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STABILITY AND RESILIENCE IN BUSINESS SYSTEMS

by

DONALD BARD WILCOX

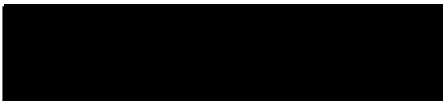
A dissertation submitted in partial fulfillment of the  
requirements for the degree of


DOCTOR OF PHILOSOPHY  
in  
SYSTEMS SCIENCE


Portland State University  
1980

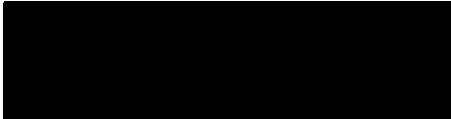
TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the thesis of  
Donald Bard Wilcox presented March 10, 1980.

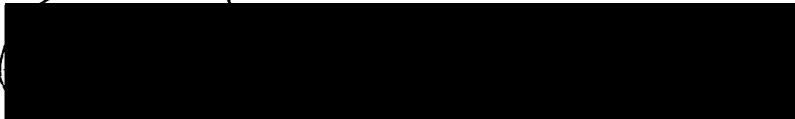
  
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AN ABSTRACT OF THE DISSERTATION OF Donald Bard Wilcox for the Doctor of Philosophy in System Science presented March 10, 1980.


Title: Stability and Resilience in Business Systems.

APPROVED BY MEMBERS OF THE DISSERTATION COMMITTEE:

  
Grover Rodich, Chairman

  
Martin Zwick, Member

  
Donald Watne, Member

  
Sheldon Edner, Member

The purposes of this research report are (1) to introduce into financial management theory, the concepts of stability, resilience and steady state from general systems theory, (2) to formulate hypotheses about the relationships among rate of return, business risk, stability and resilience as exhibited by business systems, (3) to construct quantifiable surrogates for these concepts in terms of the financial operating characteristics of business systems and (4) to test the hypotheses with an appropriate statistical methodology.

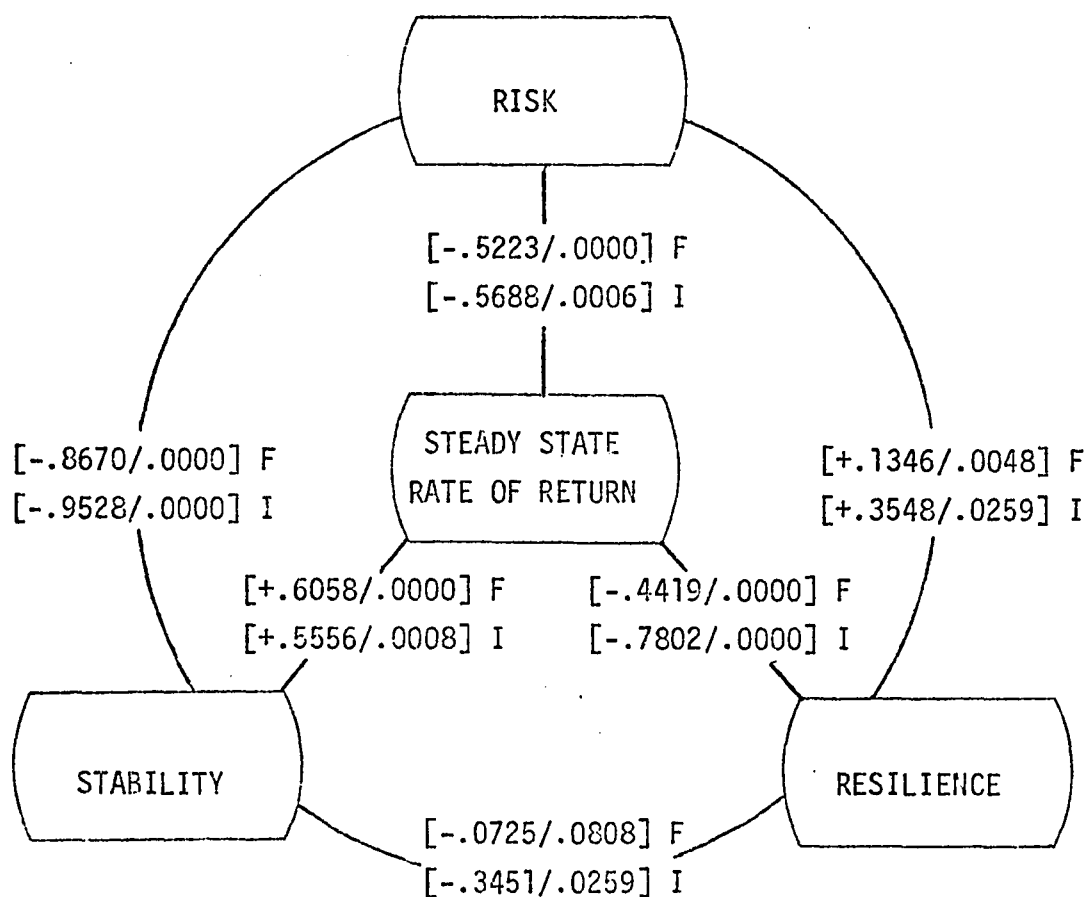
Business systems are investigated from two different perspectives or levels of aggregation. The first level treats each individual firm as the business system. The second level aggregates the individual firms into their respective industries based on the United States Department of Commerce's Standard Industrial Classification code, SIC.

By applying this model at both levels, we can generate two duplicate sets of six hypotheses, one set for individual firms and one set for industries. The six hypotheses are: (1) Business Risk and Rate of Return are negatively correlated, (2) Resilience and Rate of Return are negatively correlated, (3) Stability and Rate of Return are positively correlated, (4) Business Risk and Resilience are positively correlated, (5) Resilience and Stability are negatively correlated and (6) Stability and Business Risk are negatively correlated.

The theoretical contribution of this research project derives from the integration of general systems theory and financial management theory. The integration is based on equating the rate of return from financial theory with the steady state from systems theory. Business risk is defined in terms of the relative fluctuation in the rate of return over time. Stability is that property of a system that allows the system to maintain a steady state in spite of small or temporary perturbations to the system. Resilience is that property of a system that allows the system to maintain a steady state in spite of large or permanent perturbations.

The empirical contribution of this research project is the determination of statistical relationships among rate of return, business risk, stability and resilience within business systems.

The raw data collected for this study were derived from the Compustat II tape files available at Idaho State University. These files contain financial data on several thousand industrial and non-industrial companies listed on the major stock exchanges and Over-the-Counter stock exchanges.



The diagram above summarizes the statistical results of this research project. The numerical values superimposed upon the connecting lines are the statistical results of the tests of the twelve hypotheses and represent respectively; the spearman rank correlation coefficient/level of significance for firms (F) and industries (I). The empirical results confirmed the postulated relationships.

## ACKNOWLEDGMENTS

The data which made this study possible were supplied by the Idaho State University Computer Services Center. The computer programs written for the extraction of the raw data from the Compustat II library tapes were provided by John Moore of the Computer Services Center.

Grateful appreciation is extended to the members of the dissertation committee, Professors Grover Rodich, Donald Watne, Martin Zwick, and Sheldon Edner. Professor Martin Zwick is extended special thanks for providing the initial inspiration for the systems portion of this study. His personal advice and lecture notes provided many of the systems ideas presented in this dissertation.

I wish also to extend appreciation to Professor Charles Idol of Idaho State University for his invaluable criticisms, especially pertinent to the financial management theory aspects of this study.

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My final thank you is for my wife who provided the moral support necessary during this experience.

Donald Bard Wilcox

Pocatello, Idaho

March 10, 1980

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## CHAPTER I

### INTRODUCTION

#### STATEMENT OF THE PROBLEM

The twentieth century has been a period of growth in size and complexity for organizations in all fields - business, government, military, education, religion and medicine. We have become an 'organizational society' in which an increasing proportion of all activities occur within the boundaries of a complex social structure.

Historically, minimal consideration of problems of organizational interface and environmental relations has been due primarily to the traditional closed systems view emphasized in both management and economic theory. In the past, management theory was concerned with internal structural relationships and with problems of integration and task performance. Economic theory assumed that the business organization could pursue its activities autonomously and that the marketplace would serve to integrate the activities of many firms.

Modern scholars view a business organization as an open socio-economic system in interaction with its environment. Increasingly, organizations will operate in an ever changing and uncertain environment, a turbulent environment, one in which the accelerating rate of change and complexity of interacting elements exceed the ability of the system's prediction and control mechanisms. The dynamic processes

arising from the field itself create significant variances for the component systems. The future must bring increasing emphasis on the problems of system-environment relationship.

In systems theory, the terms 'open' and 'closed' are derived from thermodynamics and have certain technical criteria associated with their meaning and usage. In this paper, and in the papers reviewed, these terms are used in a metaphorical sense, not in the technical sense of thermodynamics. The metaphorical use of these terms can help us gain insight into organizational behavior of business systems. The fundamental difference between these two points of view, open and closed, involves respectively the interaction or non-interaction of the system with its environment, i.e., the system is open to a flow of matter, energy and information to and from its environment or the system is closed to any flows between itself and its environment.

In traditional financial management theory, measures of corporate performance have been expressed in terms of the financial operating characteristics of the organization and are essentially derived from a closed system view with the emphasis on internal parameters of performance.

The task of financial management has been to maximize the owner's equity guided by a two parameter model, rate of return and the statistical variation in the rates of return (risk). The use of these two parameters does not explicitly address the issue of measuring external forces in conjunction with internal responses of the organization.

Can we measure the impact of environmental change on business organizations? Can we measure the responsive capabilities of organi-

zations? Can we discover parameters that can be used to monitor these system-environment relationships?

It is the task of this research to address these issues. One approach to this problem can be derived from general systems theory. The general systems view is based on the idea that substantive differences in systems lie in the way they are organized, in the particular mechanisms and dynamics of the interrelations among the parts and with the environment. A goal of systems research is to discover structural and functional similarities between substantively differing systems.

The theoretical thrust of this research is to discover concepts already existant in general systems thinking that might be applied to financial management theory. If successful, this will permit us to better understand and measure the relationships between a business organization and its environment. This application of ideas from general systems theory is based on the research of various systems writers who have discovered concepts in non-business systems that might be applied analogously to business systems. The results of this research suggest that the concepts of steady state, stability and resilience can be applied both theoretically and empirically to business systems.

Before applying systems concepts to business organizations, we must ascertain whether or not individual firms and industries meet the criteria of 'systemness'. A system is defined as a set of interrelated components parts organized to achieve a common objective or purpose and that can be differentiated from its environment through the concept of a boundary.

A business firm can be defined as a set of interrelated depart-

ments and functions organized to maximize the wealth of the owners and can be differentiated from its environment both physically and conceptually; i.e., the physical being of the firm is obvious and the conceptual being of the firm is recognized as a legal entity circumscribed by its government issued charter to engage in certain business pursuits. A business firm is considered to be a valid system by many writers, [16,17,22,45,55,74,82,83,84,85].

The relationships among the aggregated firms, industries, is more tenuous than within a firm. These aggregated firms do draw from a common pool of skilled labor, raw materials, management personnel, capital, machinery and equipment. The aggregated firms engage in producing similar products or services to meet the demands of a common market.

Both financial analysts and government regulatory bodies aggregate industry data for the purpose of analysis and regulation. Federal and state governments are organized in terms of regulatory agencies pertinent to specific industries. This is apparent in the names of these agencies. As some examples; the Federal Communications Commission, Interstate Commerce Commission, Food and Drug Administration, Federal Aviation Administration, Public Utilities Commissions, etc.

The establishment of a common purpose and definition of a conceptual boundary for an industry would provide only a tenuous argument as a systemic property.

For this reason, the inclusion and analysis of industry-wide data is offered more in the nature of a statistical argument based on the averages of an aggregated population of firms.

### Significance of Research

The significance of this research is presented in terms of the interests of five major groups; debtors, investors, managers, government regulatory agencies and scholars.

The following is a general statement as to the possible significance of this research to each of the groups .

Debtors are primarily concerned with the probability of repayment of debt by borrowers. Debtors are interested in a measure of the uncertainty surrounding the ability of a firm to repay borrowed funds. The ability to measure quantitatively the relationship between a system and its environment would provide added information to a potential debtor to aid in his decision making. The impact of environmental forecasts on a specific firm would be valuable information as input to debtor decisions to risk their funds.

Investors are interested in maximizing their own wealth through investment in corporate stocks. They are concerned with measures of the ability of a firm to pay dividends and with the price appreciation of their stock. Investors range the gambit from speculative to conservative. The concepts of stability and resilience and their quantification in terms of the financial operating characteristics of a firm would enhance the buying and selling decisions of investors. Speculators would quite likely be interested in stocks that were very sensitive to environmental changes, highly volatile stocks. Conservative investors would prefer a stable stock, one that is relatively less sensitive to environmental changes.

The use of the concepts of stability and resilience can create



a greater awareness for managers of the importance and impact of external factors present in the environment, factors over which the manager has no control. By recognizing this reality and studying the empirical correlations among rate of return, business risk, stability and resilience, the manager can use these ideas as input for better decision making and as parameters for measuring and monitoring the responsive capabilities of the organization to environmental change. Both strategic and tactical levels of planning can incorporate these concepts and their impact on the system-environment relationship.

Government regulatory agencies are concerned with establishing minimal, yet adequate regulations, to promote a stable, competitive, capitalistic economy fair to both producers and consumers. The results of this research would help select those industries that are less stable for greater scrutiny.

Scholars are interested in how and why business organizations behave as they do when operating in turbulent environments exemplified by uncertainty and lack of control over many of the factors that influence corporate performance. Scholars are concerned with the selection and quantification of corporate operational characteristics, causal relationships and the degree of sensitivity of one factor to another. This research will help categorize firms and industries as to their respective degrees of stability and resilience. This can guide future research into why certain firms or industries exhibit greater or lesser degrees of these characteristics. Because of the growing complexity and accelerating rate of change exhibited by the environment, greater emphasis on environmental impacts and business responsive

capabilities will be essential to the understanding of the dynamics of business behavior.

### APPROACH

The course of this research report is (1) to introduce into financial management theory, the concepts of stability, resilience and steady state from general systems theory, (2) to formulate hypotheses about the relationships among rate of return, business risk, stability and resilience as exhibited by business firms and by business industries, (3) to construct quantifiable surrogates for these concepts expressed in terms of the financial operating characteristics of business systems and (4) to test the hypotheses with an appropriate statistical methodology.

Figure 1 represents the two parameter financial management model, the three parameter systems model and the four parameter integrated model proposed in this research project. This integrated model derives from equating rate of return and steady state within the context of a business system.

Business systems are investigated in this report at two levels of aggregation. The first level treats each individual firm as the business system. The second level aggregates the individual firms into their respective industries based on the United States Department of Commerce's Standard Industrial Classification code, SIC.

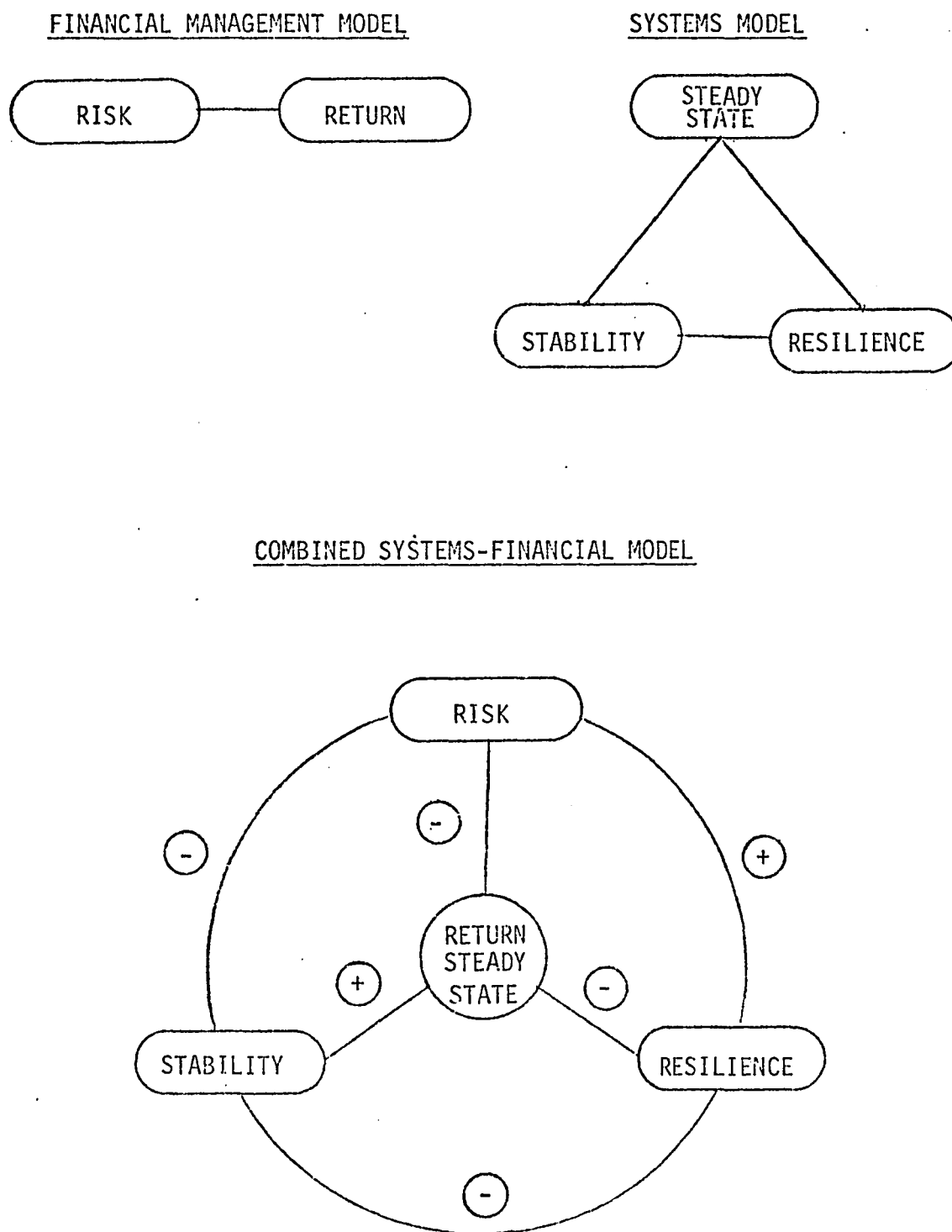


Figure 1. Integration of financial management model and general systems model.

## HYPOTHESES

Figure 1 also illustrates the six hypotheses that can be derived from the six possible pair-wise combinations among the four parameters of the integrated model. These six hypotheses are represented on the model by the lines connecting each set of parameters. The symbolic signs (+ and -) associated with each pair of parameters represent the direction of correlation hypothesized between each pair of parameters. By applying this model both to business firms and to business industries, we can generate duplicate sets of six hypotheses, each of which is subjected to statistical testing as part of the empirical portion of this research project.

The six hypotheses depicted in Figure 1 are: (1) Business Risk and Rate of Return are negatively correlated, (2) Resilience and Rate of Return are negatively correlated, (3) Stability and Rate of Return are positively correlated, (4) Business Risk and Resilience are positively correlated, (5) Resilience and Stability are negatively correlated and (6) Stability and Business Risk are negatively correlated.

Of these six sets of hypotheses, it must be stated explicitly that only three of the sets are independent hypotheses. Once three of the hypotheses have been established, the other three logically follow on mathematical grounds; they are implicitly defined in the process of defining the first three hypotheses. The non-primary or dependent hypotheses are included in this study and empirically tested in the nature of a control. They ought to be true if the primary hypotheses cannot be rejected.

## ORGANIZATION OF THE STUDY

Chapter II presents a review of the literature and the derivation of the theoretical and operational definitions of the parameters depicted in Figure 1. Since many of the readers of this research report may not be familiar with both financial management and general systems theory, a condensed version of each is included in this chapter.

Chapter II begins with a summary of financial management theory. This is followed by a review of the financial literature from which we have distilled conceptual definitions of the terms; rate of return and business risk. With these conceptual definitions as guides, quantifiable surrogates were selected, comprised of pertinent financial operating characteristics of a business system.

The latter part of Chapter II presents a simplified summary of general systems theory as it applies to this research report. This is followed by an extensive review of the literature from a wide variety of disciplines since systems theory cuts across many disciplines. The articles and books reviewed in this section were selected as relevant to the task of deriving conceptual definitions of stability, resilience, and steady state; other systems concepts that are supportive or complementary are also discussed. The objective of this task was to discover a definitional consensus from among the writings of most of the reviewed scholars as to the meaning of the terms; stability, resilience and steady state.

Using these conceptual definitions in the context of a business organization, quantifiable surrogates were defined in terms of the financial operating characteristics of a business firm.

Chapter III presents the method of research employed in this research report. Included in this chapter are the nature and source of the raw data, the rationale for the selection of the firms and industries to be investigated, the manipulation and analysis of the data, the statistical treatment of the data and the formal presentation of the twelve hypotheses.

Since the essence of this dissertation is the development, presentation and interpretation of rather extensive numerical data, the main body of Chapter IV presents tabular and graphical summaries of the findings rather than the entire detail of the findings which are found in the appendices.

Conclusions, limitations and some suggested avenues for further research are summarized in Chapter V.

CHAPTER II  
REVIEW OF THE LITERATURE AND DEVELOPMENT OF DEFINITIONS  
FINANCIAL MANAGEMENT THEORY

Introduction

Financial management theory is concerned with the task of balancing risk and return in order to maximize the market price of the owner's equity. The financial manager is involved in three main functions: financial planning, managing assets and raising funds, [2, p. 19].

The planning function entails (1) the maintenance of sufficient cash flow to finance current operations, that is, to maintain an optimum amount of working capital, and (2) to provide the funds for the long term plans of the corporation, capital budgeting. Most firms operate in a turbulent environment, an environment of uncertainty, therefore the financial manager must not only optimize the use of funds, but he must also maintain sufficient flexibility in financial arrangements to cope with unforeseen developments.

Managing assets requires the allocation of funds for and among various assets utilized by the firm in performing its function of maximizing the wealth of the firm.

Raising funds to provide large amounts of cash to finance corporate operations and major changes in corporate operations requires the acquisition of funds from outside the business from investors and debtors. This choice of capital structure, this mix of debt and equity

capital, has a multiplier effect on both the return to investors and the risk level of the firm, [3, p. 471]. The use of financial leverage to increase the return to owners also increases the risk or uncertainty of the return.

Invested capital (long term debt plus owner's equity) provides the source of funds, assets reflect the use of funds. Balancing short term and long term goals, optimizing the use of funds while maintaining flexibility and balancing risk against return are the goals of financial management theory.

If the objective of financial management is to maximize the market value of the owner's equity, what are the determinants of market value? Owners prefer more cash to less cash, cash sooner rather than later and cash inflows that have a small rather than a large variance.

Any decision that affects the amount, timing or certainty of cash flows will also affect the market value of the owner's equity. The market price of a firm's common stock is a function of these three variables; the amount, timing and risk of cash flows. To simplify our model, assume that annual cash flows are uniform and extend far into the future. In this case we can say that the price of the common stock is a function of the amount and risk of cash flows. We can show that the larger the amount of cash flows, the higher the price; the higher the risk, the lower the price. This relationship can be depicted as:

$$P = A/k$$

where;

$P$  = price of common stock

$A$  = uniform annual cash flows

$k$  = discount rate (reflects risk level)

This model tells us that if we wish to raise the market price,



ceterus paribus, we must either increase the level of annual cash flows,  $A$ , or reduce the risk of obtaining those flows,  $k$ . The choice is a compromise between risk (variance in cash flows) and return (how much cash and how soon), [3, p. 117].

Financial management theory is then essentially a two parameter model encompassing risk and return. Financial scholars generally agree that a business organization's after-tax earnings risk can be represented by the statistical fluctuations in the firm's after-tax return on common equity or the after-tax earnings per share.

Financial management theory has adopted this concept of risk (variance in the possible outcomes) and has applied it in diverse ways to measure the risk associated with past financial behavior and to estimate future returns and future risk, the latter being a basic tenet of capital budgeting theory, [3,6,24].

Researchers in capital market instruments define the concept of risk as the estimated degree of uncertainty with respect to realization of expected future rates of return. The measure of uniformity of rates of return commonly employed has been the standard deviation of the consecutive yearly rates of return.

This measure of dispersion around some measure of central tendency has been used by Markowitz [26], Lintener [27], Sharpe [28], Baumol [29], and others. Each of these investigators has focused on the uniformity of the rate of return of the investor as the relevant variable in an attempt to measure risk:

Archer and D'Ambrosio [30, p.71] questioned the use of the standard deviation, and implicitly, the variance as used by the above investigators, because there was a tendency for the mean of the rates

of return to increase with increasing poorness of grade of the security.

In this case, the coefficient of variation may be considered preferable to the standard deviation as an appropriate measure of the dispersion of investment outcomes. Archer and D'Ambrosio [30,p.71] explain the reason for this as:

The problem with the standard deviation of the rate of return as a measure of risk is that it does not reflect the magnitude of the expected outcome. To allow for this, we should be more properly concerned with relative dispersion. Only by such a relative measure are we able to make meaningful comparisons of risks existent in differing investments. To make standard deviations comparable we may express them in relation to these respective means, i.e., the coefficient of variation.

