technology (NIST) publishes an annual performance comparison of Baldrige Award winning companies with the Standard and Poor's 500 Stock Index. The winning companies have invested a great deal of human and financial capital in TQM programs. Since the award was established in 1988, the TQM companies have always outperformed the index. The implication and the conclusions drawn by the NIST is that TQM programs have resulted in superior financial performance. The problem with their method is that only the winning company is compared with the index. The other nominees and contestants for the award are not only not considered, but their names are not even released to the public. A fair question is, do all companies that invest heavily in TQM programs outperform companies that may be selected at random?

The purpose of this study is to analyze empirically observed financial measures of risk and return to determine whether or not there are significant differences in a group of firms known to have invested heavily in TQM programs, and a group of firms selected randomly, but from the same industries as the TQM group. More specifically, the study is concerned with those variables that are indicators of the firm's risk-return tradeoff, and how that risk-return tradeoff is perceived by professional analysts and investors at the margin (those willing and able to buy). Analysis such as this have in the past identified differences in theory and practice. This information would have implications for managers, investors, investment counselors, and academicians.

METHODOLOGY

The issues to be resolved are first, classification or prediction, and then evaluation of the accuracy of that classification. More specifically, can firms be assigned, on the basis of selected variables, to one of two groups: (1) firms known to have invested heavily in "TQM programs", or (2) firms selected at random (RSF), but from the same industries as the TQM group? Multiple discriminant analysis (MDA) provides a procedure for assigning firms to predetermined groupings based on variables or attributes whose values may depend on the group to which the firm actually belongs.

If the purpose of the study were simply to establish a financial profile of TQM firms, simple ratios would be adequate. In a seminal paper on the use of MDA in finance, Altman (1968) showed that sets of ratios used in multivariate analysis

were better descriptors of the companies and had more predictive power than individual ratios used in univariate tests.

The use of MDA in the social sciences for the purpose of classification is well known. MDA is appropriate when the dependent variable is nominally or ordinally measured and the predictive variables are intervally measured. In addition to its use in the Altman study to predict corporate bankruptcy, MDA has been used to predict the credit worthiness of used car loan applicants (Durand, 1941), common stock quality ratings (White, 1975), financially distressed property-liability insurance firms (Trieschmann and Pinches, 1973), and the failure of small businesses (Edmister, 1982). These studies had one thing in common, the groups in which the firms were classified were nominally measured: good-bad, failing-nonfailing, likely to bankrupt-not likely to bankrupt, or in the case of stock quality, ordinal ratings. This study also employs nominally measured dependent variables and intervally measured predictive variables. The nominally measured dependent variables are: the group of TQM firms and the group of RSF. The computer program used to perform the analysis is SPSS 8.0 Discriminant Analysis (SPSS Inc.,1988).

Since the objective of the analysis was to determine the discriminating capabilities of the entire set of variables without regard to the impact of individuals variables, all variables were entered into the model simultaneously. This method is appropriate since we are not interested in the predictive power of any one variable, but instead the predictive power of the entire set of independent variables (Hair et al, 1992, 99).

SELECTION OF SAMPLE AND INDEPENDENT VARIABLES

All data used in the analysis were gathered from *Value Line Ratings and Reports*. The sample consists of two groups of thirty-four firms. The first group was drawn from a group of companies that publicized their programs, invested money and human capital in TQM programs and whose financial data were also available in *Value Line* (Appendix I). This constraint resulted in the rather odd number of thirty-four as the sample, but it exhausted the database. The second group is a group of thirty-four firms randomly selected from *Value Line*, but from the same industries as the first group (Appendix II). Companies are organized by industry in *Value Line*. After a TQM firm was selected, a company from the same industry section was chosen randomly. Thus, the RSF were chosen randomly, but with a matching concept so that the industry profile of this group matched that of the TQM group. That is, for each company in group one, there is a company in group two that matches the financial and business characteristics of the company in group one. For example, Dow Chemical is in group one and ARCO Chemical is in group two. General Motors is in group one, and Chrysler is in group two. *Value Line's* industry grouping renders the sample matching a relatively easy process.

Previous studies using this and other statistical methods have chosen explanatory variables by various methods and logical arguments. In this paper the group of explanatory variables chosen for analysis contains a measure of return on investment, a measure of systematic risk, a measure of how investors at the margin value the company's earnings, a measure of growth, a measure of financial leverage, and a measure of the size of the firm. An evaluation of these measures is needed to

accomplish the purpose of this study.

The measure of return is return to total capital. Return to total capital includes a return to creditors as well as owners, and recognizes that value is affected by the cost of debt. A measure of return to equity could be used, but it would ignore the cost of debt and the fact that assets are financed by debt as well as equity.