Weston and Brigham [6, p.348] also discussed this problem and stated that the traditional procedure for solving the problem is to use the coefficient of variation.

Financial scholars generally agree [4,24,31] that a business organization's after-tax earnings risk can be expressed by the statistical fluctuations in the firm's after-tax earnings per share.

This risk has been partitioned by financial scholars into (1) business risk and (2) financial risk [3,4,5,6]. Business risk is most often represented by some form of statistical fluctuation in the organization's earnings before interest and taxes, EBIT. Financial risk usually is represented by some form of financial leverage such as debt to equity ratio and the earnings to interest ratio.

Business risk is represented by fluctuations in EBIT which, in turn, depend on sales fluctuations magnified by operating leverage. Operating leverage refers to the relative amount of fixed costs used in operations and the impact of fixed costs on EBIT at different levels of sales units.

The degree of operating leverage is defined as the percentage change in EBIT (operating income) that results from a specific percentage change in units sold. Operating leverage measures the influence of changes in EBIT caused by changes in sales and is a function of the ratio of fixed to variable costs.

The degree of operating leverage (DOL) can be expressed as:

$$DOL = W(P-V)/(Q(P-V)-F),$$

where:

Q - Unit sales

P = Price/unit

V = Variable Cost/unit

F = Fixed cost.

The impact of operating leverage can best be illustrated with a break-even graph which depicts the relationship of sales, costs and net operating income, EBIT. Operating cost can be partitioned into variable costs and fixed costs. Variable costs vary with production, fixed costs do not.

In Figure 2a (break-even graph for EBIT), EBIT is the difference between the revenue line (R) and the total cost line TC. Total costs are the sum of variable costs (VC) and fixed costs (F). Two levels of fixed costs,  $F_1$  and  $F_2$  produce two levels of total cost,  $TC_1$  and  $TC_2$ . Fixed costs are important because it will be shown that they induce a variability in EBIT that is greater than the variability in sales output.

The graph depicts a change in sales output from  $Q_1$  to  $Q_2$ . When fixed costs are  $F_1$ ,  $EBIT_1$  is the difference between revenue (R) and

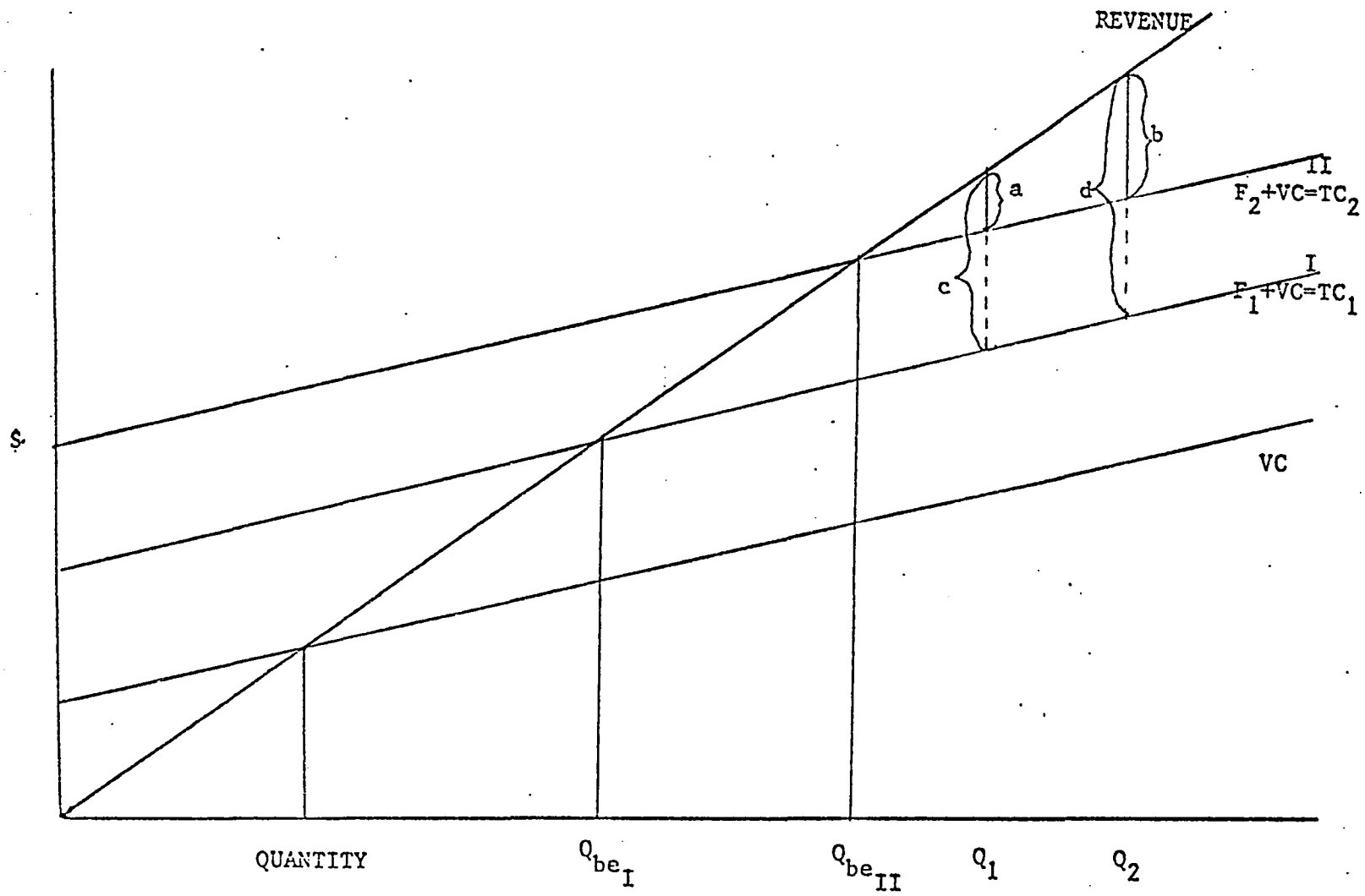


Figure 2a. Operating leverage break-even graph.

total costs,  $TC_1$  represented on the graph as the distance "c" at  $Q_1$ . At  $Q_2$ ,  $EBIT_2$  is depicted as the distance "d". The relative increase in EBIT associated with the increase in output from  $Q_1$  to  $Q_2$  is equal to the ratio  $d/c$ .

When fixed costs are increased to  $F_2$ ,  $EBIT_1$  is now the difference between revenue (R) and total costs,  $TC_2$  at sales level  $Q_1$ , depicted on the graph as the distance "a". At  $Q_2$ ,  $EBIT_2$  is depicted as the distance "b". The relative increase in EBIT associated with the increase in output from  $Q_1$  to  $Q_2$  is equal to the ratio  $b/a$ .

It is geometrically obvious that the ratio  $b/a$  is greater than the ratio  $d/c$ . In both of the examples, the relative change in sales output is identical. Any difference in the relative change in EBIT in relation to the relative change in sales must be due to a change in fixed costs since change in revenue and change in variable costs are the same for each example. This increase in fixed costs magnified the relative change in EBIT in relation to the relative change in sales output. Thus an increase in fixed costs, *ceteris paribus*, will create an increase in operating leverage. An increase in operating leverage will magnify fluctuations in sales to force an even greater fluctuation in EBIT.

Figure 2a also illustrated the relation of the break-even sales quantity to fixed costs. If unit price and unit variable costs remain constant, then operating leverage is a function of the break-even point. The EBIT break-even point can be calculated:

$$Q_{BE} = \frac{F}{P - V} = \frac{F}{C} \quad \text{where;}$$

$Q_{BE}$  is the break-even quantity

$C$  is the contribution margin ( $P - V$ )

$F$  is the fixed cost

$P$  is the unit price

$V$  is the unit variable cost.

Operating leverage is a function of fixed costs. The break-even point is a function of fixed costs, therefore, operating leverage can be defined in terms of the break-even point.

The degree of operating leverage (DOL), as a surrogate for operating leverage, has been traditionally expressed as the ratio of relative change in EBIT to the relative change in sales revenues, [6, p. 79]. This surrogate has been severely criticized [7,8,9,10,11], because it fails (denominator becomes zero) at the break-even point, however it is generally agreed that operating leverage will increase with relatively higher levels of fixed costs.

We conclude that business risk (fluctuations in EBIT) can be defined as a function of fluctuation in sales magnified by the degree of operating leverage, which in turn can also be expressed as a function of the break-even point,  $Q_{BE}$ .

Business Risk =  $f(\Delta S, DOL)$  or,

Business Risk =  $f(\Delta S, Q_{BE})$ .

The higher a firm's EBIT break-even point, the higher its business risk, ceteris paribus.

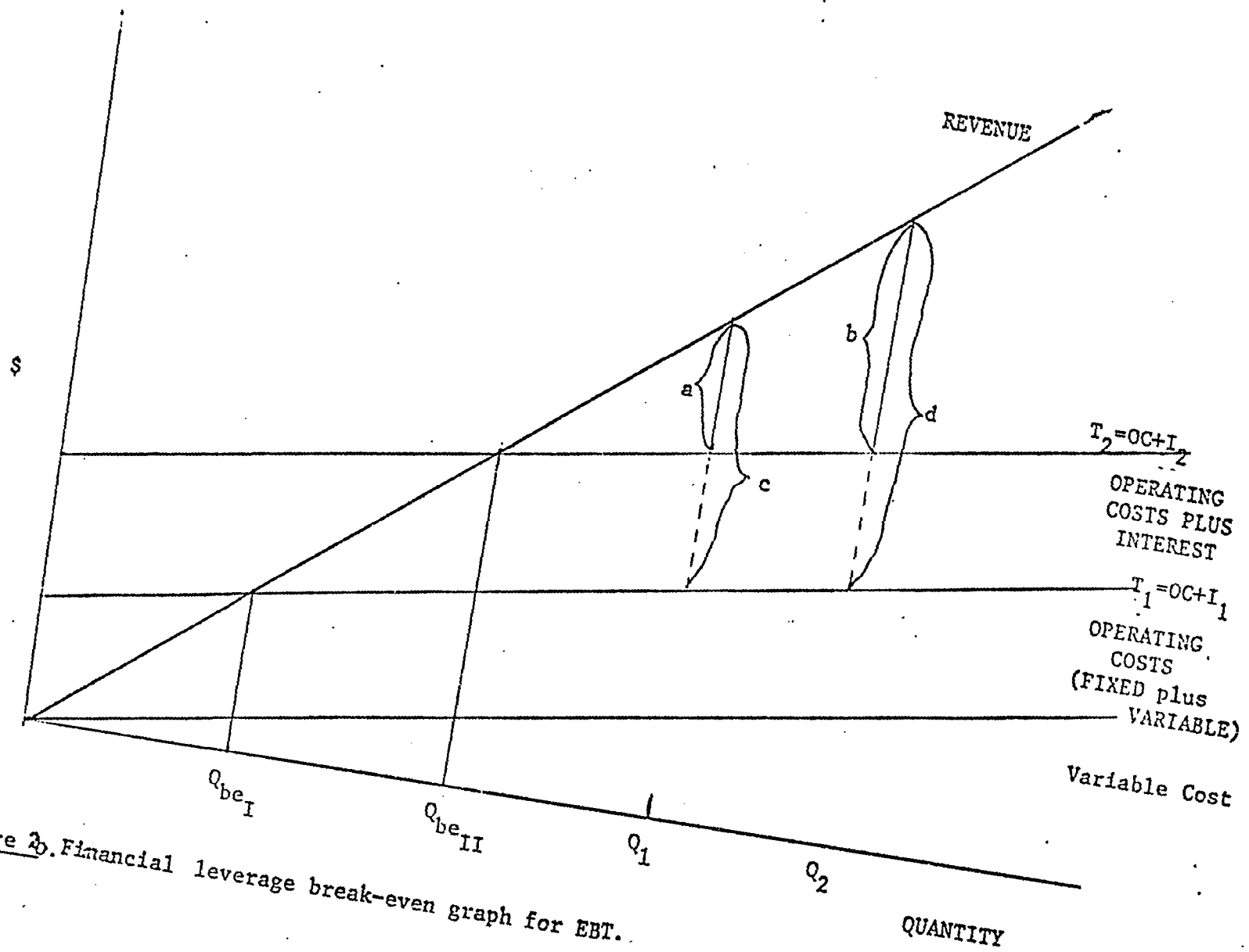


Figure 20. Financial leverage break-even graph for EBT.

As variation in sales can be magnified through operating leverage into even greater variation in EBIT, so can variation in EBIT be magnified through financial leverage into even greater variation in earnings before taxes, (EBT). Financial leverage exists whenever funds are borrowed and fixed payments required in the form of interest, [3,pp. 46-52; 6, p.687].

The impact of financial leverage can be illustrated also with a break-even graph analogous to the explanation of operating leverage. In Figure 2b earnings before taxes (EBT) is shown as the difference between the revenue line and the total cost line. Total costs are the sum of operating costs plus interest costs. Our graph shows two different levels of interest cost,  $I_1$  and  $I_2$ . This generates two different levels of total cost,  $T_1$  and  $T_2$ . Fixed interest costs are critical because it will be shown that they induce a variability in EBT that is greater than the variability in EBIT.

The argument is identical to that presented for operating leverage and therefore will not be repeated. An increase in fixed interest costs, *ceterus paribus*, will create an increase in financial leverage which will magnify fluctuations in EBIT to produce even greater fluctuations in EBT. Just as the fulcrum that provides operating leverage is the fixed portion of operating costs, so the fulcrum that creates financial leverage is the fixed interest cost for the use of funds.

The EBT break-even graph in Figure 2b also illustrates the effects of fixed interest costs on the break-even point. Financial leverage is a function of fixed interest cost, therefore financial leverage can be defined in terms of the break-even point.



The impact of the corporate tax rate operates in the opposite direction of operating and financial leverage. An increase in the corporate tax rate will diminish the variability in net earnings (total risk). This can be readily seen in the qualitative relationship:

$$\text{Total Risk} = (\text{Sales fluctuation} \times \text{Degree of Operating Leverage} \times \text{Financial Leverage} \times (1 - \text{tax rate})).$$

We conclude that business risk is a function of sales fluctuations and operating leverage; financial risk is a function of financial leverage and business risk; total risk is a function of business risk, financial risk and the corporate tax rate, [3, pp.37-53; 6, p.683].

#### Business Risk and Rate of Return

Our concern is with business risk and its relationship to the rate of return, stability, resilience and equilibrium state of a business organization. Solomon [5, p.71] defined business risk:

The quality of the expected stream of net operating earnings depends on a complex of factors which we can refer to as business uncertainty (risk). These factors include general expectations with respect to over-all economic and political trends, specific expectations about the particular regions and markets within which the company acquires resources and sells its products, and the speed and flexibility with which the company can lower its total operating costs when total revenues decline. All three factors interact, and their combined effect determines the level of uncertainty (risk) or quality which is attached to anticipations about the future flow of net operating earnings.

The use of debt...increases the degree of uncertainty ... The additional uncertainty is caused by the financial policy used and we will refer to it as financial uncertainty (risk).

Wipperfurth [32, pp.13-22] defined business risk as the culmination

of the effects of all those factors other than financing transactions which determine the uncertainty of a firm's income stream.

Weston and Brigham [6, p.663] defined business risk as the inherent uncertainty or variability of expected pre-tax returns of the firm's portfolio of assets using the probability distribution of returns on the firm's assets, EBIT/TA. They further defined financial risk as the additional risk that is induced by the use of financial leverage expressed as the ratio of total debt to total assets or to the total value of the firm.

As stated previously, it is generally accepted that business risk is a function of sales fluctuations magnified by operating leverage. There seems to be no consensus of opinion in the financial community nor generally accepted surrogate to represent business risk. A perusal of the writings of many financial scholars uncovered a variety of possible ways to quantify business risk.

Rao [34] used the relative deviation of a firm's annual growth rate in EBIT from the compound growth rate over time as a measure of business risk. Gonedes [35] work supports this approach. Rao further concluded that firms in the same industry tend to have similar risk levels, Equivalent Risk Hypothesis, (ERH).

The ERH is also supported by the work of Schwartz and Aronson [36], Scott [37], Scott and Martin [38] and Gonedes [35]. Contrary evidence has been presented by Remmers, et al. [39], Toy [40] and Wipperfurth [32].

Everett and Schwab [41] concluded that (1) variance alone was not sufficient as a measure of risk (2) that the risk-return relationship is not linear (a conclusion supported by the findings in this research report) and (3) that risk rejection rates are not always greater than the riskless rate.

Brealy [105, p.51] also found that higher risk stocks have not, on the average, provided their owners with commensurately higher rewards. This finding is compatible with the findings of this dissertation wherein business risk and rate of return were found to be negatively correlated, not positively correlated as postulated by many of the financial scholars.

Lev [42] used the standard deviation of monthly returns on common stock as a measure of risk, defined operating leverage as a function of the ratio of fixed costs to variable costs and further stated that business risk was a function of operating leverage.

Gahlon and Gentry [33, p.3] defined total corporate risk as the coefficient of variation of common stock earnings. The model they used defined total corporate risk as the product of coefficient of variation of sales times degree of operating leverage times degree of financial leverage. Implicitly business risk is measured as the coefficient of variation of sales times the degree of operating leverage.

Gahlon and Gentry [33] attempted to measure the relative contributions of sales volatility and operating leverage to a firm's business risk. Idol [31] indicated that Gahlon and Gentry failed to include an analysis of potential covariance effects between these two

business risk components. Hilliard, Lee and Leitch [4] also implied that this failure to include covariance effects could lead to a bias in the measurement of a firm's business risk.

Martin and Scott [44, p.5] attempted a multi-dimensional definition of business risk in terms of six determinants represented by nine different variables. The business risk classes derived from their clustering procedure did not perform as well as ordinary industrial classifications in explaining basic financial patterns.

A concise and lucid critique of these various measures of business risk is presented by Idol [31] who agrees with Weston and Brigham [6, p.663] that variance in Ebit/Total Assets is the most appropriate measure of business risk. Idol rejected both volatility in the ratio of EBIT to shares and the coefficient of variance in EBIT since neither attempts to scale EBIT to firm size. He also rejected the standard error of the estimate proposed by Wipperfurth [32] because it fails to provide an adequate measure of risk if debt is introduced.

Idol [31] states that the ratio of Ebit/Total Assets accomplishes the necessary scaling requirement for firm size and also states that the interpretation of the Ebit/TA ratio variance is not subject to the confusion of Wipperfurth's [32] measure which results from the firm changing its level of financial leverage over time.

Traditional measures of risk have been applied to individual capital investment projects in isolation. Newer approaches have recognized that individual projects can be combined with other projects into groups of projects or portfolios. Viewing an individual project

in its broader portfolio context changes the appropriate measure of risk to be applied [6, p.346].

A fundamental aspect of portfolio theory is the idea that the riskiness inherent in any single asset held in a portfolio is different from the riskiness of that asset held in isolation [6].

In appraising the riskiness of an individual capital investment, not only the variability of the expected returns of the project itself but also the correlation between expected returns on the project and the remainder of the firm's assets must be taken into account. This relationship is called the portfolio effect of the particular project.

A firm's business risk beta can be computed by regressing the operating profitability ratio (EBIT/TA) against holding period return of some market index over a specified time [31, p.17]. Beta measures covariability between the firm's operating profitability ratio and market holding period return. Beta is simply the covariance standardized by the market variance. With risk expressed in this way, expected return can be stated as a beta multiple of the market risk premium (expected return on the market less the risk-free rate) plus the risk-free rate [6, p.378].

From our survey, we find that the three most common measures of business risk are (1) the standard deviation, (2) the coefficient of variation and (3) the beta coefficient. Of these three measures of business risk, the prevalent view is that the coefficient of variation in EBIT is the best choice. This view is duly presented by Gahlon and Gentry [33], Gahlon and Stevens [7], Hilliard, Lee and Leitch [4] and Reilly and Bent [14].

### Proposed Business Risk Measure and Rate of Return Measure

The measure of business risk proposed in this research investigation combines (1) the arguments of Weston and Brigham [6], Gahlon and Gentry [33], and Idol [31] wherein they use the variance of the ratio of EBIT to Total Assets and (2) the argument of Archer and D'Ambrosio [30] as to the magnitude of the expected outcomes, expressed as the relative dispersion (coefficient of variation). Our measure of business risk then becomes the coefficient of variation of EBIT/Total Assets.

This measure of business risk leads naturally to the use of the ratio of EBIT/TA as the appropriate surrogate for the rate of return. EBIT/TA is also known as the operating profitability ratio or the earning power of a firm. The operating profitability ratio can also be expressed as the product of the firm's operating margin (EBIT/Sales) and the assets turnover ratio (SALES/TA) which allows us to partition the rate of return and business risk into their component parts. A detailed view of the components of operating margin and asset turnover is depicted in Figure 2c, a chart generally associated with the DuPont Company. For firms in different lines of business (but equally risky) to have similar earning powers, one would expect those with a relatively high turnover to have a relatively low margin and conversely, that those with a low turnover would have a high margin. This supposition is supported by an Internal Revenue Service Study, [44, p.44].

In summary, we have chosen to represent the rate of return as the ratio of EBIT to Total Assets, a surrogate generally accepted by the financial community. We have chosen to represent business risk as

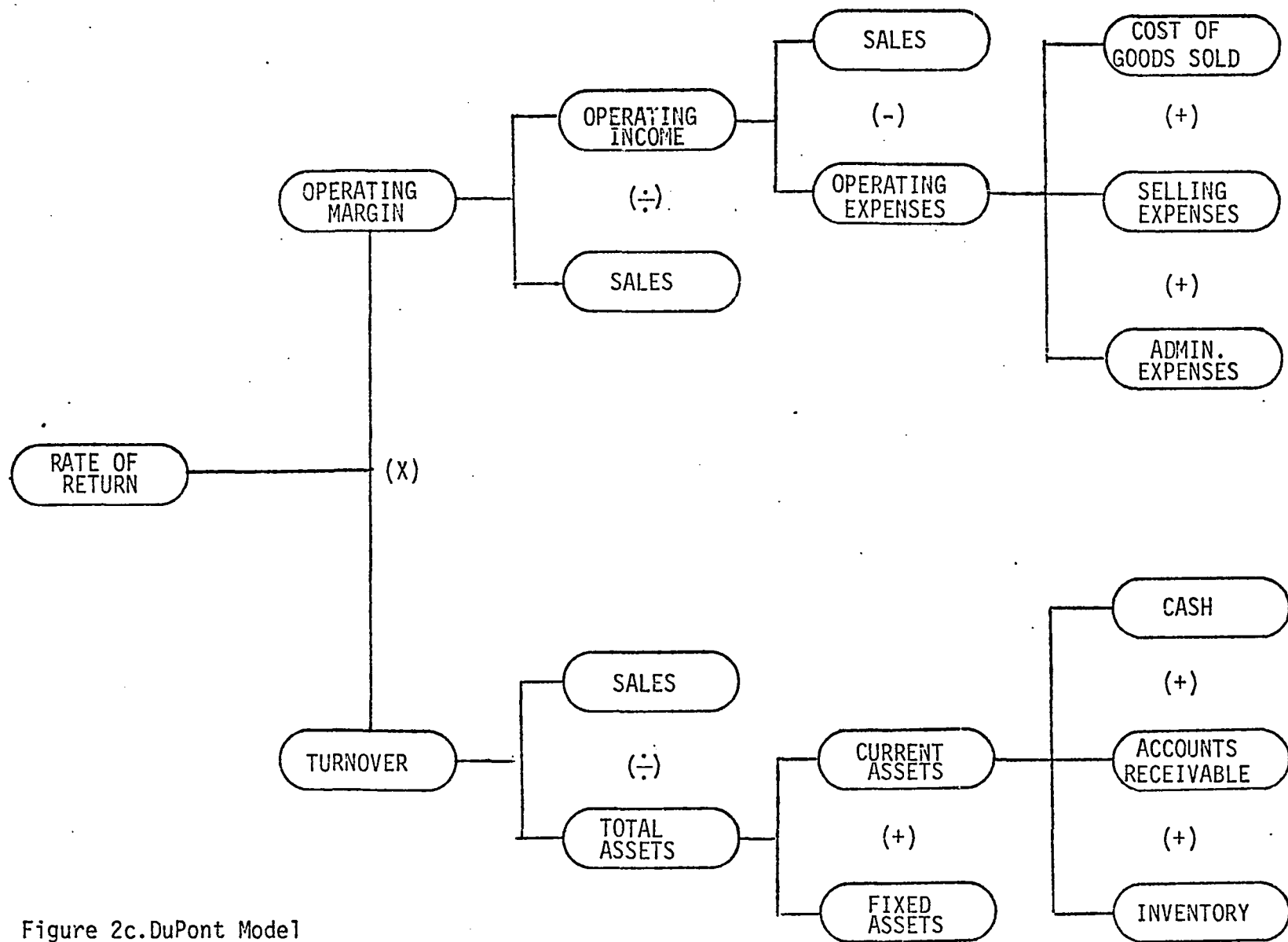


Figure 2c. DuPont Model

the coefficient of variation of the ratio EBIT/TA. We chose this surrogate based on a combination of the arguments of Idol [31], Weston and Brigham [6], Archer and D'Ambrosio [30], Johnson [3] and Gahlon and Gentry [33].