A basic tenet of this study is that investors at the margin evaluate the degree of risk in an investment and compare it to the investment's potential rate of return. In finance literature this is referred to as the "risk-return tradeoff." Investors at the margin "trade off" proxies for risk and return in buying and selling securities to establish demand and thus, price or market value. Sharpe's beta is used to measure systematic risk.

The price earnings ratio is included in the analysis to provide a rough idea of what investors at the margin think of the company. Researchers are understandably reluctant to use the price earnings ratio in academic research since accounting methods can greatly influence the denominator in this variable. The ratio can be used for comparative purposes only when the earnings are computed in exactly the same manner for all firms in the sample. *Value Line* and other reputable data sources take great care to compute all data using the same methods. Thus, *Value Line's* price earnings ratios may be used for comparative purposes among their firms. It would not be appropriate to compare a *Value Line* price earnings ratio with the same variable from another reporting source such as *Moody's* or *Standard and Poors*.

Growth may also be regarded as part of return on capital, and indeed growth has been of major interest to financial investors for years. *Value Line* measures changes in several variables over periods of ten years, five years, and forecasts of change five years into the future. In this study their five year change in sales was used. Changes in revenue, cash flows, earnings, and dividends are also given, but size was measured in sales. Thus, changes in sales as a measure of growth is consistent with the variable used to measure size. The measure of size is included because previous studies do not clearly show whether implementation of TQM programs are likely to be associated with large or small firms. The logarithm of sales is used as a measure of size.

The aforementioned measure of systematic risk includes the effects of both operating and financial leverage. It is informative to separate these two sources of risk. It is felt that the proper implementation of TQM programs should decrease both types of risk without sacrificing return on investment. The separation is accomplished by "unlevering" published betas, and using the debt to total capital ratio to measure financial risk (Van Horne, 1998, 206).

In summary, there are six explanatory variables in the multiple discriminant model. They are as follows:

X1 - Return to total capital.
X2 - Sharpe's Unlevered Beta;
X3 - Price earnings multiple
X4- Changes in Sales Revenue (Growth)
X5- Financial Leverage
X6 - Logarithm of sales. (Size)

The explanatory variable profile contains basic measures of common financial variables. They were chosen, as in any experimental design, because of their consistency with theory, adequacy in measurement, the extent to which they have been used in previous studies (Altman 1968, Edmister 1982, Trieschmann and Pinches 1973, and Payne 1993) and their availability from a reputable source.

TEST AND RESULTS

The discriminant function used has the form:

$$Z_j = V_1X_{1j} + V_2X_{2j} + ... + V_nX_{nj} \qquad (1)$$

where:

X_{ij} is the company's value for the ith independent variable.
V_i is the discriminant coefficient for the ith variable.
Z_j is the jth individual's discriminant score.

The function derived from the data in this study in equation 1 is:

$$Z_j = -1.894-.4140X_1+.6971X_2-.4721_3+.2384X_4+.0290X_5+.8771X_6 \qquad (2)$$

Classification of firms is relatively simple. The values of the five variables for each firm are substituted into equation (2). Thus, each firm in both groups receives a Z score. If a firm's Z score is greater than a critical value, the firm is classified in group two (RSF). Since the two groups are heterogeneous, the expectation is that randomly selected firms will fall into one group and the TQM firms will fall into the other. The SPSS program tests for equality of matrices by means of Box's M statistic. In this study Box's M transformed to the more familiar F statistic of 2.245 is less than the critical F_{05} 18.51 with 1 and 2 degrees of freedom. Thus, the null hypothesis that the two matrices are equal cannot be rejected, and the midpoint value between the two group means can be defined as the critical Z value. Interpretation of the results of discriminant analysis is usually accomplished by addressing four basic questions (Frank, Massey and Morrison,1965).

(1) Is there a significant difference between the mean vectors of variables for the two groups of firms?
(2) How well did the discriminant function perform?
(3) How well did the independent variables perform?
(4) Will this function discriminate as well on any random sample of firms as it did on the original sample?

To answer the first question the familiar F-test is used. The calculated value of F is 7.49. That exceeds the critical value of F 2.32 at the five percent level of significance, with 6 and 34 degrees of freedom. The null hypothesis that there is no significant difference between the financial profiles of the two groups is therefore rejected, and the first conclusion from the analysis is that the two groups have significantly different financial characteristics. The discriminant function thus has

the power to separate the two groups. However, this does not mean that it will in fact separate them. The ultimate value of a discriminant model depends on the results obtained. That is, what percentage of firms were classified correctly and is that percentage significant?

To answer the second question a test of proportions is needed. Of the 34 firms in the TQM group, 25 were classified correctly. Of the 34 firms chosen at random, 21 were classified correctly. That is, 46 firms or 67.6 percent were classified correctly. Results are shown in Table 1.