We turn now to examine the literature concerning stability, resilience and equilibrium from general systems theory.



## GENERAL SYSTEMS THEORY

### Introduction

A whole which functions as a whole by virtue of the independence of its parts is called a system and the method which aims at discovering how this is brought about in the widest variety of systems has been called general systems theory. General systems theory seeks to classify systems by the way their components are organized (interrelated) and to derive the 'laws' or typical patterns of behavior for the different classes of systems... [Rapoport 12, p. xvii].

General systems theory might better be called the general systems view. It is not a theory in the traditional scientific sense of the term. The general systems view is based on the idea that substantive differences in systems lie in the way they are organized, in the particular mechanisms and dynamics of the interrelations among the parts and with the environment. A goal of systems research is to discover structural and functional similarities and differences between substantively differing types of systems.

Typically, a scientific discipline emphasizes analysis and explanation by parts. Traditional categorization of knowledge is based on a multi-disciplinary hierarchy for explanation. The principles of physics are used to explain chemistry, chemistry to explain biology, biology to explain physiology, and physiology to explain psychology, and psychology to explain sociology.

Von Bertalanffy [14] suggested that we might use a different approach to categorize observed phenomena such as growth, competition,

feedback and purpose; phenomena which may be common to many different disciplines. He believed that the various specialized disciplines of modern science have had a continual evolution toward a parallelism of ideas. This parallelism provides an opportunity to formulate and develop principles which hold for systems in general, or at least for many different kinds of systems

### Systems Science Methods

A growing body of systems science methods can be classified as (1) modeling-simulation, (2) analysis and synthesis and (3) generalization across systems. Generalization across systems reveals that different systems may have much in common, as suggested by Von Bertalanffy [14], Rapoport [12] and Hall [47].

Boulding [45, p.5] suggested two complementary approaches to general systems theory. The first is "to look over the empirical universe and to pick out certain general phenomena which are found in many different disciplines, and to seek to build up general theoretical models relevant to these phenomena." The second approach is to "arrange the empirical fields in a hierarchy of complexity of organization of their basic 'individual' or unit of behavior, and to try to develop a level of abstraction appropriate to each."

### Overview

Figure 3 is a roadmap or an overview of the approach used in this research study related to general systems concepts. This overview indicates the hierarchical path followed in reviewing the literature to discover definitions of the terms stability, resilience and

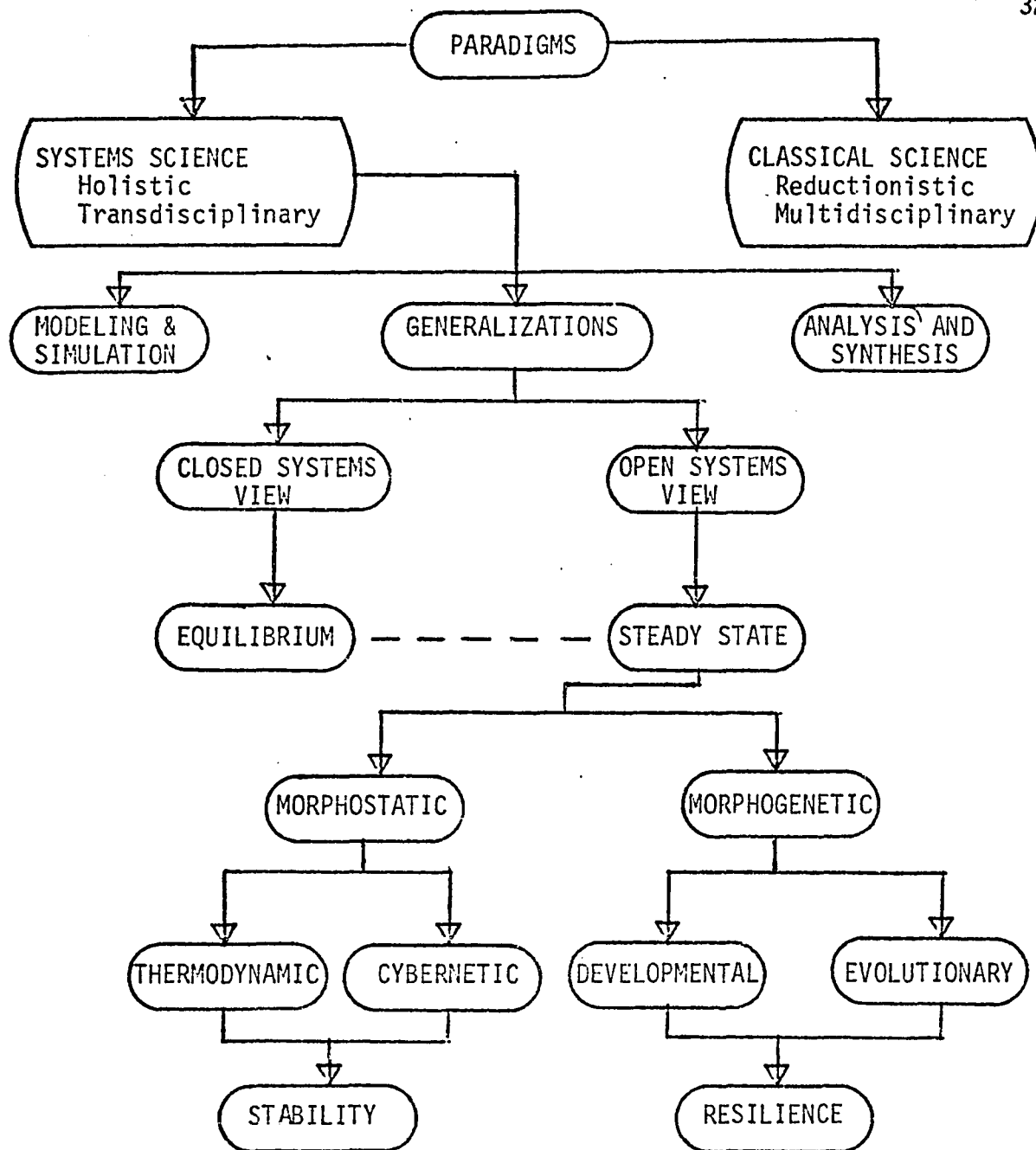


Figure 3. Roadmap (relational overview) leading to the development of definitions of the systems concepts; stability, resilience and steady state as applied to business systems.

equilibrium that could be supported by a majority of the systems writers reviewed.

Our journey through this diagrammatic schema begins with the selection of the systems science paradigm derived from a holistic, trans-disciplinary approach in contrast to the classical science paradigm that embraces reductionism in a multi-disciplinary context.

Following the systems science branch, we select the generalization across systems approach suggested by Von Bertalanffy [14] and Boulding [45], i.e., the search for isomorphisms relating models and/or theories in different disciplines. This branch leads us to the open and closed systems points of view. The terms 'open' and 'closed' are derived from thermodynamics and have certain technical criteria associated with their meaning and usage. In this paper, and in the papers reviewed, these terms are used in a metaphorical sense, not in the technical sense of thermodynamics. The metaphorical use of these terms helps us gain insight into organizational behavior. Each of these terms and their application to business organizations is reviewed in the literature. The open systems view is then selected as most appropriate to understanding the dynamic behavior of business systems. The fundamental difference between these two points of view, open and closed, involves respectively the interaction or non-interaction of the system with its environment, i.e., the system is open to a flow of matter, energy and information to and from its environment or the system is closed to any flows between itself and its environment.

The ubiquitous term 'equilibrium' is used by some writers to describe the steady state associated with the open systems view. Other writers use the term, equilibrium, to describe the balance of

forces in the closed systems view. When mathematicians use differential equations to describe or represent the state of a system, open or closed, their use of the term, equilibrium, implies that the rate of change of the state of the system is equal to zero; i.e., the first derivative of the differential equation equals zero.

Since we have rejected the closed systems view in treating business organizations as systems, only a brief discussion of equilibrium in the closed systems context will be given. The thermodynamic aspect is represented by chemical reactions in an isolated system. The reactions are stochastic and equifinal. Equifinal refers to that system property that leads a system to reach the same equilibrium state although starting from a variety of different prior states. The closed systems view of equilibrium is based on a concept of a balance of forces that do not require a set-point (standard reference point) nor a negative feedback, cybernetic loop. This point will become clearer when we describe the steady state concept.

The steady state concept is central to the open systems view. Many writers refer to this steady state as 'dynamic equilibrium'. The steady state notion can be said to encompass two different aspects based on the writers reviewed. These two aspects can be described by the terms 'morphostatic' and 'morphogenetic', terms which were used by Buckley, [19].

Morphostasis refers to those processes in complex system-environment exchanges that tend to preserve or maintain a system's given form, organization, behavior or state.

Morphogenesis, according to Buckley [19, pp.58-59], refers to those processes which tend to elaborate or change a system's form,

structure, behavior or state through the use of positive feedback loops.

Homeostatic processes in organisms such as maintenance of body temperature or ritual in sociocultural systems are examples of morphostasis. Biological evolution, learning and societal development are examples of morphogenesis.

Buckley summarized these views of equilibrium by stating that an isolated physical system typically proceeds to its most probable state of minimal organization, equilibrium, while organismic systems strive to maintain a specific set-point within fairly definite limits. This striving to minimize deviations from a set-point is the essence of the term homeostasis, introduced by Cannon [49]; or the more general term morphostasis used by Buckley, [19] and is accomplished through negative feedback loops which are essential to the maintenance of a homeostatic state.

As the concept of negative feedback provides insight into the mechanisms underlying homeostatic processes, the concept of positive feedback provides insight into the mechanisms underlying morphogenesis. For a more detailed discussion of feedback concepts, see Rosenbluth, Weiner and Bigelow [20].

We can partition the morphostatic concept into two different kinds of explanations, thermodynamic and cybernetic. The thermodynamic explanation encompasses the flow of matter and energy, is not goal oriented and uses causal loops of pseudo-negative feedback to support the system. The cybernetic explanation encompasses the flow of information, is equifinal or goal oriented and uses deviation counteracting

negative feedback for maintenance and regulation of the system.

These two different kinds of explanations, thermodynamic and cybernetic, indicate how morphostasis can contribute to the maintenance of the structural-functional state of the system, to the successful adaptation of the system to small or temporary environmental disturbances. The systemic property that results is what we call stability.

The morphogenetic concept indicates that the structural-functional characteristics of the system can change in order to re-establish a steady state relationship with its environment. This change or metamorphosis also encompasses two different kinds of explanations; developmental and evolutionary. The developmental explanation is based on the idea of a coded, i.e., pre-programmed, change. It is homeorhetic [87], that is, it preserves the pattern of the flow of change and can utilize both negative and positive feedback.

The evolutionary explanation encompasses uncoded, creative, innovative change. It can follow many paths or patterns of flow and can utilize both negative and positive feedback [59].

Each of these explanations; developmental and evolutionary, indicates how morphogenesis can contribute to the long-term adaptability of the system; to the successful response of the system to large or permanent environmental disturbances. The systemic property that results is what we call resilience.

In order to explore each of these notions in greater detail and to support the conceptual and operational definitions of the systems terms used in this research study, we will review the literature using the roadmap of Figure 3 to provide a contextual perspective. We must

recognize however, that the various systems writers usually discuss many of these concepts in a different relational order and in different combinations than those depicted in Figure 3.

### Systems View

Since general systems theory is not as well structured as financial management theory, we must survey many different disciplines, represented by a variety of systems writers. This approach is necessary in order to discover a consensus of opinion, or at least a majority view, about basic theoretical constructs and systems terminology.

Management operates in an "inherently uncertain, frequently ambiguous and dynamic environment," [6], a "turbulent" [82] environment. Control of the many factors involved in business operations is restrained by many environmental and internal forces.

Sayles [36, p.258] outlines the role of management:

The one enduring objective (of the manager) is the effort to build and maintain a predictable, reciprocating system of relationships, the behavioral patterns of which stay within reasonable physical limits. But this is seeking a moving equilibrium, since the parameters of the system are evolving and changing. Thus the manager endeavors to introduce regularity (stability) in a world ... (of) uncertainty, with ambiguity, and with battles that are never won but only fought well.

One of our objectives in this review of the literature is to understand the systems concepts of stability, resilience and equilibrium or steady state as they relate to business organizations. Each of these terms requires in turn, the understanding of other systems concepts such as disturbance and environment. As we pursue the ideas offered by



diverse systems researchers, an attempt to provide parenthetical clues that relate these writers' different terms and opinions to the business systems context of this research report will be made.

### Generalization

According to Weinberg [11, p.36], the systems researcher begins with the principles from different disciplines, searches for similarities and hopes to find a general broad principle such that the individual principles of the disciplines are thus only particular cases of the newly discovered general principle. The power of generalization through induction is that we can use the general principles to create hypotheses about cases not yet observed, or to point out research directions. This is the source of the generalist's power to move from discipline to discipline.

### Isomorphisms

Central to the idea of generalization across systems is the concept of isomorphism. The main thrust of general systems theory has been in the direction of finding analogies or isomorphisms among systems. The discovery of analogies among systems is a powerful means for stimulating a search for additional similarities and the formulation of principles having wide generalization. The advantage of general systems theory lies in its parsimony, its capacity for encompassing a wider variety of phenomena and established observations than is usually true of theories limited to a particular discipline or specialty, but the cost of being at a higher level of abstraction is that we are further removed from the phenomena themselves.

The term isomorphism refers to structural similarities among systems in different fields. The concept of isomorphism suggests that the various fields of science can be united at basic levels through underlying principles. Isomorphism is said to be the essence of the concept of the model. Two systems are isomorphic when there is a one-to-one mapping, transforming elements of one system into the elements of the other system with the conservation of the relations as discussed by Hall and Fagen [47, pp.88-89]:

There are instances in many sciences where the techniques and general structure bears an intimate resemblance to similar techniques and structures in other fields. A one-to-one correspondence between objects which preserves the relationships between the objects is called isomorphism... That there are isomorphisms, either total or partial, is neither accidental nor mystical. It just amounts to the fact that many systems are structurally similar when considered in the abstract. For example telephone calls, radioactive disintegration and impacts of particles, all considered as random events in time, have the same abstract nature and can be studied by exactly the same mathematical model.

As an example, equations depicting competition like the Volterra-Lotka model of biological struggle for existence may be isomorphic with respect to competition in the world of business and appear to be applicable to a wide variety of natural and social phenomena.

#### Closed and Open Systems

Closed and open systems represent a useful categorization of systems. A salient feature of open and closed systems is the boundary that exists between the system and its environment. As a part exists within the context of a system, so a system exists within the context of its environment. G. Spencer Brown [15] said that the drawing of a

distinction of a system creates a subjectively defined boundary between the system and its environment. The environment surrounding a system plays a critical part in its existence, and indeed is the key to the organismic, dynamic nature of open systems.

The concept of open systems is treated by Von Bertalanffy [14] in his book General Systems Theory. This book was his vehicle for expounding on his ideas of wholeness and isomorphisms, ideas valid for most systems whatever the nature of their component parts and whatever the nature of the relations between them. The concept of the open system is trans-disciplinary and wide-ranging.

Kast and Rosenzweig [16] have stated that in the past, traditional business theory treated the business organization as a closed system dealing with internal relationships and ignoring external or environmental factors, whereas the modern systems approach treats the business organization as an open system in dynamic interaction with its environment. We can contrast these two points of view.

In general, a closed system does not interact with its environment while an open system reacts to and adapts to its environment by changing the structure or processes of its internal components. A business organization may be considered in terms of a general open systems model as depicted in Figure 4.

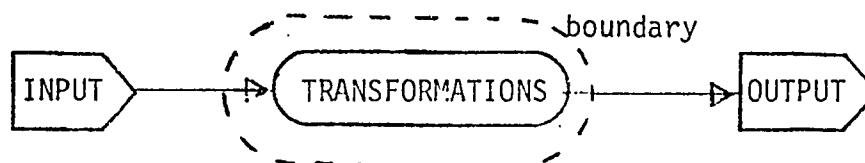


Figure 4. Open System Model

The open system is in continual interaction with its environment and may achieve a 'steady state' or dynamic equilibrium while retaining the capacity to maintain its identity. This view of the firm as an open system dictates that there are permeable boundaries which separate it from the environment. The concept of boundaries facilitates the distinction between open and closed systems. The closed system has rigid, impenetrable boundaries, whereas the open system has permeable boundaries.

A characteristic of all closed physical systems is that they have an inherent tendency to move toward a macroscopically-static equilibrium and higher entropy. Entropy is a concept which originated in thermodynamics and can be applied metaphorically only with great care to non-physical systems, where use of the term is usually metaphoric. The second law of thermodynamics asserts that there is a tendency for a system to move toward a chaotic or random state in which there is no further potential for energy transformation or work. Miller [17] defined entropy for a system as the "disorder, disorganization, lack of patterning, or randomness of organization of a system."

However, an open system such as a business organization [16], can offset the tendency of entropy to increase in the metaphorical sense and an organization concerned with matter-energy transformation in a literal sense by continually importing material, energy and information in one form or another, transforming them and exporting products, services and waste (entropy) to the environment. An open system may attain a steady state where the system remains in dynamic equilibrium through the continuous inflow and outflow of material, energy and information.

Kast and Rosenzweig [16, p.125] describe the concept of a steady

state as closely related to the concept of negative entropy (negentropy). Negentropy is the conceptual opposite of entropy. Negentropy represents more complete organization and ability to transform resources. A negentropic system can develop toward states of increased order and organization by importing negentropy in the form of materials, energy and information from the environment.

The relationship between negative entropy and the steady state for social systems is described by Emery and Trist [8, p.21].

In contradistinction to physical objects, any living entity survives by importing into itself certain types of material from its environment, transforming these in accordance with its system characteristics, and exporting other types back into the environment. By this process an organism obtains the additional energy that renders it 'negentropic'; it becomes capable of attaining stability in a time-independent steady state - a condition of adaptability to environmental variance.

Kast and Rosenzweig [16] suggest that the steady state has an additional meaning. Within the organizational system, the various subsystems have achieved a balance of relationships and forces which allow the total system to perform effectively. For a social organization, (including a business system) it is not a static state but rather a dynamic or moving equilibrium, one of continual adjustment to environmental and internal forces. The organization attempts to accumulate a certain reserve of resources which help it to maintain a steady state relationship and the resilience to mitigate some of the unexpected variation in the inflow and environmental requirements.

The maintenance of an equilibrium state or a steady state by a system when perturbed by environmental disturbances or the process of returning to a steady state after a system has been disturbed was named

'homeostasis' by Cannon [49].

### Homeostasis

Biologists have long been impressed by the ability of living beings to maintain their internal constancy. In 1900 the French physiologist, Charles Richet [48, p.57] emphasized the remarkable fact, "The Living Being is stable. By an apparent contradiction it maintains its stability only if it is excitable and capable of modifying itself according to external stimuli and adjusting its response to the stimulation. In a sense it is stable because it is modifiable - the slight instability is the necessary condition for the true stability of the organism."

Walter B. Cannon [49, p.245] introduced the term 'homeostasis' to describe Richet's "remarkable fact" and suggested its application beyond organisms. Cannon indicated that he had considered the term 'equilibria', but felt that it applies to relatively simple physio-chemical states, where known forces are balanced. He wrote:

I have suggested a special designation for these states (steady states of the brain, nerves, lungs, kidneys, spleen, all working cooperatively) homeostasis. The word does not imply something set and immobile, a stagnation. It means a condition - condition which may vary, but which is relatively constant ... homeostasis may present some general principles for the establishment, regulation and control of steady states, that would be suggestive for other kinds of organization - even social and industrial - which suffer from distressing perturbations. Perhaps a comparative study would show that every complex organization must have more or less effective self-righting adjustments in order to prevent a check on its functions or a rapid disintegration of its parts when it is subjected to stress.

For organizations, although the analogy is not precise, the concept of homeostasis is still useful. Organizations have relatively programmed behavior patterns, standard operating procedures, which provide stability over time (maintenance sub-systems). On the other hand, there are processes for making innovative decisions (adaptive sub-systems) which move the organization along its life cycle in response to external and internal stimuli. Organizations are not static, they change and adjust over time while exhibiting goal directed behavior.

The fact that a system is in a steady state does not mean that nothing is happening, but means that some sort of flow is going steadily through the system. What remains stationary is the pattern of this flow.

#### Homeorhesis

Waddington [87, p.105] introduced the term homeorhesis to describe that kind of stability not concerned with preserving the measure of some component of the system at a constant value, as in homeostasis, but with preserving the mode of change of the system, i.e., the system goes on altering in the same sort of way that it has been altering in the past. "Whereas the process of keeping something at a stable or stationary value is called homeostasis, ensuring the continuation of a given type of change is called homeorhesis, a word which means preserving the flow." The term homeostasis is similar to Buckley's term morphostasis; the term homeorhesis could be associated with Buckley's term morphogenesis, in that the pattern of changes is preserved. Change in conjunction with equilibrium leads us next to Boulding's notion of the equilibrium niche [73].

### Equilibrium Niches

A concept of great importance in biological and societal evolution is that of an ecosystem of interacting populations of different species. Boulding [73, p. 13] defines the equilibrium population as the niche of the species. "If the niche of any species declines to zero, the population will become extinct. Any ecosystems will have "empty niches"; that is, a potential species, which would have a positive population in the system, if it existed. Biological and societal evolution consist mainly in the filling of empty niches by mutation." Mutation is an adaptive mechanism, not always successful, but apparently essential to the long term survival of a system.

### Adaptive Systems

Boulding believes that fundamental to the survival pattern is the relationship between adaptability and adaptation. Adaptation to a particular niche, leads to short run survival and is seldom adequate for long term survival. Adaptability is the capacity to expand niches or to find new niches.

Boulding's terms of adaptation and adaptability are analogous to our terms of stability and resilience. The evolution of business systems are akin to Boulding's ideas as to evolutionary patterns for physical, biological and societal evolution. He states [78, p.14] "This process follows a phase pattern. That is, environments change, and existing structures become unstable and are transformed into new structures that are stable in the new environment."



Evolution seems to be a contradiction to the second law of thermodynamics (that entropy increases in any process). Boulding explains this apparent paradox [78, p.10] by "looking at evolution as the segregation of entropy, the building up of little islands of order and complexity at the cost of still more disorder elsewhere." This seems to generate an imperative, pollute thy neighbor. We gain order in our system by dumping our waste (entropy) into our neighbor's system.

A fundamental principle of open adaptive systems is that persistence, continuity or evolution of an adaptive system may require, as a necessary condition, change in its structure, the degree of change being a complex function of the internal state of the system, the state of its relevant environment, and the nature of the interchange between the two. Buckley [77, p. 182] says, "Thus the complex, adaptive system as a continuing entity is not to be confused with the structure which the system may manifest at any time."

Ackoff [78, p. 110] describes a system as adaptive when there is a change in its environmental and/or internal state which reduces its efficiency in pursuing its common purpose. It reacts or responds by changing its own state and/or that of its environment so as to increase its efficiency. Thus adaptiveness is the ability of a system to modify itself or its environment when either has changed to the system's disadvantage.

As a fundamental principle, it may be concluded that a condition for survival may be a structural change. Both stability and resilience are a function of a similar set of variables, which must include both characteristics of the internal state of the system and the state of its environment along with the nature of the interchange between the

two. This conclusion is important in that it provides general criteria for our selection of surrogates to represent stability and resilience.

### STABILITY, RESILIENCE AND STEADY STATE

Stability has been distinguished into different types by many systems writers analogous to the partitioning of risk in financial management theory. These different types can be placed into two categories. The first category is characterized by terms such as conservative stability, rigid stability, maintenance stability, regulatory stability. This approach generally defines stability as that system characteristic that represents the ability of the system to return to a prior equilibrium state after a temporary or small disturbance. We shall use the term 'stability' to refer to this first type of category.

The second category is characterized by terms such as plastic stability, flexibility, adaptability, resilience stability, ultra-stability and multistability. This approach defines stability as that system characteristic that represents the ability of the system to return to a prior equilibrium state or to reach a new and different equilibrium state after a permanent or large disturbance. We shall use the term 'resilience' to refer to this second type of category.

The following textual material is a compilation of the various definitions of stability proposed by the systems writers reviewed. This compilation presents the basis for the two categories of stability suggested above.

Stability, according to Kramer and de Smit [51], refers to the process of returning to a prior state. Systems that demonstrate this ability possess the property of finality or teleology (striving toward a goal or desired state) from any initial state. Within their range of stability, they "strive" to attain this state.

Hall and Fagen [47, p.87] noted that a system can be said to be stable when, after having been brought out of its stable state by a disturbance (e.g., displacing a pendulum), it returns to its prior state after elimination of the disturbance.

Rubenstein [23, p.449] defines a system as stable if a disturbance from an equilibrium state which it occupies creates in its wake a tendency to return to equilibrium after the disturbance stops. He also states that stability must be discussed with respect to a state of equilibrium and that the disturbance must be of a magnitude which is in the range of normal performance. If the disturbance exceeds the ability of the system to recover, then the system is unstable.

Rubenstein also defines a neutrally stable state [23, p.450]; "a sustained oscillation of constant amplitude with respect to a reference state," somewhat akin to the steady state definitions of other writers.