Table 1

Classification Results

	Predicted Results	
Actual Results	Total Quality Management Firms	Randomly Selected Firms
TQM Firms	25	9
Randomly Selected Firms	13	21

To test whether or not 67.6 percent correct classification rate is statistical significant, the Press's Q test is appropriate (Hair et al, 1992, 106). Press's Q is a Chi-square random variable.

$$\text{Press's Q} = [N-(n \times k)]^2 / N(k-1) \qquad (3)$$

where:

N = Total sample size
n = Number of cases correctly classified
k = Number of groups

In this case:

Press's Q = $[68-(46 \times 2)]^2 / 68(2-1) = 8.47, > \chi^2_{.05} = 3.84$ with one degree of freedom. (4)

The null hypothesis that the percentage classified correctly is not significantly different from what would be classified correctly by chance is rejected. The evidence suggests that the discriminant function performed well in separating the two groups.

The arithmetic signs of the adjusted coefficients in Table 2 are important to answer question number three. A positive sign indicates that the greater a firm's value for the variable, the more likely it will be a TQM firm. On the other hand, a negative sign for an adjusted coefficient signifies that the greater a firm's value for the variable, the more likely it will be classified as a RSF. Thus, according to Table 2, the greater the size of the firm, the greater the rate of systematic risk, and the greater the return to total capital, the more likely the firm will be a TQM company. Conversely, the greater the greater the price-earnings multiple, the greater the rate of growth, and the greater the degree of financial leverage, the less likely the firm will be a TQM company.

The relative contribution of each variable to the total discriminating power of the function may be obtained by standardizing (pooled within group variances) the canonical coefficients of the discriminant function. These coefficients are given in the output of the SPSS 8.0 program. Alternatively, the coefficient weights may be obtained by adjusting the discriminant coefficients for differences in the units of measure of the original variables. This adjustment is made arithmetically by multiplying the square root of the diagonal elements of the variance-covariance matrix for each variable by the discriminant coefficient of that variable. The product of this multiplication also gives the relative contribution of each variable to the total discriminating power of the function (Altman, 1968). Standardized canonical coefficients are shown in Table 2.

An examination of Table 2 reveals that size (the logarithm of sales) is the variable with the greatest contribution to the overall discriminating function, followed by systematic risk (beta), the price earnings multiple, return to total capital, growth, and financial leverage, respectively. Some multicollinearity exists between the variables, because the numerator in the price earnings ratio may depend on all the other variables. Hair, et al (1992) wrote that this consideration becomes critical in stepwise analysis and may be the factor determining whether a variable should be entered into a model. However, when all variables are entered into the model simultaneously, the discriminatory power of the model is a function of the variables evaluated as a set and multicollinearity becomes less important.

Table 2
Relative Contribution Of The Variables

Variables	Coefficient	Adjusted Rank
Size (Log of Sales)	.877	1
Unlevered Systematic Risk	.697	2
Price Earnings Multiple	-.472	3
Return on Total Capital	.414	4
Growth	-.238	5
Financial Leverage	-.095	6

VALIDATION OF THE MODEL

Before any general conclusions can be drawn, determination must be made whether the model would yield valid results for any group of randomly drawn firms. The procedure used here for validation is referred to as the Lachenbruch or, more informally, the "jackknife" method. In this method, the discriminant function is fitted to repeatedly drawn samples of the original sample. The procedure estimates (k - 1) samples, and eliminates one case at a time from the original sample of "k" cases (Hair et al, 1992, 98). The expectation is that the proportion of firms classified

correctly by the jackknife method would be less than that in the original sample due to the systematic bias associated with sampling errors. The major issue is whether the proportion classified correctly by the validation test differs significantly from the original test. That is, is the difference in the two proportions classified correctly by the two tests due to bias? The objective is to see if this bias is significant. The jackknife validation resulted in the correct classification of 55.9 percent of the firms. Since there are only two samples for analysis the binomial test is appropriate:

$$38 - 68\ (.68)/\ [68\ (.68)\ (.32)]^{1/2} = .0376 < t_{05}\ 1.645 \qquad (5)$$

Thus, the null hypothesis that there is no significant difference between the proportion of firms classified correctly in the original test and the proportion classified correctly in the validation test cannot be rejected. Therefore, it can be concluded that while there may be some bias in the original analysis, it is not significant. The procedure will classify new firms as well as it did in the original analysis.

CONCLUSIONS

The purpose of this study was to establish a risk-return profile of firms that are known to have invested money and human capital in "TQM programs." There will be no attempt here to comment on the merits or lack of merits for TQM programs in general, or whether or not they make a significant difference in the value of the firm.