However, the concept of stability includes more than merely returning to a prior state after a disturbance. It is not always possible for the system to return to a prior state because of environmental constraints. The system can still behave stably by achieving a new equilibrium state different from the prior one. Systems that behave this way are called ultrastable by Klaus, [52]. This view is supported by Cadwallader [57, p.348] who says that ultrastability is the capacity of a system to persist through a change of structure and behavior.

Kramer and de Smit [51] define multistable systems as capable of absorbing disturbances through changes in the relationships among the sub-systems encompassed within the system. They stated, "Reciprocal influencing and adaptation, however, will enable the entire system gradually to attain a new stable state via the interrelationships and with the help of the sub-systems' ultrastable qualities. Systems with such properties are called multistable."

Kramer and de Smit also indicate that the concept of adaptation could be regarded as the highest form of stability (in the series; stable, ultastable, multistable). Their use of the term adaptation is similar to Buckley's term adaptability [19]. Buckley reserves the word adaptation for the morphostatic concept.

### Morphogenesis-Adaptability

In dealing with complex social systems, including socio-economic systems, Buckley [19, p.15] argues that we need a new term to express not only the structure-maintaining feature of systems, but also the structure-elaborating and changing feature of the inherently unstable system, i.e., a concept of morphogenesis.

Buckley accepts the use of the term 'steady state' if it is understood that the state that remains steady is not to be identified with the particular structure of the system, but the system-environment relationship. In order to maintain a steady state, the system may have to change its particular structure.

Buckley's ideas [19, p.63] underlying the evolution of more complex adaptive systems means that "our adaptive system ... must manifest: (1) some degree of plasticity ... or tension vis-a-vis its environment such that it carries on a constant interchange with environmental events, acting on and reacting to them; (2) some source or mechanism providing for variety, to act as a potential pool of adaptive variability to meet the problem of mapping new or more detailed variety and constraints in a changeable environment." Buckley's morphogenic model [19, p.128] assumes an ongoing system of interacting components in a state of tension, the whole of which is engaged in continuous transaction with its varying external and internal environment. "The adaptive process involves a source of variety against which to draw a number of selective mechanisms which sift and test the environmental variety against some criteria of viability, and processes which tend to bind and perpetuate the selected variety for some length of time."

Structure is never self-maintaining; a constant expenditure of energy is required to maintain any open system's steady state. In an open system, the normal operation constantly generates an input of variety and strains thereby contributing to a continuous process of structure elaboration and reorganization contributing to but not guaranteeing survival. Both stability and resilience are understandable in terms of similar principles, the basic interaction process between the system and its environment.

To paraphrase Buckley [19, p.26]; is the issue whether stability and order on the one hand, and resilience and change on the other, are to be considered on a par as system characteristics? If yes, we should balance mechanisms of control or conformity with an equally ardent search for mechanisms of innovation and change. Each should have equal status. These mechanisms are postulated to exist in business organizations by Kast and Rosenzweig [16, p.12].

#### Maintenance and Adaptability

Kast and Rosenzweig suggest that systems must have two mechanisms which are often in conflict, two mechanisms that must be balanced:

First, in order to maintain an equilibrium, they must have maintenance mechanisms which ensure that the various sub-systems are in balance and that the total system is in accord with its environment. The forces for maintenance are conservative, and attempt to prevent the system from changing so rapidly that the various sub-systems and total system become out of balance. Second, adaptive mechanisms are necessary in order to provide a dynamic equilibrium, one which is changing over time. Therefore, the system must have adaptive mechanisms which allow it to respond to changing internal and external requirements. These counter-acting forces will often create tensions, stresses, and conflicts which are natural and should not be considered as totally dysfunctional.

Katz and Kahn [83, p.39] describe the importance of maintenance and adaptive mechanisms for organizations.

If the system is to survive, maintenance substructures must be elaborated to hold the walls of the social maze in place. Even these would not suffice to insure organizational survival, however. The organization exists in a changing and demanding environment, and it must adapt constantly to the changing environmental demands. Adaptive structures develop in organizations to generate appropriate responses to external conditions.

Luchsinger and Dock's [84, p.25] discussion of organizational maintenance and adaptive subsystems corresponds to Kast and Rosenzweig's [16, p.126] two mechanisms for dealing with conflict; maintenance and adaptive mechanisms (which in turn are posited as analogous to our terms of stability and resilience). Luchsinger and Dock say that maintenance sub-systems face inward to the organization and keep the system parts functioning. Maintenance is concerned with preservation of the system. Adaptive sub-systems face outward toward the environment, act as sensors in detecting environmental cues, are flexible, and are future oriented. The adaptive sub-systems anticipate change and include research and development, long-range planning and market research for coping with environmental change. A flexible system permits the system to accept and process a wider variety of inputs than if the structure is rigid. Berrien [74, p.161] states "adaptation and growth have been shown to be related to each other and that growth is limited by the adaptability of the system."

Adaptability also pertains to the output of a business system. When we say that some of the output of a system must be useful to the supra-system, we are making an assumption that has wide and fundamental implications. We mean that each system must, if it is to survive,

deliver products that are acceptable to its environment.

If the products are unacceptable, either the producing system takes on a different state or the environment operates in such a fashion that the system is destroyed. Berrien concluded, "All systems are capable of outputs that may have no utility to their supra-systems as now constituted." Perhaps this is a property of a system that contributes to resilience, to flexibility in dealing with an unpredictable future.

Adaptation is a survival-extending process. Bronowski [75, p.xiv] expressed this opinion, "What a surviving species inherits is not (just) a set of adaptations, but the capacity to adapt. A system that lacks variety or resilience in its behavior may not survive internal or external changes, while a system that responds to all environmental influences quickly dissipates resources in useless, frenzied activity. Nichols' [26] research on business organizations suggests that firms need to maintain a balance between stability and flexibility (resilience) in their exchanges with the environment.

#### BALANCE - STABILITY AND RESILIENCE

This balance between stability and resilience is a critical point in Holling's [1] research into ecological systems. In discussing the different kinds of behavior of ecological systems, in particular the budworm-forest community, Holling said [1, p.14]:

If we view the budworm only in relation to its associated predators and parasites, we might argue that it is highly unstable in the sense that populations fluctuate widely. But these very fluctuations are essential features that maintain persistence of the budworm, together with its natural enemies and its host and associated trees. By so fluctuating, successive generations of forests are replaced, assuring a



continued food supply for future generations of budworms and the persistence of the system. ...In this sense, the budworm forest community is highly unstable and it is because of this instability that it has an enormous resilience.

Holling [1] felt it was necessary to distinguish these two types of behavior. One he termed stability, which represents the ability of a system to return to an equilibrium state after a temporary disturbance; the more rapidly it returns and the less it fluctuates, the more stable it would be. The second he termed resilience, a measure of the persistence of systems and their ability to absorb large and permanent changes and still maintain the same relationships between populations or state variables.

Holling, in his various ecological studies, stressed the idea of the trade-off between stability and resilience. This trade-off between stability and resilience is the basis of one set of hypotheses in this research study in which we postulate a negative correlation between stability and resilience in business systems.

Holling [1, p.21] indicated that a different view of the world is obtained when we concentrate on the boundaries of a domain rather than on equilibrium states. Holling was discussing ecological systems, but we can paraphrase his comments to apply analogously to business systems.

There are two different approaches to the management of corporate resources. The first approach is to maintain stability. This approach emphasizes equilibrium, the maintenance of a predictable world and the harvesting of the market with as little fluctuation as possible. The second approach, based on the resilience of the organization, emphasizes the need to keep options open, to take the regional or global view rather than the local view, the long range versus the short range, a need

to emphasize heterogeneity.

To achieve stability we plan for the future. We establish regulatory controls based on future expectations much like the 'cause controlled' system from our discussion previously about cybernetic stability.

To achieve resilience, we design for the future. The idea of resilience does not require an ability to predict the future, but only a capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take. This view was expressed by Slobodkin [94] when he said that the system's goal of persistence is like a game with the payoff being to stay in the game. This suggests that a strategy of a business organization might not be to maximize short-term productivity, efficiency or profits, but to persist by maintaining flexibility above all else. The long range goal of a corporation should not be profits, per se, but survival, i.e., profits are a means to an end.

To summarize our conceptual definitions, it is proposed that the concept of stability posited in this research study embodies the ideas subsumed under the morphostatic segment of Figure 3. This includes the notions of homeostasis, negative and pseudo-negative feedback, short-term adaptation, regulation, maintenance and cybernetic control.

Resilience embodies the ideas subsumed under the morphogenetic segment of Figure 3. This includes homeorhetic patterns of flow, convergent and non-convergent positive feedback, long-term adaptability, multistability, ultrastability, developmental and evolutionary change.

This leads us next to a review of a few articles that discuss the problems of trying to quantify these conceptual definitions.

According to Margalef [89, p.28], "If stability is to be a useful concept, it needs quantification, but the difficulties appear forbidding." He continued, "One might choose as an expression of stability, the ratio between the size of the whole area of the states from which the system can return and where it goes under the impact of moderate environmental disturbance." He indicates that this would not be a reliable solution since systems that spontaneously fluctuate more, can also return from a wider range of induced deviation. In addition, the boundary between the two areas would be difficult to specify.

Margalef also discusses the dichotomy of stability, that is, conservative stability and adaptive stability. He says, "Here we are at a loss to decide whether the word in question should be applied to the head or to the tail of our serpent. Perhaps it would be wiser to refer to the two ends by separate names, for instance, by adjustment or lability to one, and by conservatism, endurance or persistence to the other."

Lewontin [91] partitioned stability into neighborhood stability and global stability. His model is based on the concept of the vector field in  $n$ -dimensional space used in physics and population genetics. Neighborhood stability relates to the vector field near a stationary point. If all the vectors point toward the stationary point, then it is a stable point. Small perturbations will result in the system returning to that point.

Global stability exists if a system converges to that point from all other points in the space. While neighborhood stability treats the response of the system to small perturbations, global stability asks how the system will behave for large perturbations. If the system is far away from a stable equilibrium point, will it go toward that point or toward some quite different one? Lewontin [91, p.16] states, "This is the question of the size and configuration of the domain of attraction of an equilibrium."

Lewontin [91, p.19] suggests that the basin of attraction concept can be represented by a model shaped like a volcano. A volcano with steep sides and a deep crater would represent a small domain of attraction with a very stable point in the crater. Conversely, a volcano with gently sloping sides and a shallow crater would represent a larger domain of attraction, but a less stable point in the pit of the crater. See Figure 4a below for a graphic representation.

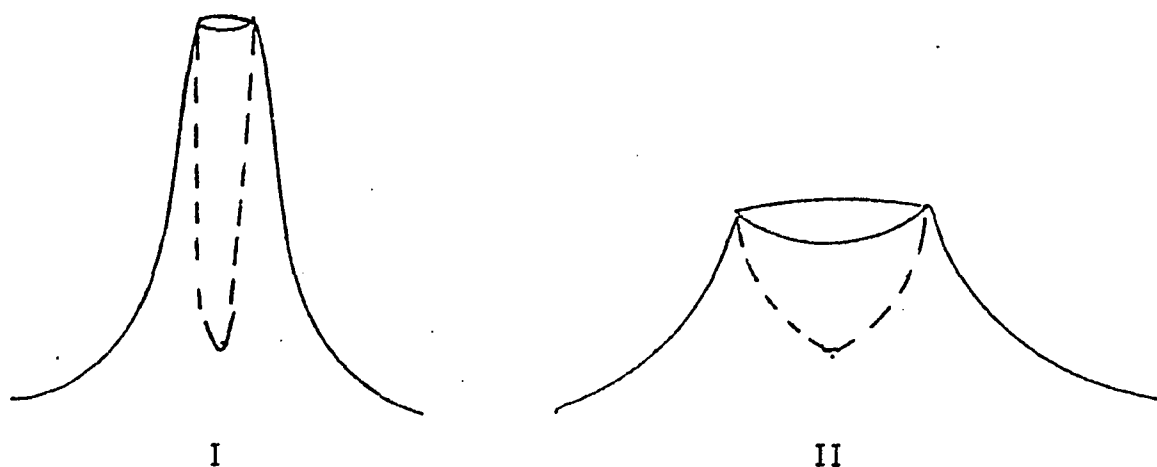


Figure 4a. Volcano analogy model of relationship between stability and resilience.

In Figure 4a, the depth of the volcano could be used to represent stability and the area of the mouth of the volcano could be used to represent resilience. In Figure 4a (I), we would be representing low resilience and high stability; in (II), we would be representing higher resilience and lower stability.

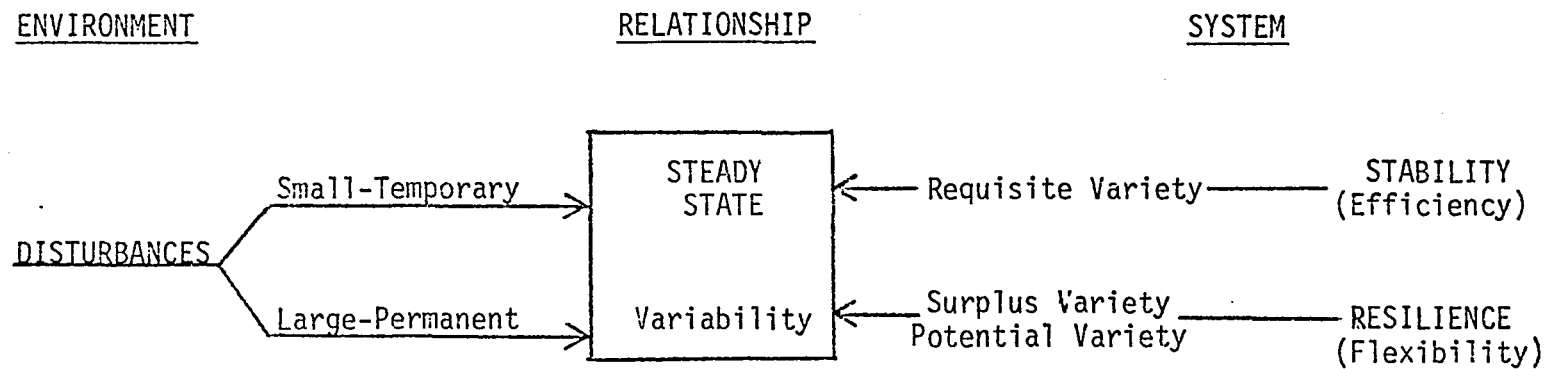
This completes our review of the literature pertinent to the development of conceptual definitions of stability, resilience and steady state or equilibrium. Our next step is to derive operational definitions of these concepts in the context of the financial behavior of business organizations.

## OPERATIONAL DEFINITIONS

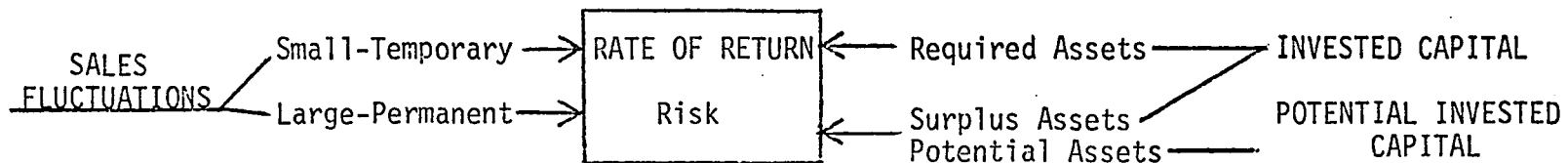
Figure 4b represents the posited comparison between a theoretic systems hypothesis and a real organization. Part A represents the systems theoretic model. The system tries to maintain a steady state relationship with the environment by successfully responding to environmental disturbances. Stability is that system property that helps maintain the steady state by responding to small or temporary disturbances. This presumes that the system possesses the requisite variety of resources to meet each of the perturbations.

Resilience is that system property that helps maintain the steady state relationship by responding to large or permanent disturbances. Our theory of resilience is that the firm maintains a certain reserve of resources above that requisite variety needed to meet the normal small temporary disturbances expected as part of routine operations. In addition to this reserve of current resources, the system also has the ability to change the resources of the system, that is, it has the potential for making necessary changes to meet the large or permanent changes in the environment.

If the system converts its reserve resources to current resources in terms of use or changes the resource base, the result would tend to increase stability by providing more resources to meet normal disturbances, but the result would also reduce resilience by reducing the reserve of slack resources and by reducing the potential for change by consuming part of that potential. This is the trade-off hypothesis between stability and resilience posited in this research study and



A. Systems Theoretic Model.



B. Business Organization Model.

Figure 4b. Comparison between theoretic systems hypotheses and real organizational phenomena.

posited by Holling [1], Nichols [76], and implicit in the work of other writers reviewed in this report, [16,19,84,89,91].

Part B represents a real business organization. The firm tries to maintain a steady state rate of return. The fluctuation in this state or rate of return is that organizational property denoted as 'risk' by financial writers.

Disturbances are represented by fluctuations in sales or demand for the firm's products. Stability is posited as that property of the firm that allows it to use its current complement of resources (assets) to meet small, temporary perturbations. A firm can achieve stability if it has the requisite variety of assets to meet the normal anticipated disturbances.

Resilience is posited as that property of the firm that allows it to meet large, permanent disturbances by utilizing the firm's reserve assets or by alternating the asset mix available to the firm.

Assets are the use of corporate funds. Invested capital is the source of corporate funds. Resilience is a function of the ability to change assets, a function of the potential to change assets, and therefore a function of invested capital.

If the firm converts its reserve assets to current assets or changes the asset base, the result will increase stability by providing additional assets to absorb disturbances, but again the result would also reduce resilience by reducing the reserve of slack assets and by reducing the potential for change by consuming part of the potential for increasing invested capital, which is a limited resource.

This demonstrates the balance or compromise between the amounts of stability and resilience in a firm. In a sense, it is a compromise



between efficiency and flexibility.

Stability and resilience as conceptually defined are subjective concepts and have no specific, empirical referents. The estimate of stability or resilience exists in the mind of the person who creates an operational definition and is not necessarily inherent within the system under investigation. Therefore, the degree of existence of these characteristics is dependent upon the operational definition as applied to a business system.

We cannot measure the degree of stability or resilience, as conceptually defined, to be attributed to a specific business system. However, a statistical, empirical investigation involving stability and resilience as variables requires an exact and objective definition. What must be measured is some characteristic or relationship among characteristics, such that model builders might be expected to agree in their aggregate judgments as to the degree of stability and resilience that are associated with that particular business system.

Figure 4c represents the correspondence between the conceptual and operational modes of the integrated general systems - financial management model.

From financial management theory, EBIT/TA was selected to represent the rate of return for the business organization. Each business firm targets a rate of return commensurate with its risk class. The actual rate of return achieved is a function of both internal and external factors.

To equate the financial management term 'rate of return' with the general systems term 'steady state', we can employ three different

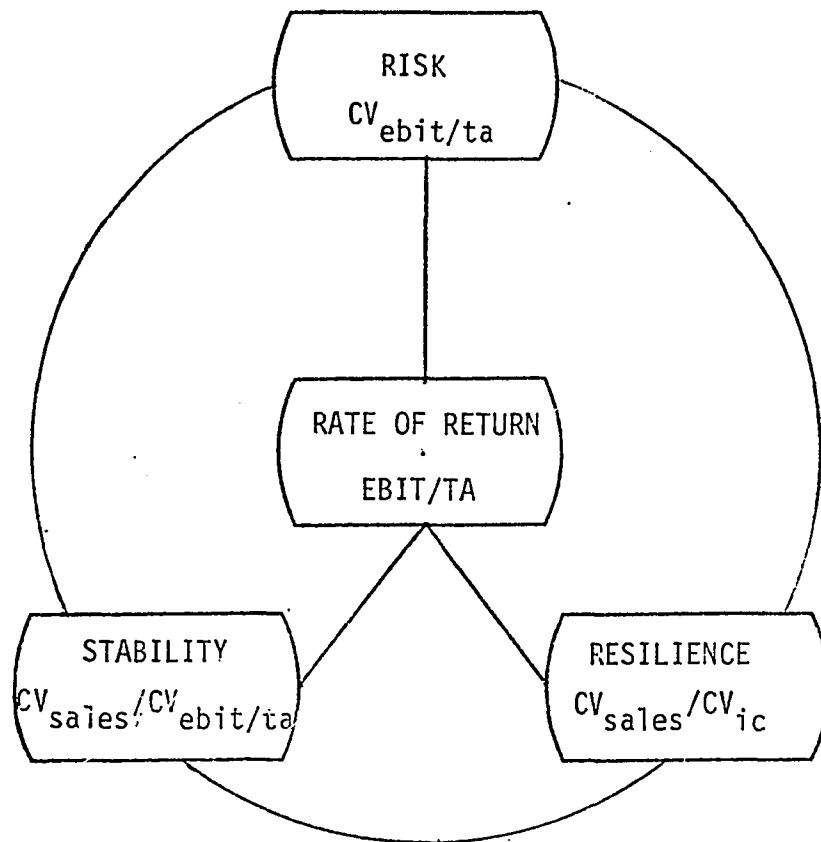


Figure 4c. Operational version of the financial management and general systems model.

points of view based on three general systems terms; equilibrium, morphostasis and morphogenesis as depicted in Figure 3.

If we choose the term 'equilibrium' in the context of the closed systems point of view, we are describing the rate of return as a financial state in terms of a balance of the economic forces of supply and demand. The resultant rate of return or equilibrium financial state is a function of this balance.

If we choose to use the term 'morphostasis', we are equating the rate of return with the idea of a financial steady state where steady state is described in terms of the maintenance of a homeostatic set-point. The firm selects a target set-point rate of return and marshals the resources of the corporation in order to maintain the set-point. Cybernetic feedback supplies information to management which is used to make decisions leading to actions that will maintain or restore the target rate of return.

If we choose the term 'morphogenesis', we are equating the rate of return with the idea of the maintenance of a financial steady state where steady state is described in terms of the ability of the firm to change and adapt to environmental variety.

Risk, in the financial management model is represented by fluctuations in the rate of return; in the general systems model, by fluctuations in the steady state. The surrogate, coefficient of variation of EBIT/TA, represents risk.

A definition of stability, based upon a composite view of the systems writers reviewed, proceeds from the partition of stability into two meanings of the term: (1) conservative stability, maintenance or regulatory stability, or local stability which we shall henceforth

denote as stability; and (2) flexibility, adaptability, ultrastability or multistability which we shall henceforth denote as resilience.

Most systems writers agree that stability and resilience are not so much properties of the system as they are descriptions of the relationship between the system and its environment. From this point of view, we should then construct operational definitions of these relational properties in terms of measurable relationships that relate both the system and the environment.

One obvious indicator of the relationship between the system and its environment would be sales volume. This tends to reflect the supply (system) - demand (environment) forces at work.

As previously posited in the stochastic model of risk from financial management theory, risk is a function of fluctuation in sales which when magnified by operating leverage produces a larger fluctuation in rate of return, EBIT/TA. Risk and stability are linked concepts. Both are associated with the fluctuation of some indicator of the steady state rate of return as a measure of the financial behavior of a business system.

This is analogous to Leigh's [90] research in ecological systems. He related stability to the inverse of the frequency of fluctuations, (risk) as has been posited in this paper for business systems.

While fluctuations in sales indicate disturbances to the system-environment relationship, any measure of stability should also reflect the response or result of the disturbance. The response to sales fluctuations is reflected in fluctuations in the rate of return, EBIT/TA, as accepted in financial management theory. It is proposed that the operational surrogate chosen to represent the stability relationship be a

function of the fluctuations in sales and the fluctuations in rates of return.

As argued in the operational definitions of business risk and rates of return, we argue here also for a relative, rather than an absolute measure of stability. The specific surrogate proposed is the ratio of relative fluctuations in sales (measured by the coefficient of variation of sales,  $CV_{\text{sales}}$ ) to the relative fluctuations in rate of return (measured by the coefficient of variation in EBIT/TA,  $CV_{\text{EBIT/TA}}$ ).

This measure encompasses compensation for firm size as suggested by Idol [31] and absolute size of variations as suggested by D'Ambrosio and Archer [30].

#### DEFINITION OF STABILITY

$$CV_{\text{sales}}/CV_{\text{ebit/ta}}$$

The more stable firm can absorb fluctuations in sales with minimal fluctuations in the rate of return, EBIT/TA. The larger the ratio, the more stable the firm; the lower the ratio, the less stable the firm.

Selection of a surrogate for resilience presents a more challenging task. Resilience is also related to the system - environmental relationship but connotes a more flexible approach to the problem of maintaining a viable long-term systems-environment relationship. As stated previously, sales fluctuations are one way to indicate the state of the relationship between the system and its environment. What we require is some indicator of the flexibility of the system in response to sales fluctuations.

It is proposed that a system is more flexible financially if it can absorb sales fluctuations without a basic change in its financial state. A system that is less flexible would exhibit greater fluctuations in its financial state in response to changes in sales levels. The financial state is represented by the invested capital of the firm. Invested capital (debt plus equity) is the source of corporate funds - assets are the use of these funds. The ability of a firm to respond to large sales fluctuations without changes in its invested capital implies that the firm already commands the necessary variety, the necessary resources, the flexibility, to absorb large disturbances. If a firm lacks these essential resources to absorb large or permanent disturbances, then the firm would have to respond by altering or modifying its resource base. This restructuring of resources or the corporate asset base normally would encompass a change in invested capital which provides the means for the innovative juggling of corporate assets.

This suggests a possible surrogate for representing resilience; the fluctuation in sales in relation to the fluctuation in invested capital. Again, we prefer a relative measure in contrast to an absolute measure for the reasons previously offered, size of firm and absolute size of the deviations. The specific surrogate proposed is the ratio of relative fluctuations in sales (measured by the coefficient of variation of sales,  $CV_{\text{sales}}$ ) to the relative fluctuations in invested capital (measured by the coefficient of variation in invested capital  $CV_{\text{IC}}$ ).

#### DEFINITION OF RESILIENCE

$$CV_{\text{sales}}/CV_{\text{ic}}$$

The more resilient firm can absorb large fluctuations in sales with minimal fluctuations in invested capital. The larger the ratio, the more resilient the firm; the lower the ratio, the less resilient the firm.

It has been posited that the more resilient firm has a larger variety of resources to meet the challenge of disturbances than have the less resilient firms [16,19,24]. This suggests that more resilient firms control more resources than are necessary to meet the usual small, temporary or short term variations in the system-environment relationship, that they have in reserve the resources to meet unexpected, large, or permanent variations in the system-environment relationship.

This view is supported by Berrien [74], "all (resilient) systems are capable of outputs that may have no utility to their suprasystems as now constituted"; by Kast and Rosenzweig [16, p.125], "The ... organization will attempt to accumulate a certain slack of resources which helps it to maintain its equilibrium and to mitigate some of the possible variations in the inflow and environmental requirements," and by Buckley's [19] "... goal of adaptive variability."

An organization tends to maintain a ready reserve (resilience) to help it sustain its equilibrium state when faced with large or unexpected fluctuations in its interface with the environment. Systems operate to produce useful and useless outputs, the criterion of usefulness being established by the environment. Thus, if the environment changes, a useless output may become a useful output (resilience).

Neither zero variety nor extreme variety in any system may be functionally appropriate for long term survival. Eoyang [21] comments, "A system that has no variety (static stability) in its behavior may not survive threatening changes, while a system that responds to any and all

environmental fluctuations quickly dissipates substantial resources in useless activity."

Nichols' [76] is quoted in his research on industrial organizations, "... firms need to maintain a balance between stability and flexibility in their transactions with environment."

Holling's [1, p.17] work also demonstrates a trade-off between stability and resilience:

I have touched on examples like the spruce budworm forest community in which the very fact of low stability seems to introduce high resilience. Nor are such cases isolated ones, as Watt [41] has shown in his analysis of thirty years of data collected for every major forest insect throughout Canada. ... This statistical analysis shows that in those areas subjected to extreme climatic conditions the populations fluctuate widely but have a high capability of absorbing periodic extremes of fluctuation. They are ... unstable, but highly resilient. In more benign, less variable climatic regions, the populations are much less able to absorb chance climatic extremes. ... These situations show a high degree of stability and a lower resilience. The balance between resilience and stability is clearly a product of the evolutionary history of these systems.

Holling said that his research showed that "The more homogeneous the environment in space and time, the more likely is the system to have low fluctuations (high stability) and low resilience." This relationship also seems to be reflected in industries. Utilities are immersed in a slowly fluctuating, highly controlled environment. They generally show greater stability in rates of return than do industries in highly technical, rapidly changing environments.

Another of our hypotheses is that a stable firm, a firm with the minimal, but correct mix of assets, in a stable environment and with no excess assets in reserve, will exhibit a greater rate of return than a



firm with a ready reserve of surplus assets. This contrast is obvious in that the divisor for the rate of return surrogate is total assets. The firm with the lower total assets, ceterus paribus, will exhibit a greater rate of return.

Stability should then correlate positively with the rate of return. This can be seen in the following equation;

$$\text{Stability} = CV_{\text{sales}}/CV_{\text{rr}} = CV_{\text{sales}}/\sigma_{\text{rr}}/\text{rr} = CV_{\text{sales}} \text{ rr}/\sigma_{\text{rr}} =$$

$$CV_{\text{sales}} \text{ ebit/ta}/\sigma_{\text{rr}} = CV_{\text{sales}} \text{ ebit/ta } \sigma_{\text{rr}}.$$

where:

$CV_{\text{sales}}$  = coefficient of variation in sales

$CV_{\text{rr}}$  = coefficient of variation in rate of return

$\text{rr}$  = rate of return

$CV_{\text{rr}} = \sigma_{\text{rr}}/\text{rr}$

$\text{ebit/ta} = (\text{earnings before interest and taxes})/\text{total assets}$

The above equation also indicates that, ceterus paribus, stability would correlate negatively with total assets.

Resilience should correlate negatively with the rate of return. This is implicitly true if stability and resilience are negatively correlated. If stability is negatively related to total assets, then resilience should be positively related to total assets. This can be demonstrated algebraically as follows:

$$\begin{aligned}\text{Resilience} &= CV_{\text{sales}}/CV_{\text{ic}} = CV_{\text{sales}}/\sigma_{\text{ic}}/\text{ic} = CV_{\text{sales}} \text{ ic}/\sigma_{\text{ic}} \\ &= CV_{\text{sales}} \text{ ta}/\sigma_{\text{ic}}\end{aligned}$$

where:

ic = invested capital

$CV_{\text{ic}}$  = coefficient of variation of invested capital

ta = ic

ta = total assets

If resilience is directly related to total assets and rate of return is inversely related to total assets, then resilience should be inversely related to rate of return.

The hypothesis that stability and risk are negatively correlated is implicit in our definitions of these terms. Risk is a function of fluctuations in the rate of return, the greater the fluctuation, the greater is the risk. Stability implies a minimal fluctuation in rate of return in response to environmental variety; the lower the fluctuation, the greater the stability.

The DuPont model depicted in Figure 2c can be used to clarify our discussion of the concepts and the relationships among the surrogates selected to represent the parameters; stability, resilience, business risk and rate of return.

### Rate of Return

Rate of return is one way of expressing the earning power of a business firm in quantitative terms. A perusal of the DuPont model

shown in Figure 2c points out the relationship among the factors that contribute to this earning power or rate of return. The surrogate for rate of return,  $EBIT/TA$ , is depicted in Figure 2c as being derived from the product of operating margin ( $EBIT/sales$ ) times turnover ( $sales/total\ assets$ ). The rate of return is thus a function of sales, EBIT and total assets; three factors which can be readily identified on most financial statements, i.e., income statements and balance sheets.

### Stability

Stability is that property of a system that restores equilibrium between the system and its environment when the system is perturbed by small, temporary disturbances. A stable firm is one that has been consistently able to produce a stable (uniform) rate of return in spite of fluctuations in sales. We have denoted an organization as being relatively more stable, the more uniform (less fluctuation) its rate of return in relation to fluctuation in sales.

The statistical variation in sales (as measured by the coefficient of variation of sales) divided by the statistical variation in rate of return (as measured by the coefficient of variation of rate of return) will serve as our surrogate for stability as previously indicated. A large ratio denotes high stability, a small ratio denotes low stability.

This research project is not directed to the discovery of nor to an empirical demonstration of cause and effect relationships, but as a measure of association between parameters. We have however, indicated within the context of our model the generally accepted causality factors as propounded in most texts on business. On this basis, we may ask,

what are the generally accepted causal factors that contribute to the fluctuation in organization profits? What are the managerial control mechanisms that could regulate stability?

If we equate stability with the fluctuation in sales in relation to fluctuation in rate of return, then our model of business systems indicates that the fluctuations in rate of return are derived from the three factors that are used to compute rate of return, revenue, costs and total assets. It would seem reasonable to conclude that the causal factors that relate to stability in operating profits will be encompassed within the factors that contribute to fluctuations in revenue, costs and total assets.

Revenue is derived from selling products to meet consumer demand. In the context of our model, revenue is the result of successfully matching the internal resources of the firm in producing products that match external demand. Inconsistency in matching products to market demand could create fluctuations in revenue. Stability derives from the successful matching process. Instability would be the result of inconsistent matching.

Costs originate from producing and selling products to meet consumer demand. In the context of our model, costs are generated as the result of internal corporate operations. Inconsistency in controlling production, selling and administrative costs could yield fluctuating costs and thus create fluctuations (instability) in operating profits. Cost stability would be the result of consistent control of production, selling and administrative costs, *ceterus paribus*.

## Risk

Business risk has been operationally defined as the relative variation in rate of return. In our business model, we represent business risk as the relative statistical variation in the box labeled, "earnings." Our prior discussion concerning stability is most appropriate in that our surrogate for business risk also serves as the divisor in our definition of stability, i.e., the ratio of sales fluctuations to rate of return fluctuations. Business risk is a measurement of an internal characteristic (fluctuations in rate of return) while stability is a measurement of the relationship between an internal characteristic and an external characteristic (rate of return and sales).

## Resilience

Resiliency is a measure of the ability of a system to successfully respond to large or permanent changes in the environment, the market. Chris Holling [1] defined resilience in terms of persistence or long term survival for ecological systems. Resilience is the ability to establish a new equilibrium zone or to restore a prior zone based upon a new system-environment interface. A similar definition for business organizations is used in this research report.

If a firm faces a large or permanent change in its environment, what actions can help it to survive: The organization must change its interface with its environment. The organization must match changed external demand with reserve internal corporate resources, or if the internal variety of the corporate resources of the organization is no longer adequate to control or match the external variety of the environment,

then the organization must initiate internal changes (morphogenesis) in order to restore the requisite internal variety or attempt to reduce the external variety of the market. This latter choice is beyond the effective capability of most organizations. How does a firm change its internal variety? How does a firm change its structure and/or its behavior?

To answer this question within the context of our model, we can ask how do we restore the match between our products and the market and how do we control our costs? If the market demand has changed beyond the capability of the organization to respond profitably, then the organization must alter its product mix. If the organization is unable to alter its product mix within its current complement of internal resources, then the internal resources must be changed.

If the cost of production, selling and administration are unstable, better management practices are required. If the organization is unable to control costs within its present complement of internal resources, then the internal resources should be changed. If revenues are as budgeted with respect to market conditions (product and demand are matched) and the organization is still operating below targeted profit levels, then either internal resources should be better managed to reduce costs or internal resources should be changed to increase production efficiency.

Eoyang[21] discussed these managerial problems, "Industrial practices in highly competitive markets are rich with corporate attempts to reduce the uncertainties in their environments. Legal contracts are instruments to regulate the variability of inputs (e.g., material, labor and capital) and to ensure the stability of outputs (e.g., sales

agreements). Other examples include patents which prevent competitors from using a certain technology, price cutting to eliminate competition, licensing to regulate secondary markets, trade agreements, etc."

Thompson [17, pp.18-24] offered another view as to how organizations attempt to control or at least minimize the impact of environmental variety on the organizational system. Thompson suggested "interactive strategies such as; buffering, leveling, forecasting and rationing." Buffering refers to setting up organizational components, (stock piles, inventories, backlogs, etc.) to absorb and cushion environmental variety. Leveling refers to attempts to reduce fluctuations in the environment. Examples cited are companies that try to smooth market demand through selective advertising. Forecasting consists of anticipation and adaptation to expected environmental change. Rationing is essentially the coping with external change by distributing its impact throughout the system.

Chandler [2] investigated methods of organizational innovation as strategies for coping with environmental variety. He found the following adaptive strategies among some of the larger business firms. DuPont initiated a vast program of product diversification; General Motors developed decentralized management policies as did General Electric Co.; Sears and Roebuck utilized geographical-decentralization.

We will conclude this section with one last reference to research in the field of ecology which tends to support our choices of surrogates. Margalef [89, p.33] related diversity and stability (persistence) as expressions of the degree of organization of an eco-system. He proposed a convenient measure for purposes of comparison; the primary production divided by the total biomass of the eco-system. This ratio can be

called productivity. Perhaps this is analogous to our definition of productivity in business systems, EBIT/TA (production of profits divided by the mass of assets). Margalef said, "... in general, diversity is negatively correlated with productivity.", implying that resilience is negatively correlated with productivity.

Armed with these operational definitions and their respective surrogates, we now proceed to the empirical research data which supports our hypotheses.



## CHAPTER III

### METHOD OF RESEARCH

#### Nature and Source of Data

The raw data compiled and analyzed in this research report were extracted from the COMPUSTAT II tape files available in the Idaho State University Computer Service Center. COMPUSTAT II is a service provided by Standard & Poor's Compustat Services, Inc. [95]. The COMPUSTAT II service consists of a number of computer readable libraries of financial, statistical and market information covering several thousand industrial and non-industrial companies listed on the New York, American and Over-the-Counter Stock exchanges.

The total industrial file contains (1) the primary industrial file (approximately 900 companies), specifically includes all companies in the S&P 400, some companies in the S&P 40 Utilities Index, the S&P 20 Transportation Index, plus companies of greatest interest, primarily companies on the New York Stock Exchange; (2) the supplementary industrial file (approximately 900 companies) contains companies which are followed on the major exchanges but which may have a lesser degree of investor interest; (3) the tertiary industrial (approximately 900 companies) completes the coverage of industrial companies followed on the New York and American Stock Exchanges. It also includes about 300 non-industrial companies which have been modified for comparability to the industrials; and (4) the over-the-counter file (approximately 950 companies) which contains those companies traded over-the-counter that command the greatest

investor interest.

All companies are identified by the CUSIP (Committee on Uniform Security Identification Procedures) Issuer Code, providing a unique numeric identification. All companies are also identified as to major industry classification by way of industry codes based on the United States Department of Commerce's Standard Industrial Classification (SIC) codes.

Compustat II maintains a highly reliable and efficient system of data collection and validity procedures. There are several checks implemented within the system to ensure that the data is of the highest quality.

Appendix A contains a list of primary sources of information, input and flow of data, and validity procedures used to provide data to COMPUSTAT II.

A random technique was used to select approximately 25 percent of the industries for study in this report. This selection method provided 30 different industries representing 367 firms with an average of about 12 firms per industry. Data was gathered for the time period 1968 through 1977 which represents the most recent decade of industrial activity for which complete data were available.

In order to provide better insight as to what type of companies are being followed on the COMPUSTAT II files, general criteria for acceptance on the New York, American and Over-the-Counter stock exchanges are listed:

New York Stock Exchange Minimum Requirements

1. Net tangible assets over \$16 million
2. \$16 million in market value of publicly held common shares

3. 3,000 round-lot shareholders
4. 1,000,000 publicly held common shares
5. Earning power of \$2.5 million pretax

#### American Stock Exchange Minimum Requirements

1. Net income of \$400,000 for last fiscal year
2. Net tangible assets of \$4 million
3. 400,000 publicly held common shares
4. \$3 million in market value of publicly held shares
5. 1200 shareholders, including 800 round-lot shareholders

#### Over-the-Counter

The basic requirement for a company to be treated over-the-counter is that it must meet State or Securities and Exchange Commission requirements. The companies included in COMPUSTAT II represent the major National Association of Securities Dealers Automated Quotations companies in terms of Sales, Total Assets and Market Value.

#### Collection and Analysis of Data

A computer program was written in the FORTRAN language (Appendix B) to extract from the COMPUSTAT II library tapes certain data items from the decade 1968 through 1977 for all firms within those industries previously chosen using a random selection technique. The specific data items extracted from the tapes for each firm were:

<u>VARIABLE NAME</u>	<u>FINANCIAL ITEM</u>
V1	CURRENT ASSETS
V2	CURRENT LIABILITIES
V3	TOTAL ASSETS
V4	LONG TERM DEBT
V5	SALES
V8	INTEREST
V9	NET WORTH
V10	EARNINGS BEFORE INTEREST & TAXES (EBIT)
V12	FIXED ASSETS

The computer program also summed by year each data item for every firm within an industry to provide a value for each industry for each data item by year.

From these original data values, the computer was also programmed to calculate the following financial parameters for each firm and for each industry for the decade 1968-1977.

V11	WORKING CAPITAL
V13	EBIT/TOTAL ASSETS (RETURN)
V14	NET WORTH/INVESTED CAPITAL
V15	FIXED ASSETS/LONG TERM DEBT
V16	INVESTED CAPITAL (EQUITY+DEBT)
V17	EBIT/SALES (OPERATING MARGIN)
V18	SALES/TOTAL ASSETS (TURNOVER)
V20	EBIT/(EBIT+INTEREST)

V21	WORKING CAPITAL/SALES
V22	CURRENT ASSETS/CURRENT LIABILITIES
V23	EBIT/INTEREST

The computer program also calculated a mean, standard deviation, and a coefficient of variation for each variable (V1-V23) for each firm and for each industry for the decade under investigation.

Finally, values were calculated for each firm and each industry for each of the surrogates chosen to represent respectively; stability, resilience, business risk and rate of return.

The surrogate chosen to represent stability is the ratio of the coefficient of variation of sales to the coefficient of variation of EBIT/Total Assets,  $(CV_{\text{sales}}/CV_{\text{EBIT/TA}})$ .

The surrogate chosen to represent resilience is the ratio of the coefficient of variation of sales to the coefficient of variation of invested capital  $(CV_{\text{sales}}/CV_{\text{IC}})$ .

The surrogate chosen to represent business risk is the coefficient of variation of EBIT/Total Assets  $(CV_{\text{EBIT/TA}})$ .

The surrogate chosen to represent rate of return is EBIT/Total Assets.

Appendix C is a compilation of values for stability, resilience, business risk and rate of return for each of the 367 firms studied. Appendix D is a compilation of values for each of these same surrogates for each of the 30 industries selected for study. Scattergrams for each pair-combination are presented in the Findings section of this research report. These scattergrams provide a more readily discernible visual pattern than the tables of comparative values in Appendices

G and D.

### Statistical Treatment of Data

The working hypotheses of this research report call for a specific directional correlation between each set of surrogates selected for investigation, both by industry and by firms.

In applying a test of statistical significance to the results of this kind of research, the question one attempts to answer is; what is the probability that the results achieved could have occurred purely by chance if there were no underlying relationship between the data?

The test for no relationship is expressed in a null hypothesis. If the null hypothesis is rejected, the implication is that the observed correlation between surrogates did not occur merely by chance and could be the result of some causal relationship between the variables. It must be kept in mind however, high correlation coefficients do not prove any causal relationships but merely measure the degree of association between the measured variables.

In correlation analysis no attempt is made to estimate one variable from another as in regression analysis and it makes no difference which label is associated with which variable. Both are considered random variables. The purpose of correlation is to provide a mathematical statement of the degree of closeness of the relationship existing between the variables.

Our measure of the closeness of the empirical relationship between two variables, X and Y is the coefficient of determination from parametric statistical theory [96]. The coefficient of determination,

$r^2$ , represents the degree of the linear relationship between two random variables, i.e., the ratio of the variation explained to the total variation.

$$r^2 = \frac{\text{explained variation}}{\text{total variation}} = \frac{b \sum xy}{y^2}$$

$b$  = slope of the linear relationship between the variables,

$$x = (X_i - \bar{X})$$

$$y = (Y_i - \bar{Y})$$

The coefficient of correlation,  $r$ , is more widely known and used than the coefficient of determination, ( $r$  = the square root of  $r^2$ ). The sign of the slope of the linear relationship between the variables  $x$  and  $y$  determines the sign of the correlation coefficient. If  $r = -1$ , there is perfect negative correlation between the variables; if  $r = 0$ , there is no correlation between the variables; and if  $r = +1$ , there is perfect positive correlation between the variables. It is possible to test the null hypothesis that the true value of the correlation coefficient is equal to zero or to set up a confidence interval for the true coefficient of correlation. The test to determine whether it is reasonable to believe that the true coefficient of correlation,  $\rho$ , is equal to zero follows the usual parametric procedures [96].

The use of a parametric model is not, however, applicable in this situation because (1) we must assume that each of the samples is drawn from a normal population and (2) that each of these populations has the same variance. If the sample sizes are large enough, we do not need the assumption of normality because of the central limit theorem, however, equality of variance among the different firms and industries cannot be

assumed to hold. Concern over the often assumed appropriateness of a parametric model is alleviated by the use of a non-parametric model [35,98,97].

The non-parametric model chosen to improve the generality of the statistical results generated in this report is the Spearman's Rank Difference Method.

Rank tests were first introduced for their ease of use, as short-cut methods. It then came to be realized that they have another advantage; their validity does not require the specific assumptions needed by the parametric tests that had been used previously. These often unreliable assumptions (population normally distributed and equality of variances among the different populations) are expressed in terms of probability models that are mathematical functions precisely specified except for the values of some parameters. In recent years it has been learned that rank tests, in addition to advantages of simplicity and freedom from parametric assumption, are often more sensitive than the parametric tests for detecting effects of the kind that arise in practical work [97,98].

The practical problem we are concerned with testing is whether there exists a relationship between two factors in a population of business organizations. With each organization are associated two characteristics. To test the hypothesis of independence, that there is no relationship between the two characteristics, a sample of  $n$  subjects is drawn from the population and the values of the two characteristics are obtained for each member of the sample. We then assign rankings to the values for each of the two variables we are studying and from this, a rank correlation coefficient can be calculated. This



is a measure of the correlation (a measure of the degree of association between the variables) that exists between the two sets of ranked data. The equation to calculate the Spearman Rank coefficient of correlation is:

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

where  $r_s$  = coefficient of rank correlation

$n$  = number of paired observations

$d$  = difference between the ranks for each pair of observations.

The study of the power and efficiency of tests of independence is complicated by the difficulty of defining natural classes of alternatives to the hypothesis of independence. Some qualitative results requiring only a concept of positive and negative association are given by Lehmann [98] and by Yanagimoto and Okamoto [99]. In the normal case, natural alternatives to independence are provided by the bivariate normal distributions with nonzero correlation. Some power values in this case are given by Bhattacharyya, Johnson and Neave [101]. See also Kraemer [102]. The Pitman efficiency of the test based on Spearman's coefficient  $r_s$ , as well as that based on the statistic  $B$ , relative to the test based on the correlation coefficient.

$$R = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}}$$

is  $(3/\pi)^2 = .912$ . [Lehmann, 96, p.316].

The correlation coefficient  $r_s$  is a popular estimate of the strength of the association between the two characteristics in the population from which the sample is drawn. Unfortunately, the precise

measure of strength being estimated is somewhat complicated, and difficult to interpret. We shall not consider this aspect any further here. For a detailed discussion of this and related measures see, Kruskal [102] and Kendal [103].

One other basic issue should be raised. The choice of a one-sided test is justified if a priori consideration narrows the possible alternatives to the one-sided class or if there is no interest in detecting the existence of treatment differences. If such justification on prior grounds is not available, one must guard against the temptation to choose the one-sided test because the particular order of the alternatives is suggested by the data. If the choice is made under the influence of the data, the highly significant result becomes illusory, the significance probability meaningless. Since the hypothesis would then also have been rejected if the data had been equally significant in some other direction, the computed significance probability is the probability of only part of the rejection rule. The true significance probability, which has to take account of all the different arrangements for which the hypothesis would also have rejected, is much larger, and the claimed significance is a fraud. To make sure that a look at the data does not in some way influence the choice between the alternative hypothesis, the choice should always be made before the results of the study are available. The choices in this investigation were made prior to the availability of results.

The determination of an acceptance or rejection level for the null hypothesis requires the computation of the standard error of  $r_s$ . When the sample size is greater than 30, the sampling distribution of  $r_s$  is approximately normal with a mean of zero and a standard deviation of

$1/\sqrt{n-1}$ ; thus the standard error of  $r_s$  is:

$$\sigma_{r_s} = \frac{1}{\sqrt{n-1}}$$

and we can use the students "t" distribution table to find the appropriate "t" values for testing hypotheses about the population rank correlation.

The nonparametric rank correlation method has a useful advantage over the parametric correlation method usually used. Suppose we have cases in which one or several very extreme observations exist in the original data. Using the parametric test, the correlation coefficient may not be a good description of the association that exists between two variables because of the very extreme values. Yet extreme observations in a rank correlation test will never produce a large rank difference. The rank correlation method is less sensitive to an extreme value and avoids the unduly large effect on the value of the correlation coefficient.

#### Null and Alternative Hypotheses

We posited three hypotheses:

- I. Stability and Resilience are negatively correlated.
- II. Stability and Business Risk are negatively correlated.
- III. Stability and Rate of Return are positively correlated.

From these three major hypotheses we can logically derive three associated sub-hypotheses:

- IV. Resilience and Business Risk are positively correlated.
- V. Resilience and Rate of Return are negatively correlated.

VI. Business Risk and Rate of Return are negatively correlated.

The null and alternative hypotheses are:

I. Stability and Resilience

$$H_0: r = 0. \quad H_1: r < 0.$$

II. Stability and Business Risk

$$H_0: r = 0. \quad H_1: r < 0.$$

III. Stability and Rate of Return

$$H_0: r = 0. \quad H_1: r > 0.$$

IV. Resilience and Business Risk

$$H_0: r = 0. \quad H_1: r > 0.$$

V. Resilience and Rate of Return

$$H_0: r = 0. \quad H_1: r < 0.$$

VI. Business Risk and Rate of Return

$$H_0: r = 0. \quad H_1: r < 0.$$

### Levels of Significance

Instead of simply reporting the rejection of the hypothesis ( $H$ ) at a given significance level, it is more informative to report the probability under  $H$  of obtaining a value as extreme as, or more extreme than, the observed value. This probability is called the significance probability ( $\frac{\Lambda}{\alpha}$ ) of the observed result.