Three of the six results may have been expected. Two of the six follow logically from the analysis and had no prior expectation, and one may have been a mild surprise. The measure of size, return to total capital, and systematic risk were all higher for the TQM firms. Thus, it may be concluded that the TQM firms are larger and probably have a higher risk-return tradeoff curve than firms selected at random. Those results may have been expected. The rate of growth, the degree of financial leverage (financial risk), and the price earnings multiple were all greater for the firms selected at random. It may be logical that the rate of growth would be greater for the RSF since the TQM firms were larger in size. No firm conclusions concerning the rate of growth should be offered here because of the small sample size, but that is one result of the analysis. Financial risk was removed from systematic risk leaving only systematic operating risk. The degree of financial risk was higher in the RSF. This may have been expected in the smaller, growing firms. Shuman and Seegar (1968) write that those firms rely more on debt financing. The price earnings multiple is a rough measure of how investors at the margin value firms. If TQM contributes to the value of firms, investors at the margin are not aware of it, because high price earnings multiples were characteristic of the RSF. This may have been a mild surprise. If TQM adds value to companies and price earnings multiples are a rough measure of value, it would have been expected that the higher multiples would have been characteristic of TQM firms. Another conclusion follows the result that the TQM firms had greater operating risk (systematic risk measured with unlevered betas), and the RSF had greater financial risk (measured by the debt to total capital ratio). To the extent that investors consider risk in buying and selling

and thus establishing price, they may be less concerned with financial risk than with operating risk. That would contribute to the higher price earnings multiples for the RSF. There will be no attempt here to analyze why the variable profile is as it is, but given the popularity of TQM both in the literature and in practice, it is an area that certainly deserves further study.

This study has resulted in a contribution toward the construction of a theory that describes the risk-return characteristics of companies that implement TQM programs. Construction of a complete theory would aid managers, investors, and investment counselors in identifying the merits, or lack of merits in implementing those programs.

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APPENDIX I
TOTAL QUALITY MANAGEMENT COMPANIES

1. Allen Telecommunications
2. Aluminum Company of America
3. AT&T
4. Bankone Corporation
5. Boeing Aircraft
6. Corning Incorporated
7. Dow Chemical
8. Du Pont Chemical
9. Eaton Corporation
10. Ford Motor Company
11. General Electric
12. General Motors
13. Hewlett Packard
14. NCR Corporation
15. Northrop Grumman Corporation
16. Pitney Bowes Corporation
17. Polaroid Corporation
18. Reynolds Metals
19. Rockwell International
20. Teradyne Incorporated
21. United Technologies Corporation
22. Weyerhaeuser Corporation
23. Solectron Corporation
24. Merrill Lynch & Company
25. Armstrong World Industries
26. Lucent Technologies
27. Dana Corporation
28. Eastman Chemical
29. GTE Corporation
30. Motorola Incorporated
31. Texas Instruments
32. Wallace Computer Services
33. Xerox Corporation
34. ITT Corporation

APPENDIX II
RANDOMLY SELECTED FIRMS

1. Andrew Corporation
2. Asarco Incorporated
3. AIT Touch Communications
4. Comerica Corporation
5. Bombardier Incorporated
6. Emerson Electric
7. Arco Chemical
8. Georgia Gulf Company
9. Excel Industries
10. Damiler-Benz
11. Honeywell Corporation
12. Chrysler Corporation
13. Identix Incorporated
14. Newbridge Networks
15. Precision Castparts
16. Reynolds & Reynolds
17. Scitex Corporation
18. Phelps Dodge
19. Magnetek Incorporated
20. Watkins-Johnson
21. Tyco International
22. Westvaco Corporation
23. Sensormatic Electric Company
24. Lehman Brothers
25. Butler Manufacturing
26. Pairgain Technologies
27. Borg-Warner Corporation
28. Goodrich Corporation
29. MCI Communications
30. Micron Technologies
31. Standard Microsystems
32. Viking Office Products
33. United Stationers
34. Internet Corporation

APPENDIX III
INDUSTRIES

INDUSTRY	TQM COMPANIES	RANDOMLY SELECTED COMPANIES
1. Telecommunications Equipment	2	2
2. Telecommunications Services	1	1
3. Metals and Mining	1	1
4. Metals and Mining (Diversified)	2	2
5. Bank (Midwest)	2	2
6. Electrical Equipment	2	2
7. Chemical (Basic)	1	1
8. Chemicals (Diversified)	2	2
9. Auto Parts (Original Equipment)	1	1
10. Auto and Truck	1	1
11. Electrical Equipment	1	1
12. Computer and Peripherals	2	2
13. Aerospace/Defense	1	1
14. Office Equipment and Supplies	1	1
15. Precision Instruments	1	1
16. Semiconductor Equipment	2	2
17. Diversified Companies	1	1
18. Paper and Forest Products	1	1
19. Electronics	1	1
20. Securities and Brokerage	1	1
21. Building Materials	1	1
22. Semiconductor Industries	1	1
23. Semiconductor Equipment	3	3
24.Office Equipment and Supplies	2	2
Total	34	34