The significance probability has the important property of showing in a single number, whether or not to reject the hypothesis at any attainable level  $\alpha$ . Suppose that large values of a test statistic ( $R_s$ ) are significant. If  $r$  denotes the observed value of  $R_s$ , the significance probability is then defined as:

$$\frac{\Lambda}{\alpha} = P_H (R_s \geq r).$$

The hypothesis is rejected when  $r > c$  and hence when  $\alpha \geq \frac{\Lambda}{\alpha}$ . The constant  $c$ , the critical value, is conventionally determined so that under  $H$  the probability of getting a value of  $R_s$  greater than or equal to  $c$  is equal to some specified small number  $\alpha$ , the level of significance.

$$P_H(R_s \geq c) = \alpha$$

where the subscript  $H$  indicates that the probability is computed under  $H$ , that is, under the assumption that there is no correlation.

Conversely,  $H$  is accepted for any critical value exceeding  $r$ , and hence for any attainable significance level  $\alpha$  which is less than  $\frac{\Lambda}{\alpha}$ . Because of this property, when reporting the outcome of a statistical test, one should state not only whether the hypothesis was accepted or rejected at a given significance level; one should also publish the significance probability, thus enabling others to perform the test at a level of their own choice. The level of significance chosen for this research is 5%. The empirically derived significance probabilities are shown in the findings section of this research report.

## CHAPTER IV

### FINDINGS

This chapter is organized into two sections; (1) scattergrams of the relationships among stability, resilience, business risk and rates of return are presented with the aggregated individual firms comprising the first group of results and with industries comprising the second group of results. A summary of the tests of the statistical significance of the over-all results for all of the six hypotheses relating to the individual firms and the six hypotheses relating to the thirty industries are presented in this chapter in Figures 24 and 25.

Tables of the surrogate numerical values for stability, resilience, business risk and rates of return for each of the 367 different firms and for each of the 30 different industries are listed in Appendices C and D.

The original raw data was extracted from the COMPUSTAT II tapes for the individual firms and for the industries. Appendix B is a listing of the computer software program written in the FORTRAN language for the selection, extraction, computation and analysis of the raw data collected from the ten year period, 1968-1977.

The computer programs are included in this report to provide a method of verification of the validity of the computer produced results and are offered for use by any reader who may wish to extend or modify the approach used in this paper without the necessity of recreating the software to support further analysis.

### SCATTERGRAMS

The following twelve scattergrams were produced using a DECWRITER terminal in conjunction with a Hewlett Packard HP 2000 computer. The software packages employed in producing the scattergrams and in calculating the Spearman Rank Correlation Coefficients and the empirical levels of significance of the rank correlation coefficients were derived from the Hewlett Packard Statistical Programs for the Social Sciences as they exist in the library of computer programs supported by the Computer Service Center at Idaho State University.

The specific program utilized to produce the bivariate plots or scattergrams was the "LEAST SQUARES" program. "SPEARMAN CORR" was the specific program employed to calculate the Spearman Rank Correlation Coefficients and levels of significance.

### FIRMS

#### Stability versus Business Risk - Firms

Figure 8 is a bivariate graph of stability on business risk. The resultant curve appears visually to resemble a negative exponential or monotonically decreasing function. This supports our first alternative hypothesis of a negative correlation between stability and business risk.

The Spearman Rank Correlation Coefficient for this bivariate relationship was found to be -0.8670. This is a relatively high degree of correlation. The empirical level of significance calculated for this correlation coefficient was almost 0.0000.

At the 0.05 level of significance, chosen as our criteria for

STABILITY & RESILIENCE IN BUSINESS SYSTEMS  
 FILE: FIRMS (CREATION DATE = 08/21/79)  
 GRAPH OF STABILITY ON RISK

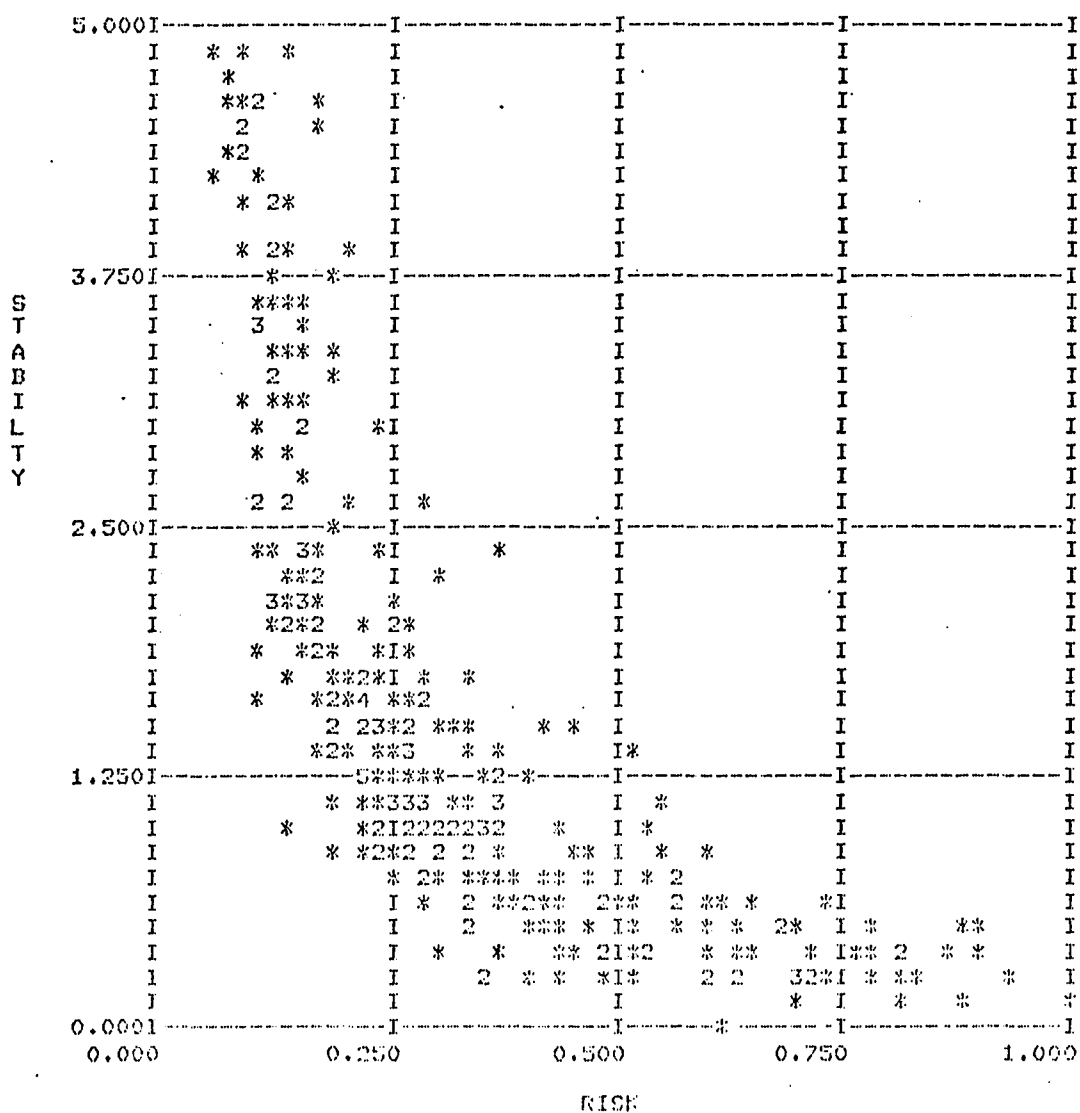


Figure 8. Stability on business risk - firms.





accepting or rejecting the null hypothesis, we can easily reject the null hypothesis that there is no correlation between stability and business risk. We would also reject the null hypothesis if we had chosen a more stringent criteria on such as a 0.01 level of significance. The actual empirical level of significance as calculated was less than 0.00005. The computer program only provided four decimal places of significant digits.

#### Stability versus Rate of Return - Firms

Figure 9 is a bivariate graph of stability on rate of return. Although points on the graph are more dispersed than those seen in Figure 8, there is a visual suggestion of a positive slope to the relationship between the two variables.

The Spearman Rank Correlation Coefficient was found to be +0.6058 which represents a reasonably high degree of positive correlation. The empirically derived level of significance was 0.0000 to four decimal places. This means that we again can reject the null hypothesis that there is no correlation between stability and rate of return for the aggregated firms. We can thus accept the alternate hypothesis that there is a statistically significant degree of positive correlation between stability and rate of return. Again, we could have rejected the null hypotheses even if we had chosen a 0.01 level of significance as our criterion.

#### Stability versus Resilience - Firms

Figure 10 is a bivariate graph of stability on resilience. The resultant curve appears to suggest (visually) a possible negative

DATA FILE FOR STAB V RES FIRMS

FILE: FIRMS (CREATION DATE = 08/21/79)

GRAPH OF STABILITY ON RESILNCE

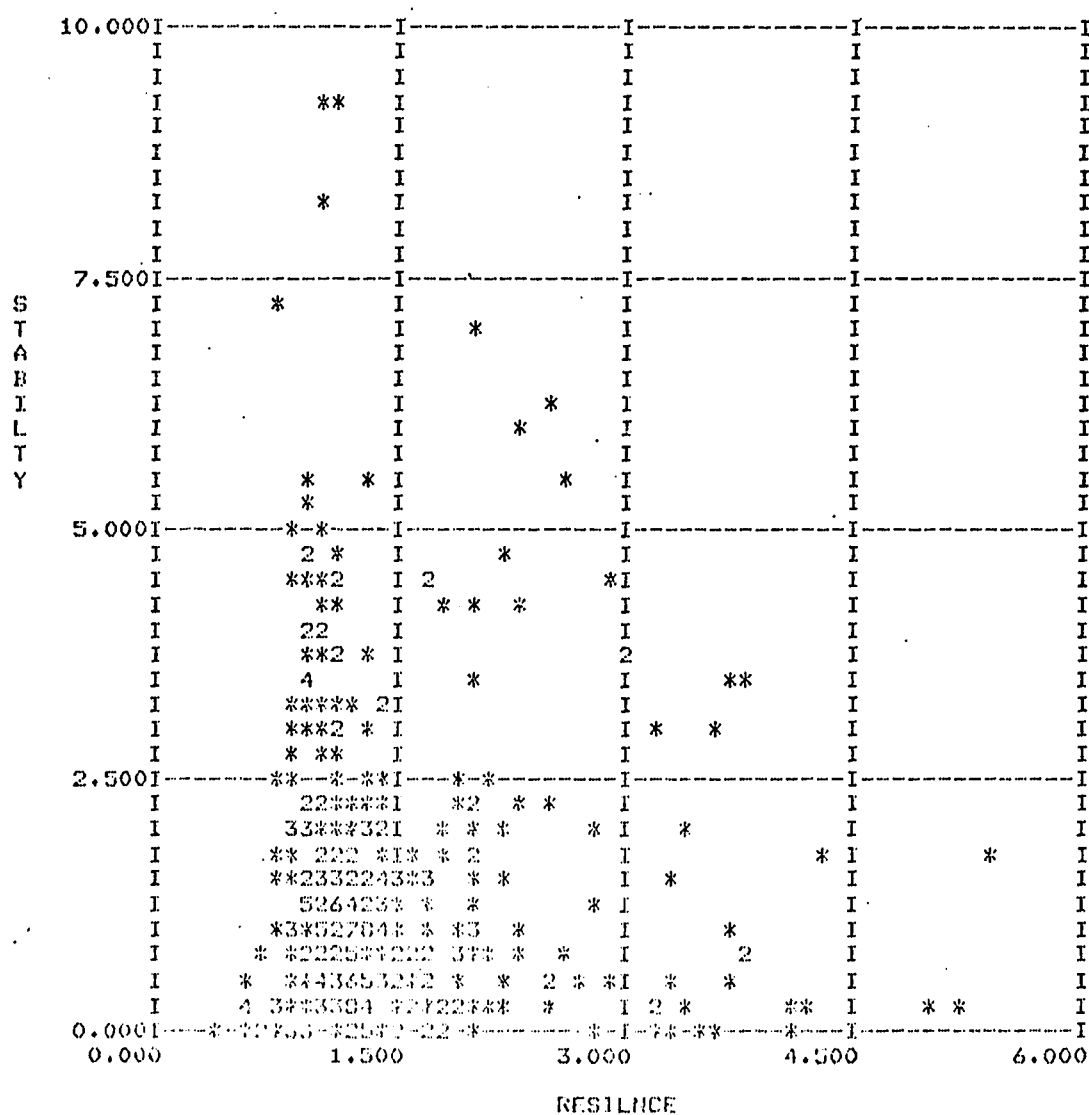


Figure 10. Stability on resilience - firms.

STABILITY & RESILIENCE IN BUSINESS SYSTEMS  
 FILE: FIRMS (CREATION DATE = 08/21/79)  
 GRAPH OF RESILIENCE ON RISK

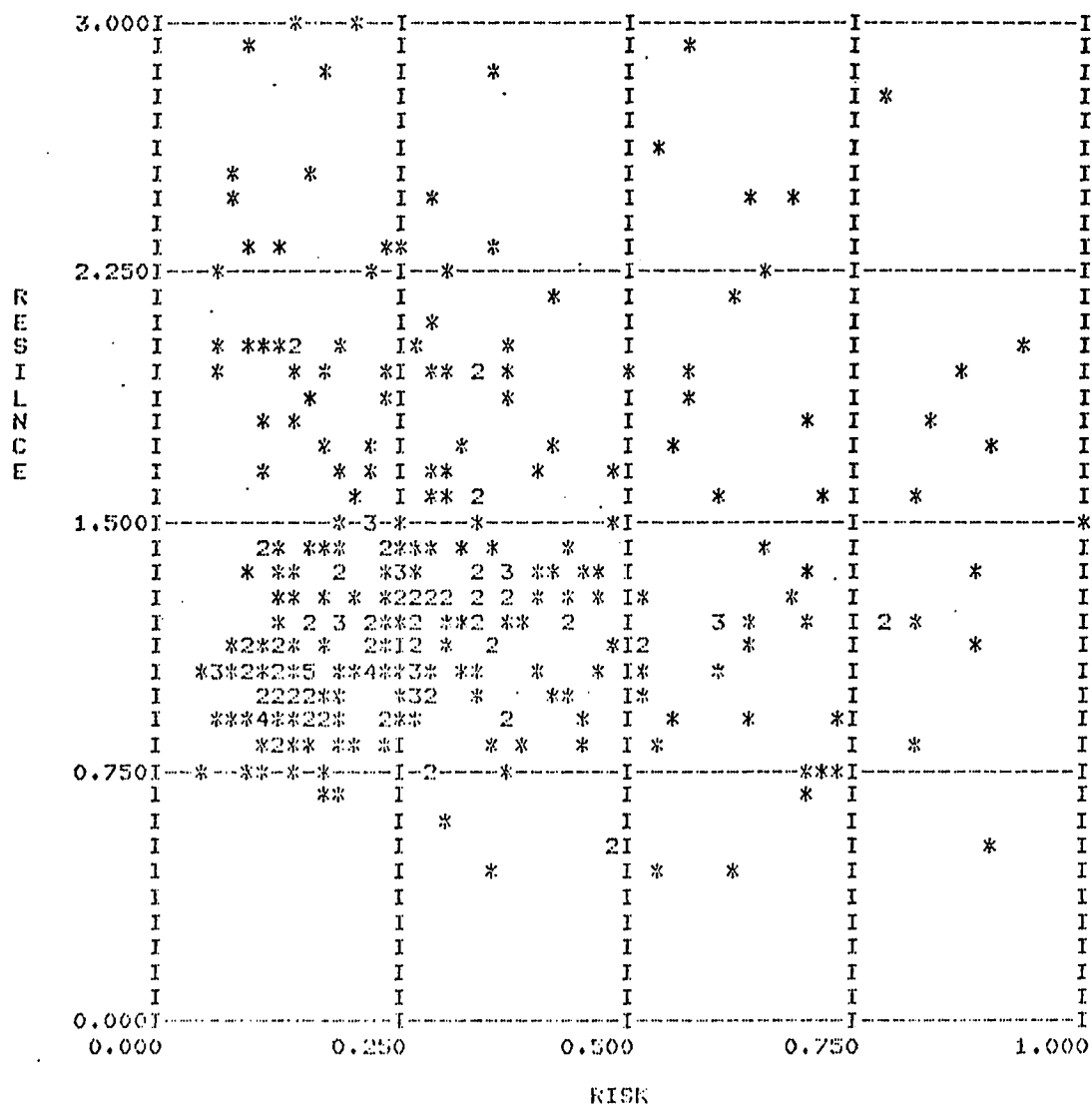


Figure 11. Resilience on business risk - firms.

correlation between the two variables, even though the major portion of the plotted points appear in the lower left corner of the graph.

The Spearman Rank Correlation Coefficient found for this bivariate relationship was  $-0.0725$  indicating a weak degree of negative correlation. The empirically derived level of significance was calculated to be  $0.0808$ . At the  $0.05$  level of significance (our criterion), we cannot reject the null hypothesis that there is no correlation between the two variables, stability and resilience for the aggregated individual firms.

If however, we are willing to accept type I errors (rejecting a true hypothesis) of slightly more than eight percent (specifically, more than  $0.0808$ ), then we could reject the null hypothesis at a level of significance of greater than  $0.0808$  and we could accept the alternate hypothesis that there is a negatively correlated degree of association between stability and resilience that is statistically significant.

#### Resilience versus Business Risk - Firms

Figure 11 is a bivariate graph of resilience on business risk. The pattern indicates little association between the variables, even a close visual perusal does not give an inkling of an apparent correlation. In this particular case, a visual judgment would be misleading.

Computer analysis of this graph produced a Spearman Rank Correlation Coefficient of  $+0.1346$  which demonstrates a higher degree of correlation than was found for stability versus resilience. The calculated level of significance was  $0.0048$  which is less than our criterion of  $0.05$  and we may then reject the null hypothesis that there is no

STABILITY & RESILIENCE IN BUSINESS SYSTEMS  
 FILE: FIRMS (CREATION DATE = 08/21/79)  
 GRAPH OF RETURN ON RESILNCE

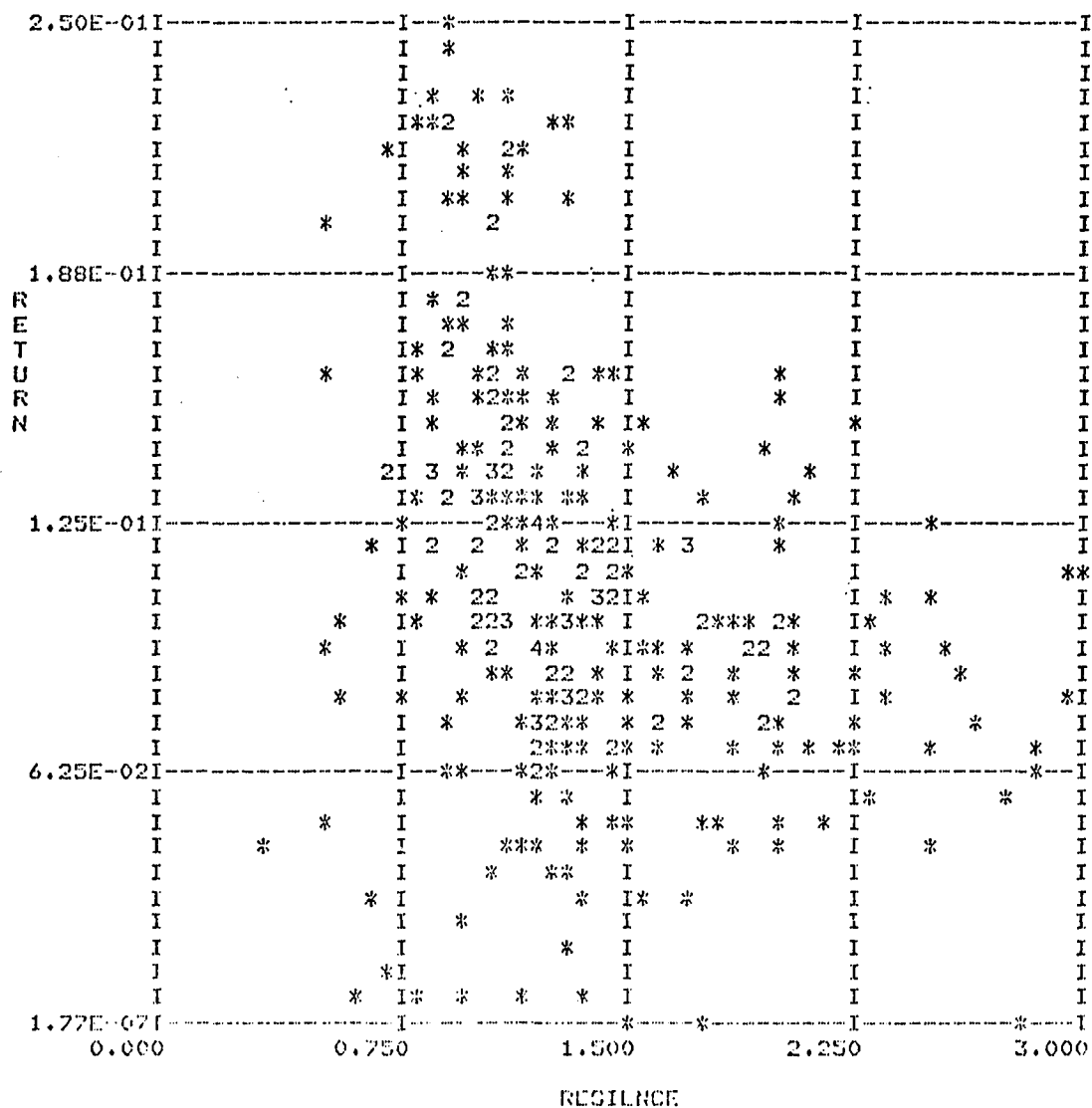


Figure 12. Rate of return on resilience - firms.

STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES - HP VERSION 4.04

FILE: FIRMS (CREATION DATE = 08/21/79)

GRAPH OF RISK ON RETURN

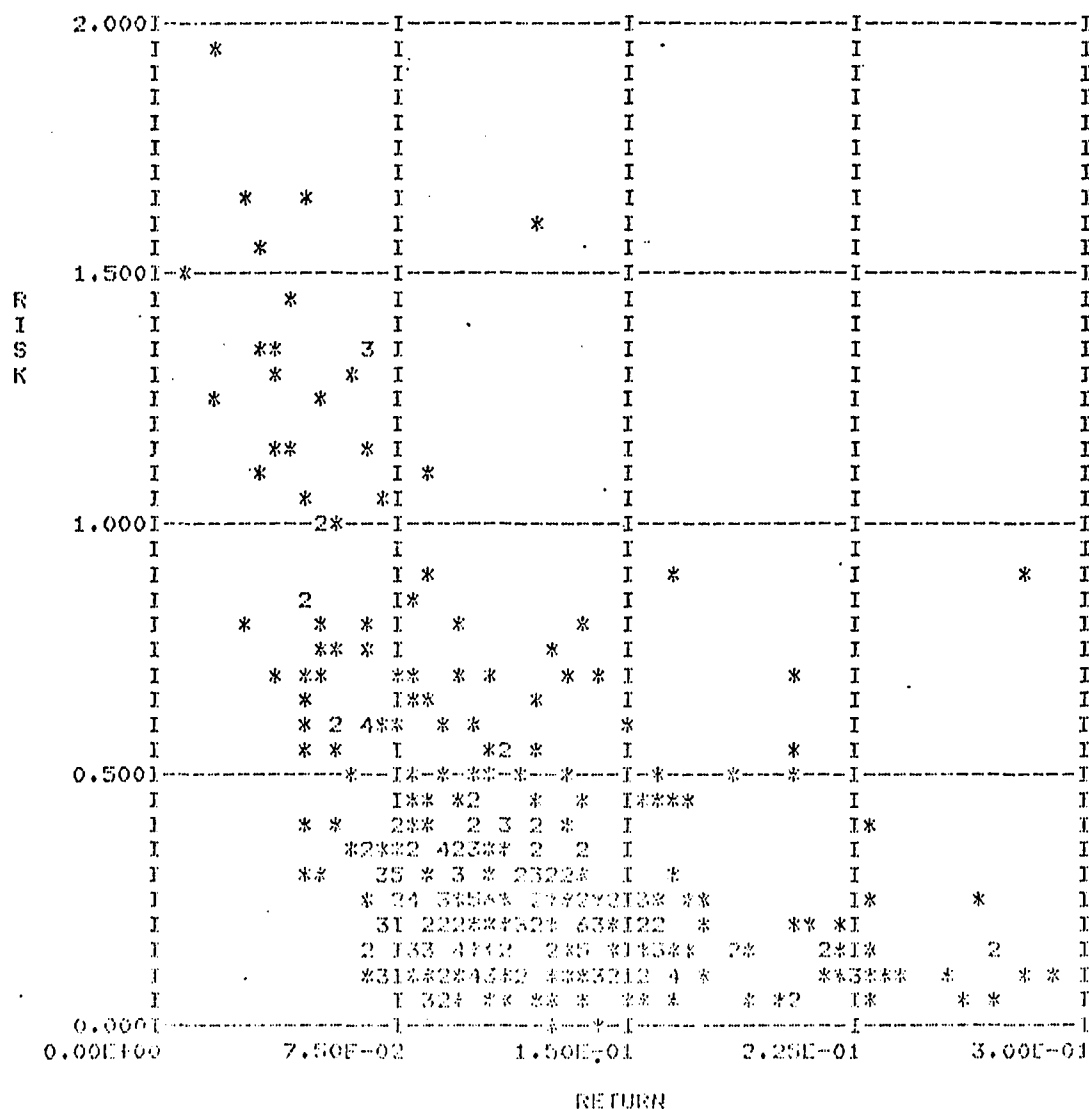


Figure 13. Business risk on rate of return - firms.

correlation between resilience and business risk. We may accept the alternate hypothesis that there is a statistically significant degree of positive correlation between resilience and business risk. In spite of the apparent random pattern of this graph, we could also have rejected the null hypothesis with a more stringent level of significance such as 0.01.

#### Resilience versus Rate of Return - Firms

Figure 12 is a bivariate graph of rate of return on resilience. The pattern of points is suggestive of a negative correlation between the two variables. This is confirmed by the Spearman Rank Correlation Coefficient of -0.4419 as computed by the statistical software routine.

The empirical level of significance for this correlation coefficient was 0.0000 to the nearest four decimal places. On this basis, we reject the null hypothesis that there is no correlation between the variables resilience and rate of return for the 367 aggregated individual firms for the decade 1968 through 1977.

We can accept the alternate hypothesis that there is a statistically significant degree of negative correlation between resilience and rate of return for this data. Again, we could have rejected the null hypothesis even if we had chosen a more stringent level of significance as our criterion such as 0.01.

#### Risk versus Return - Firms

Figure 13 is a bivariate plot of business risk on rate of return. This time the pattern is visually obvious, resembling a negative exponential or monotonically decreasing function as we saw in Figure 8



which was a bivariate plot of business risk and stability.

The calculated value of the Spearman Rank Correlation Coefficient was -0.5223 indicating a reasonably high degree of negative correlation between the two variables. The empirically derived level of significance for this measure of correlation was again 0.0000 to four decimal places.

With our 0.05 level of significance as our criterion, we can again reject the null hypothesis that there is no correlation between business risk and rate of return for the firms tested. We accept the alternate hypothesis that there is a statistically significant degree of negative correlation between business risk and rate of return for the aggregated firms as tested for the decade 1968-1977.

#### Firms - Hypothesis Tests Summary

Our investigation included the testing of four different attributes considered as properties of business organizations. Correlation analysis, using non-parametric procedures, was selected as the most appropriate way to test our hypothesis rather than regression analysis which implies a dependence relationship, an approach we felt was not justified since we do not have sufficient information to determine the direction of dependency, nor do we have a sufficiently rich model to identify the network of all the factors involved in creating causal explanations.

Four things, taken two at a time, yield six different combinations. The six bivariate combinations naturally suggested the six different hypotheses posited. The statistical tests allowed us to reject five of the six null hypotheses at the 0.05 level of significance.

We also noted that we could reject the one hypothesis (not rejected at the 0.05 level) if we were willing to chance a type I error of slightly more than 0.0808.

Considering the difficulty of attempting to quantify the systemic properties posited, and considering the multiplicity of factors that no doubt contribute to each of these properties, it is somewhat surprising and gratifying that we found statistically significant support for our hypotheses.

## INDUSTRIES

### Stability versus Business Risk - Industry

Figure 14 is a bivariate graph of stability on business risk for the thirty industries tested. The resultant curve visually appears to be a monotonically decreasing function, resembling a negative exponential curve. Our subjective, visual deduction is strongly supported by the calculated Spearman Rank Correlation Coefficient of -0.9528 which demonstrates a high degree of correlation between stability and business risk when the test data are arranged by industry.

The empirical level of significance found was 0.0000 to four decimal places. We can easily reject the null hypothesis that there is no correlation between the two variables and we can accept the alternate hypothesis that there is a statistically significant degree of negative association between stability and business risk for the industries tested. It can be noted that the correlation coefficient for these two variables when measured for the industries was higher than when we measured for the individual firms.



Stability versus Rate of Return - Industry

Figure 15 is a bivariate plot of stability on rate of return by industry. The pattern suggests a positive linear relationship between the two variables. The Spearman Rank Correlation Coefficient was computed to be 0.5556 which demonstrates a strong degree of positive correlation between stability and rate of return.

The empirical level of significance was calculated to be 0.0008. This readily allows us to reject the null hypothesis that there is no correlation between the two variables and therefore allows us to accept the alternate hypothesis that there is a statistically significant degree of positive correlation between stability and rate of return for the industries tested during the period of 1968 through 1977.

Stability versus Resilience - Industry

Figure 16 is a bivariate graph of stability on resilience by industry classification. The pattern visually suggests a moderate degree of negative correlation between the two variables.

The Spearman Rank Correlation Coefficient found for this relationship was -0.3451. This can be compared to the value of -0.0725 which was the corresponding coefficient for stability versus resilience determined for the firms treated individually. There is a much stronger degree of correlation between these variables for the thirty industry classes tested than for the individual firms.

The empirical level of significance calculated for this relationship between stability and resilience for industries was 0.0295. In

## DATA FILE FOR STAB V RES INDUSTRY

FILE: INDUST (CREATION DATE = 08/20/79)

## GRAPH OF STABILITY ON RETURN

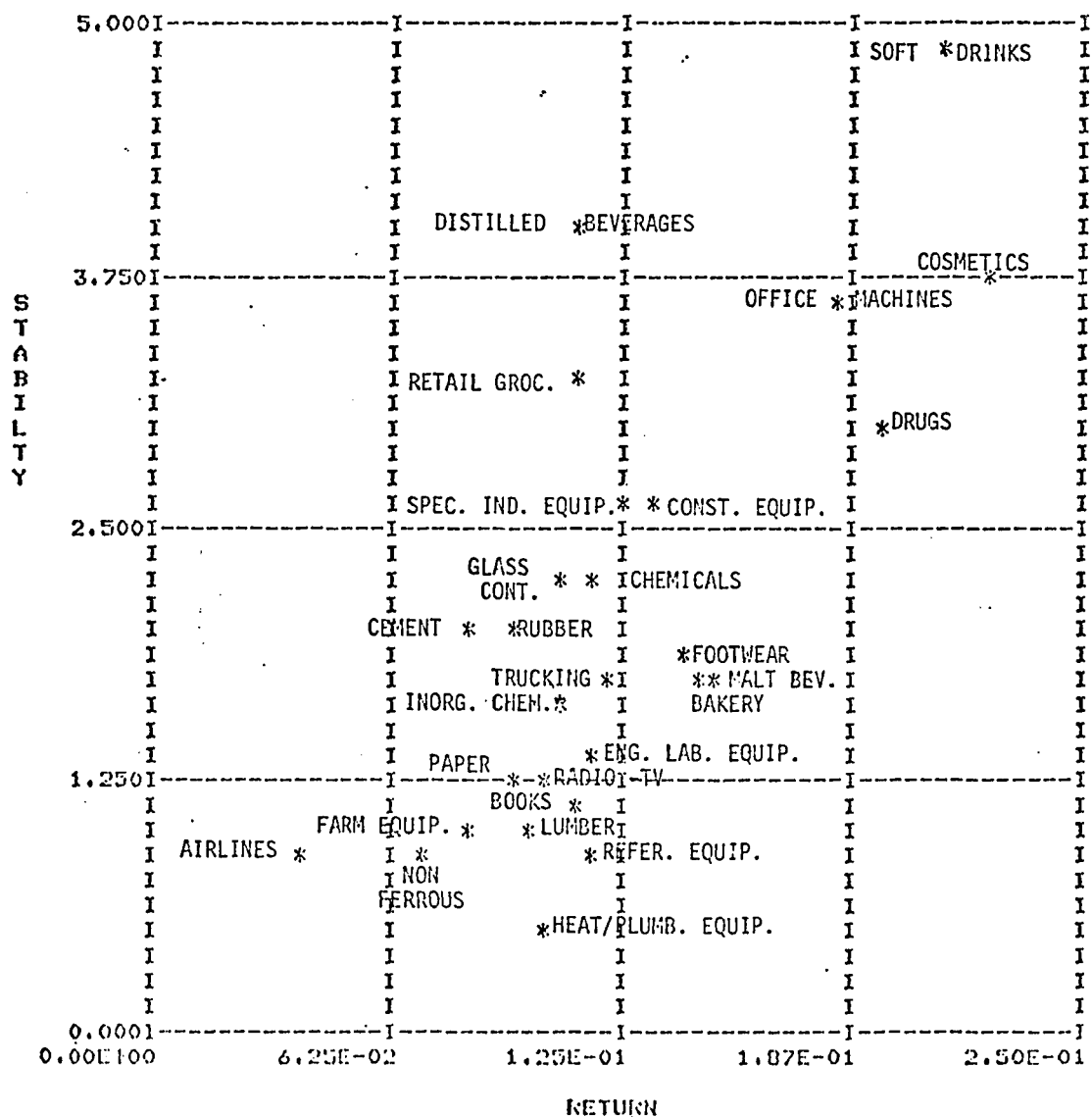


Figure 15. Stability on rate of return - industry.

## STABILITY &amp; RESILIENCE IN BUSINESS - INDUSTRY

FILE: INDUST (CREATION DATE = 08/20/79)

GRAPH OF STABILITY ON RESILIENCE

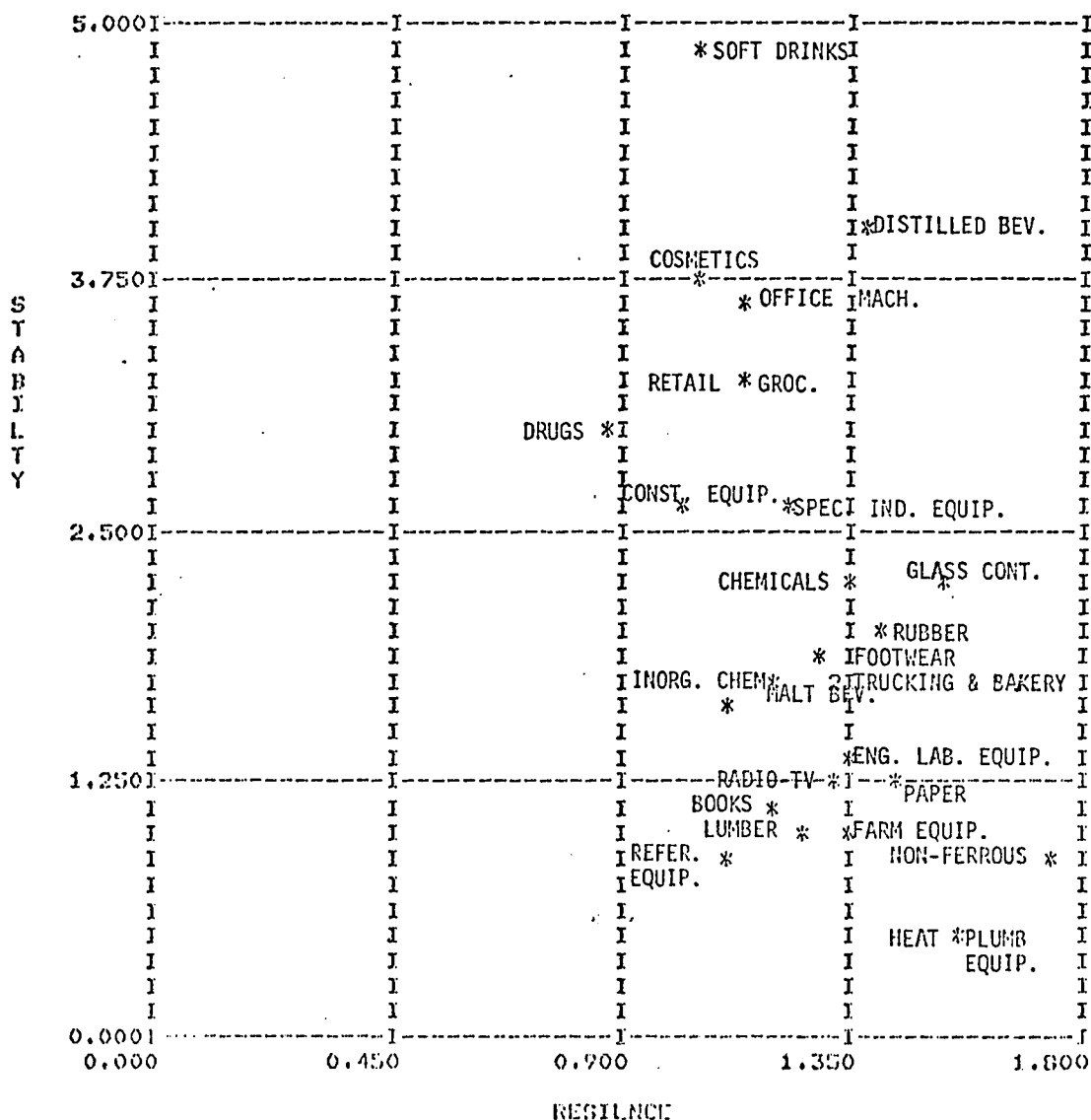


Figure 16. Stability on resilience - industry.

comparing this to our criterion of 0.05 level of significance, we can readily reject the null hypothesis that there is no correlation between the two variables and we can accept the alternate hypothesis that there is a statistically significant degree of negative correlation between stability and resilience for the industries tested for the decade 1968 through 1977.

#### Resilience versus Business Risk - Industry

Figure 17 is a bivariate plot of resilience on business risk. The patterns of points indicates a tendency to a positive sloping relationship. A value of 0.3548 was determined for the Spearman Rank Correlation Coefficient. This indicates a moderate degree of positive correlation between the two variables.

The level of significance calculated for this degree of correlation was found to be 0.0259. This allows us to reject the null hypothesis that there is no correlation between the two variables using the 0.05 level as our criterion. We can accept the alternate hypothesis that there is a statistically significant degree of negative correlation between rate of return and resilience for the industries tested.

#### Business Risk versus Rate of Return - Industry

Figure 19 is a bivariate graph of risk on rate of return for the thirty industries. We again perceive a pattern suggesting a negative correlation between the two variables.

The Spearman Rank Correlation Coefficient is -0.5688 demonstrating a strong degree of negative correlation between the two variables. The

## STABILITY &amp; RESILIENCE IN BUSINESS - INDUSTRY

FILE: INDUST (CREATION DATE = 08/20/79)

GRAPH OF RESILNCE ON RISK

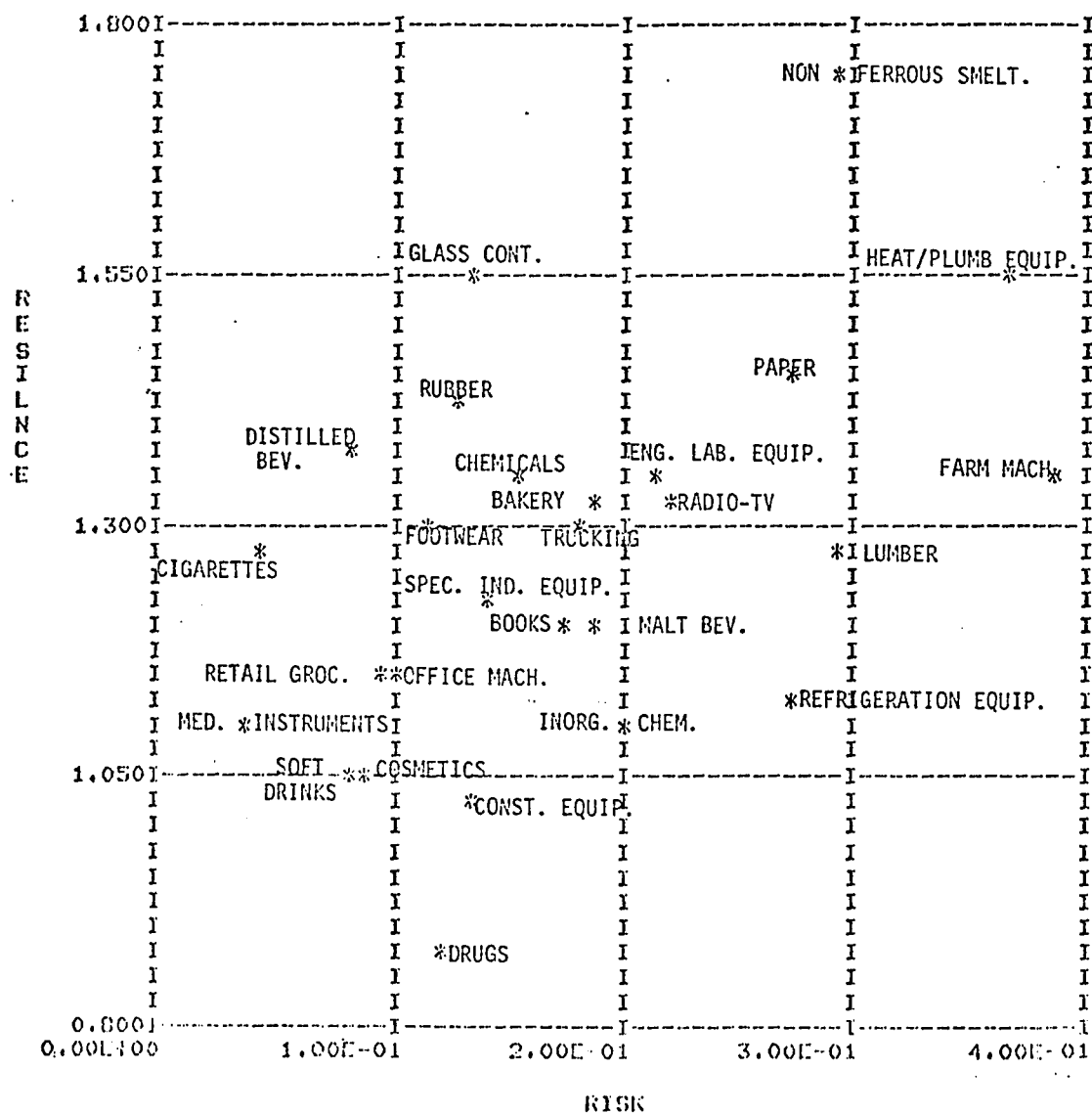


Figure 17. Resilience on business risk - industry.



## STABILITY &amp; RESILIENCE IN BUSINESS - INDUSTRY

FILE: INDUSTY (CREATION DATE = 08/20/79)

GRAPH OF RETURN ON RESILIENCE

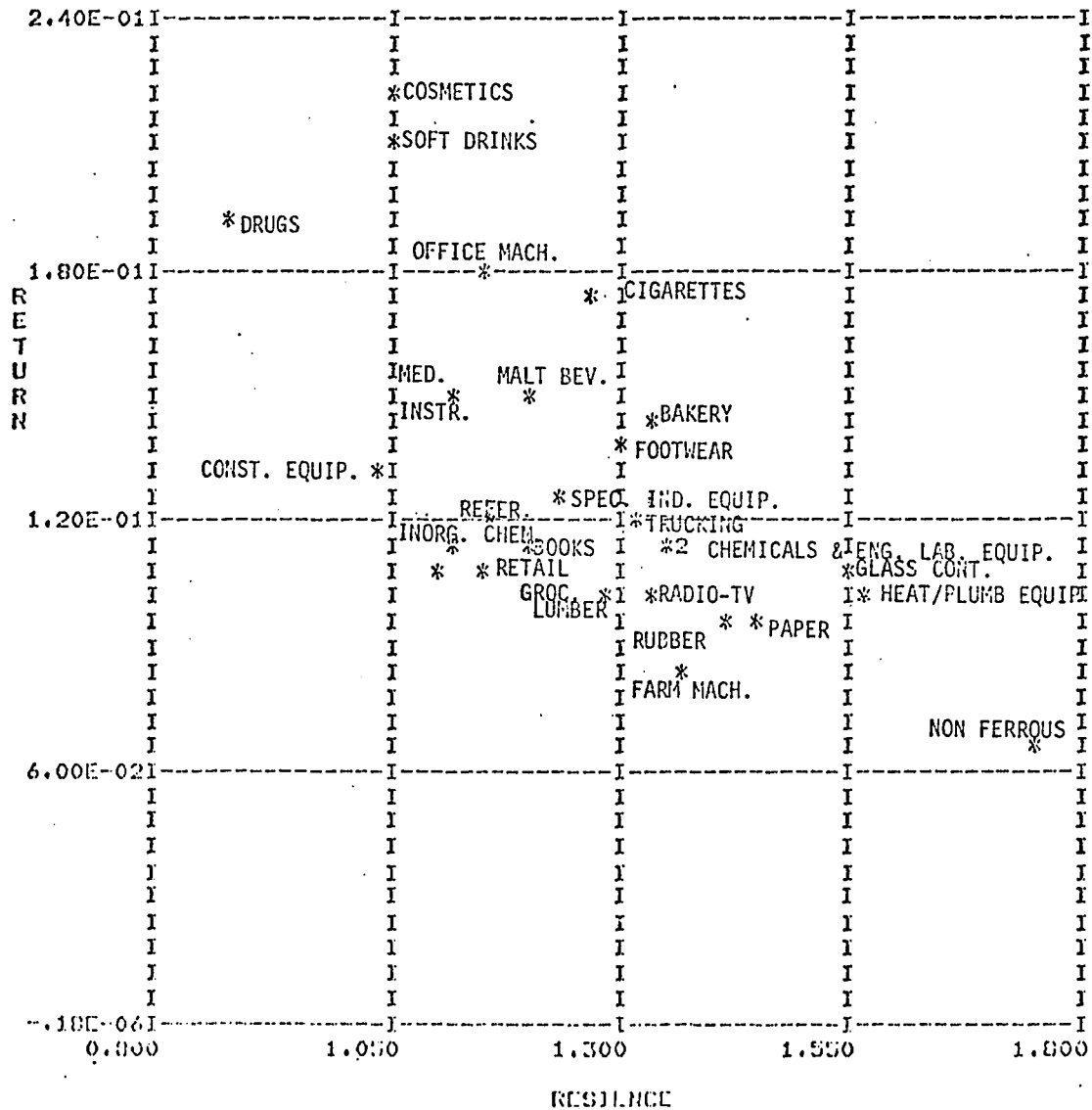


Figure 18. Rate of return on resilience - industry.

## DATA FILE FOR STAD V RES INDUSTRY

FILE: INDUST (CREATION DATE = 08/20/79)

## GRAPH OF RISK ON RETURN

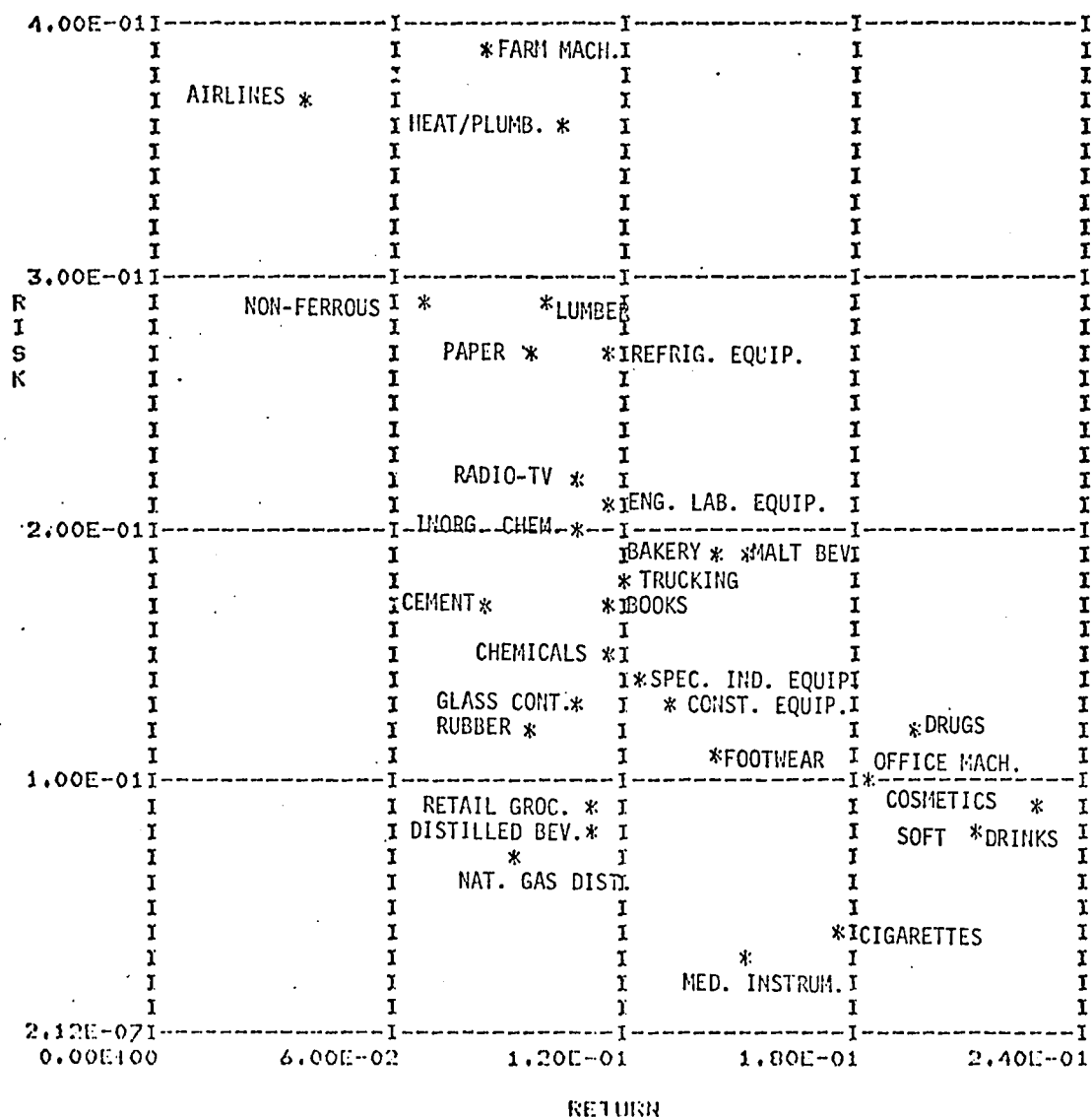


Figure 19. Business risk on rate of return - industry.

empirical level of significance was calculated to be 0.0006. We can easily reject the null hypothesis that there is no correlation between the two variables at both the 0.05 level of significance. We can accept the alternate hypothesis that there is a statistically significant degree of negative correlation between business risk and rate of return for the thirty industries tested during the decade 1968 through 1977.

#### Industry - Hypothesis Tests Summary

Using the Spearman Rank Correlation non-parametric model to test our hypotheses, we were able to reject all six of our null hypotheses and accept each of the alternate hypotheses thus supporting the aims of this research report.

#### Scattergrams - Ranges

It must be noted that each of the scattergrams do not include several extreme values. These extreme values were excluded in order to expand the range of the plots to facilitate a visual appreciation of the patterns presented by the relationships between each pair of variables. Although extreme values were excluded from the scattergrams, these were included in the computation of both the Spearman Rank Correlation Coefficients and their associated levels of significance. The actual values for each of the surrogates (stability, resilience, business risk and rate of return) for the 367 individual firms and for the 30 industries are listed respectively on Appendices C and D.

### STATISTICAL TEST SUMMARY

A summary of the statistical tests for the twelve different hypotheses are presented in Figures 20, 21, 22, and 23. This format should facilitate a comparison of the results and highlight the relative values found for the different hypotheses.

Figure 20 presents the upper right half of a symmetrical matrix of the tabular values for stability, resilience, business risk and rate of return. In each box of the matrix, the first value is the Spearman Rank Correlation Coefficient. The second value, following the "/" is the empirical level of significance found for the correlation coefficient.

	Resilience	Business Risk	Rate of Return
Stability	-.0725/.0808	-.8670/.0000	+.6058/.0000
Resilience		+.1346/.0048	-.4419/.0000
Business Risk			-.5223/.0000

Figure 20. Matrix of Spearman Rank Correlation Coefficients and levels of significance for 367 individual firms.

Figure 21 presents the industry version of the same relationships presented in Figure 20 for the individual firms.

	Resilience	Business Risk	Rate of Return
Stability	-.3451/.0295	-.9528/.0000	+.5556/.0008
Resilience		+.3548/.0259	-.7802/.0000
Business Risk			-.5688/.0006

Figure 21. Matrix of Spearman Rank Correlation Coefficients and levels of significance for 30 industries.

As a matter of curiosity and for a comparison, a Pearson Correlation Coefficient was calculated for each bivariate relationship for both firms and for industries. Although we cannot, as previously noted, assume equal but unknown population variances (which is required for a parametric test such as Pearsons Correlation Coefficient), we have performed the Pearson Correlation test and present the findings as a matter of record.

The presence of extreme values and the obvious fact (at least visually) that the bivariate plots are not all linear would lead us to suspect that we would not find as high a degree of correlation as we did using the Spearman Rank Correlation model, nor would we expect to find a level of significance that allows rejection of the null hypotheses at a criterion of 0.05 as the rejection level of significance.

Figure 22 follows the same format as was presented in Figures 20 and 21 with the correlation coefficient present first followed by the empirically derived level of significance.

	Resilience	Business Risk	Rate of Return
Stability	-.0639/.1097	-.0569/.1383	+.4327/.0000
Resilience		+.1367/.2450	-.3446/.0000
Business Risk			-.0762/.0705

Figure 22. Matrix of Pearson Correlation Coefficients and levels of significance for 367 individual firms.

Figure 23 also uses the same format as Figure 22 with each box containing first the Pearson Correlation coefficient followed by the calculated level of significance.

	Resilience	Business Risk	Rate of Return
Stability	-.1533/.2119	-.6830/.0000	+.4173/.0104
Resilience		+.3810/.0180	-.6796/.0000
Business Risk			-.6132/.0002

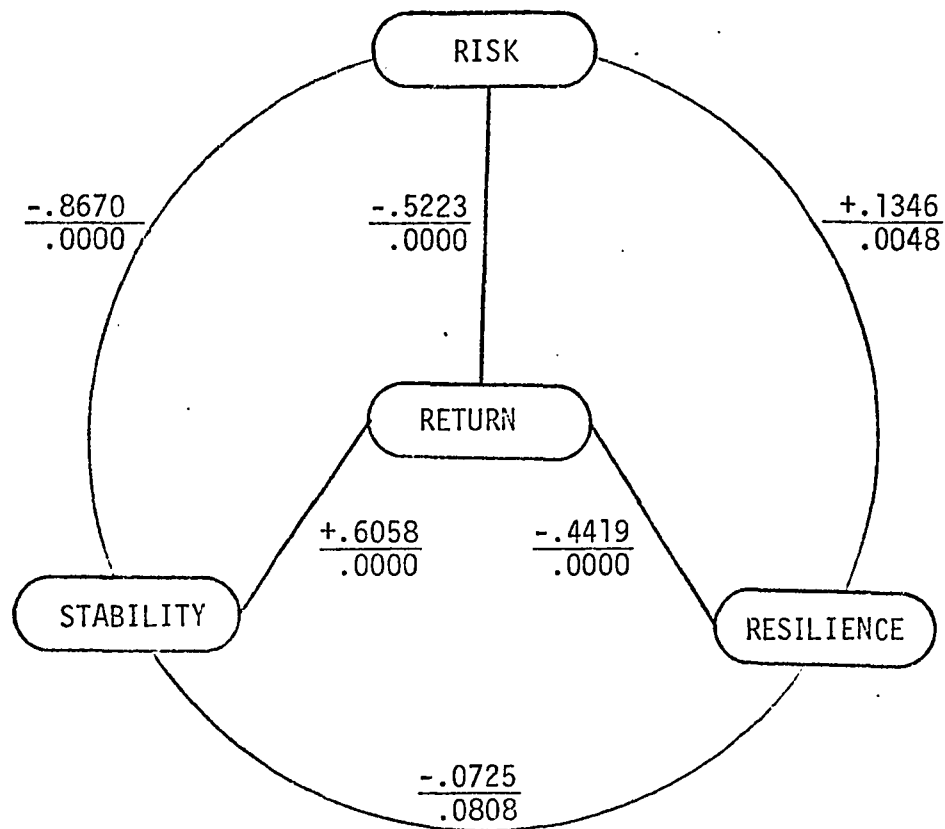
Figure 23. Matrix of Pearson Correlation coefficients and levels of significance for 30 industries.

It is of interest to note that the direction of the correlations for each of the twelve hypotheses does agree with this paper's posited direction of correlation. We can also note that we could reject all but one of the null hypotheses for industries using the Pearson model and a 0.05 level of significance as our criterion.

At the firm level, the relationships are not as well pronounced. If we chose to be somewhat more liberal in our choice of a criterion

higher than 0.05, we could reject most of the null hypotheses. However, our research rests upon the non-parametric Spearman Rank Correlation model, not the parametric Pearson Correlation model. We can conclude that we have substantiated our original claims of statistically significant correlation among our chosen surrogates.

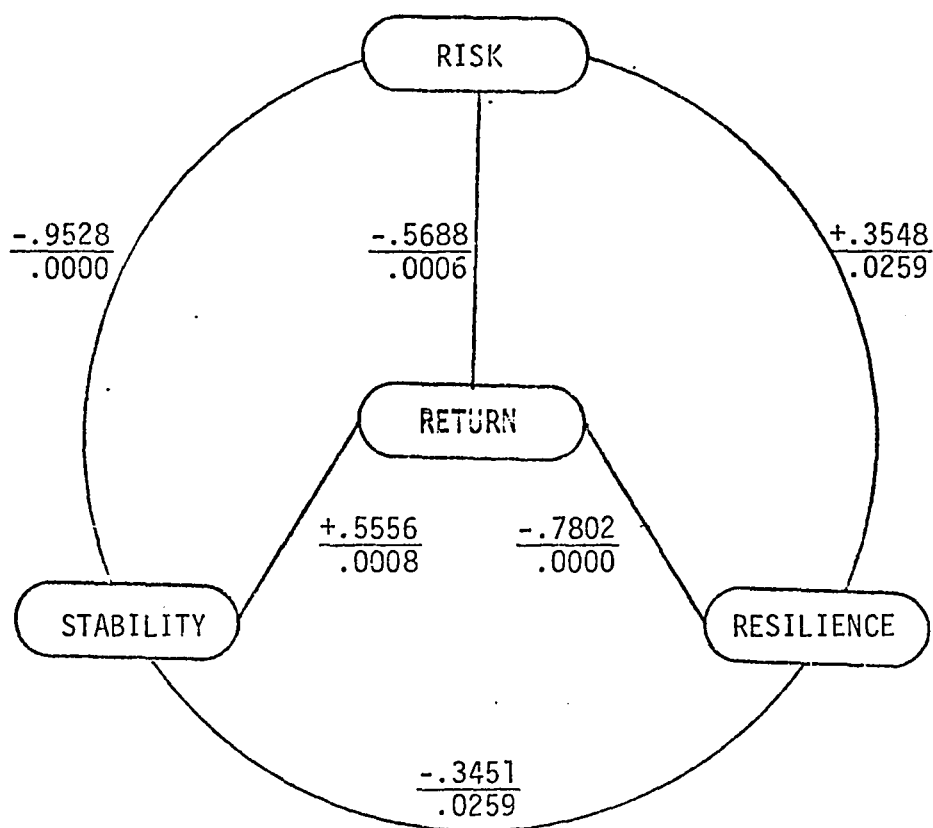
Figures 24 and 25 are graphical summaries of the hypotheses tests respectively for individual firms and for industries. Each figure depicts the directional relationship and strength of the relationship between each pair-wise combination. The values on the lines connecting the parameters represent respectively the Spearman Rank Correlation coefficient and the level of significance of the statistical test.



CODE =  $\frac{\text{correlation coefficient}}{\text{level of significance}}$

Figure 24. Summary of hypotheses tests for firms.





CODE =  $\frac{\text{correlation coefficient}}{\text{level of significance}}$

Figure 25. Summary of hypotheses tests for industries.

## CHAPTER V

### CONCLUSIONS, LIMITATIONS, FURTHER RESEARCH

#### CONCLUSIONS

##### Goals

The goals of this research study have been met. In the original statement of the research problem, four goals were established. The first of these was to integrate the concepts of rate of return and business risk from financial management theory with the concepts of steady state, equilibrium, stability and resilience from general systems theory. The postulated integration of these concepts was illustrated in Figure 1. This integration required the development of conceptual definitions of each of these parameters based on a review of the literature.

A review of the financial literature indicated a consensus of opinion among financial scholars that maximization of the wealth of the corporation is the goal of financial management, [3,5,6]. This consensus extended to the validity of employing the rate of return concept and the uncertainty about the rate of return, as a measure of risk, as the appropriate parameters to be balanced in making the financial decisions that lead to maximizing the wealth of the firm.

A review of the systems literature suggested that the term, steady state implies the maintenance of some aspect of a system-environment relationship. Two different approaches to the maintenance of

this relationship were extracted from the review of the literature. In the first approach, maintenance of the steady state is accomplished through the preservation of the system's given form, organization or behavior. In the second approach, maintenance of the steady state is accomplished through a change in the system's given form, organization or behavior. We refer to these two methods of maintaining the system-environment steady state as stability and resilience respectively.

The earning power of a firm, represented by the firm's rate of return, is one aspect of a system-environment financial relationship. Maintenance of this earning power is maintenance of a financial steady state aspect of the firm.

The second goal was to formulate hypotheses about the relationship that exists among these parameters. The six hypotheses for firms and a duplicate set of six hypotheses for industries were illustrated in Figures 24 and 25 respectively.

The hypotheses for individual firms and for firms aggregated into their respective industries are also illustrated in Figure 1 where the symbolic signs, + and -, indicate the direction of the correlation relationship postulated between each pair of parameters.

The third goal was to construct quantifiable surrogates to represent each of the above parameters. The criteria for constructing these surrogates are that they (1) incorporate characteristics of the system-environment relationship, (2) reflect the dynamic nature of these characteristics, (3) facilitate the comparison among business systems by providing a common or normalized base that takes into account the relative size of the different firms and industries and the

relative size of the fluctuations in the parameters, (5) can be expressed in terms of the financial operating characteristics of the business system, (6) are capable of being quantified and (7) are amenable to statistical testing.

As stated previously, there was a consensus of opinion among financial scholars as to the validity of employing the rate of return concept and the uncertainty about the rate of return (risk) as the appropriate parameters to be balanced in making financial decisions.

There was less consensus as to the specific surrogates to be used to represent the concepts of rate of return and business risk. The conclusion reached in this research report was to use the ten-year mean ratio of EBIT/TA (earnings before interest and taxes/total assets) as a surrogate for the rate of return or financial steady state of the business system. This surrogate has strong support from many financial scholars, [3,6,30,31,33].

The surrogate selected to represent business risk was the relative variation in the rate of return, i.e., the coefficient of variation of the rate of return surrogate over time. This surrogate is supported explicitly or implicitly by some of the financial scholars, [6,30,31,33]. The arguments supporting these choices are delineated in the initial part of Chapter II.

A review of the systems literature indicates that most systems writers would agree that stability and resilience describe two different phenomena that contribute to the preservation of the steady state system-environment relationship.

Stability was defined as maintenance of the steady state rate of return without significant changes in the system's financial structure

while subject to small or temporary environmental disturbances. The surrogate constructed to represent stability was the ratio of relative fluctuations in sales (coefficient of variation of sales) to the relative fluctuations in the rate of return (coefficient of variation in EBIT/TA over the ten year period of the study).

Resilience was defined as the maintenance of the steady state rate of return through changes in the system's financial structure when the system is subject to large or permanent disturbances that exceed the ability of the firm to respond successfully without a change in the financial structure of the system. The surrogate selected to represent resilience was the ratio of relative fluctuations in sales to relative fluctuations in invested capital.

The fourth goal was to select an appropriate statistical methodology to test the hypotheses. For the reasons presented in the methodology section of this report, the Spearman Rank Correlation coefficient was chosen from the non-parametric category of testing techniques. The four parameters; rate of return, business risk, stability and resilience were empirically quantified for each of the 367 individual firms and for each of the 30 industries for the time period 1968 through 1977.

### Findings

Possible explanations for the relationships determined empirically are discussed for firms and industries for each pair-wise combination of parameters.

The scattergrams of stability on risk (Figures 8 and 14) for both individual firms and for industries indicate a hyperbolic function with

the origin at the intersection of both axes. This relationship should not surprise us as it is implicit in our definition of the terms stability and business risk. If we examine the definition of stability, we find that it equals the ratio of relative sales fluctuations to relative rate of return fluctuations or the ratio of sales fluctuations to the risk surrogate. The form of this definitional equation might lead us to suspect a negative correlation between stability and risk, however; this equation does not inherently require such a relationship since  $CV_{\text{sales}}$  and risk are not independent variables, a point made in our discussion of risk in the financial management section of this report.

Our next set of scattergrams (Figures 9 and 15) depict the relationship between stability and rate of return respectively for both individual firms and for industries. The pattern of points suggests a positively sloped linear relationship. In this bivariate plot, there is no implied mathematical relationship. The implication in this set of graphs is that those firms or industries that maintain a relative uniform rate of return over time, in spite of sales fluctuations, tend to achieve a higher rate of return on the average. It can be posited that this is due to the control exercised by the organizations over their internal resources and mode of operation and their interface with their environments as was discussed in our review of the literature wherein Thompson [61] and Chandler [62] cited examples that included buffering, leveling, forecasting, rationing, stockpiling, backlogging, organizational restructuring, research and development, sales agreements, union labor agreements, patents, licensing, price cutting, advertising, etc. These examples represent strategies to increase internal variety,

decrease external variety and modify outcomes or utilities.

The scattergrams of stability on resilience (Figures 10 and 16) for individual firms and for industries yielded the lowest degree of association (relatively) among the various pair-wise comparisons, although the degree of correlation was statistically significant. The pattern of the graphs do support the hypothesized trade-off between stability and resilience as has been posited by others [1,16,53,76,89].

The scattergrams of resilience on risk (Figures 11 and 17) for individual firms and industries indicated a positive correlation which was visually apparent for industries, but difficult to see for individual firms although each bivariate plot yielded a statistically significant degree of correlation.

This supports my view that resilience is a difficult property to quantify. The difference between the plots for firms versus the plots for industries suggests that resilience as defined in this research report in terms of corporate operating characteristics is more consistently quantified as a macro variable (across industries) than as a micro variable (across individual firms).

Resilience is conceptually a long-term parameter and it may prove to be true that a ten year period of comparative data is insufficient as a data base. The logistical problem of gathering the appropriate data over long (25-50 years) periods of time is incredibly time consuming unless an organization such as Standard and Poor [95] with their COMPUSTAT tapes were to expand their data base back over the past 50 years. At the time of this research report, the necessary data for prior periods of time was not available on the tapes.

The scattergrams (Figures 12 and 18) of rate of return on resilience show a definite negative correlation. This relationship was hypothesized on the assumption that resilience, at least partially, derives from the maintenance by the corporation of a ready reserve, but not currently used, of excess assets predicated on their probable future use to meet unexpected situations.

Again, it should be noted that the surrogate for rate of return has total assets as a divisor. The ready reserve of extra assets would tend to create a lower rate of return in comparison to a firm that did not carry the same degree of ready reserves, *ceterus paribus*.

Our final set of scattergrams (Figures 13 and 19) show business risk plotted against rate of return. There is a fairly strong degree of negative correlation that is statistically significant. These results conflict with the popular notion that a greater reward accompanies the greater risk. I again caution, however, that we are looking at a relatively short time base of ten years. This may have the effect of biasing the results to the short term view of earnings. It may well prove that this relationship would reverse if a significantly longer period of time were analyzed as was suggested in the investigation of the surrogate resilience.

Research by Everett and Schwab [41] into common stock behavior support this paper's findings in that they concluded that risk rejection rates are not always greater than the riskless rate, i.e., the rate of return was not always greater for the riskier investments; the positive correlation between risk and rate of return was not substantiated.



Brealey [105] also found that higher risk stocks have not, on the average, provided their owners with higher rewards. Pratt [106] in his dissertation as to the relationship between risk and rate of return for common stocks stated, "It is not possible, on the basis of the research findings, to completely accept nor to completely reject the hypothesis of increasing returns ... as applied to common stocks, that the rates of net return realized by all investors over long periods tends to increase with increasing poorness of grade (risk)."

## LIMITATIONS

### Lack of Comparative Models

The models from financial management theory and from general systems theory used in this research are not the only models that might reasonably be used to investigate the relationships among rate of return, business risk, stability and resilience.

Because of lack of comparisons among alternative models, there is no objective basis by which to judge whether the model used is better or worse in any sense than alternative models that might reasonably be used.

The high degree of statistical significance for most of the bivariate comparisons suggests that the model is valid based on the underlying assumptions. The lower degree of statistical significance for stability and resilience indicates that the model might be modified in some ways to produce results with a higher degree of statistical significance and a higher degree of correlation.

### Causal Forces not Identified

The research design does nothing per se to identify any cause and effect relationship between variables. The rates of return, stability, resilience and business risk identified may reflect the effects of some unidentified, but common factor or factors.

Since the true cause and effect relationship is merely suggested by the analysis, but not known with any certainty, the study does not

purport to offer any direct evidence as to whether or not, or the extent to which, the relevant causal forces can be expected to continue to prevail in the future.

The proposition that the population characteristics in the future will approximate those evidenced in the past is valid only to the extent that the causal forces generating those characteristics remain similar to those forces which prevailed in the past. Since the study itself provides no evidence with respect to the causal forces at work, it can offer no assurance that risk-return-stability-resilience relationships in the future will continue to resemble those that were found to have obtained during the period of this study.

This study is further limited by the fact that the relationships were studied only for the decade 1968 through 1977. No attempt was made to determine whether there was any evidence of change in the general relationships in the later years encompassed by the study as compared with the earlier years. It should be emphasized that the general findings are valid only when applied to large numbers of firms and adequately long periods of time.

It is important to keep in mind that the over-all findings are averages based on an exhaustive analysis of massive amounts of data, encompassing about two dozen operating characteristics for 367 individual firms and 30 industries during a time span of ten years. I suspect that it would be easy to find examples of several dozen firms for short periods of time (less than ten years) where the relationships would not be consistent with the average results realized by all the firms listed on the stock exchanges over the entire ten year time span encompassed

by this study. As previously suggested, it must also be recognized that a significantly longer time base period, 25-50 years, may produce different results, especially in terms of the resilience surrogate relationships.

It should be further recognized in the case of research into common stocks that the investors "utility function" affects the price of stocks and therefore is not directly comparable to our measure of corporate rate of return. The total corporate risk would reflect both business risk and financial risk which would be somewhat more comparable, however; the thrust of this research report was to business risk only and did not include the added effects of financial risk in computing rates of return nor the subjective 'utility function'.

#### FUTURE RESEARCH

A logical extension of this research would entail the construction of a different set of surrogates to represent the parameters under investigation. The surrogate for resilience in particular presents a fertile area for additional research in terms of the development of a more rigorous theoretical base, the derivation of a different operational definition and the construction of different surrogates used to quantify the 'resilience' of a system. This is especially pertinent in conjunction with the following section of this chapter on the significance of the research thrust of this study.

For example, by experimenting with several different formulations of the resilience measurement, it might be possible to develop a basis for combining certain operational characteristics and environmental characteristics that would consistently provide a greater degree of

correlation over time. It is also possible that deviation over time could be replaced by some other base, e.g. a beta factor based on firm performance in comparison with gross national product or some industrial index analogous to the beta factor for common stocks and the capital market line from financial management theory.

Resilience was defined in this research report in terms of invested capital among other parameters. The invested capital of a firm is composed of debt and equity capital. The financial leverage and the financial risk of a firm have also been discussed by financial scholars in terms of the debt-equity structure of the firm. Future research might focus in financial risk as well as business risk and their relationships with stability, resilience and rates of return.

It should be noted that this research study did not include any business firms that are not listed on the major exchanges. This then biases the results in that the listed firms are probably more stable than the unlisted firms because of the listing requirements (financial) of the exchanges. This suggests a study of firms partitioned by stages of growth.

This points to another extension of this investigation which would include unlisted firms as appropriate business entities to be studied. It would also be of interest to examine firms that have failed as business organizations to determine whether the concepts of stability and resilience could be of value in predicting business failures.

We previously introduced Lewontin's [91] volcano shaped model to represent the concepts of global and neighborhood stability; resilience and stability. This model was graphically depicted in Figure 4a.

If this model could be applied to business systems, future empirical research might show a relationship whereby the radius of the basin could be used to represent resilience (adaptable stability) and the depth of the basin could be used to represent conservative stability. Our hypothesis as to the trade-off between stability increases (depth of crater deepens), resilience decreases (radius shrinks).

The above model also resembles a probability distribution. The actual shape of the crater could be described by a probability distribution. This approach is compatible with Lewontin's [91, p.20] discussion of relative stability as a statistical ensemble:

Since the state of the system is being perturbed, it will never be exactly at any equilibrium point. Rather, its position will be determined by a combination of random perturbations ... and a restoring force expressed by the Lyapunov function. Through time the system will occupy a series of points in the hyperspace, and the ensemble of those points will form a cloud around the stable equilibrium position. ... It is useful to think of the 'temperature' of the ensemble measuring the mean square distance of points in the ensemble from the average.

A thermodynamic analogy applicable to social or economic change can be derived from the work of Prigogine and Lefever [68, p.27] who have shown that certain open systems, when switched from equilibrium to far from equilibrium conditions become unstable and undergo a complete change of their macroscopic properties.

Prigogine and Lefever believed, "There appears to exist a thermodynamic threshold for self-organization that corresponds to a clear distinction between the class of equilibrium structures and those structures that have been called dissipative structures because they only appear as a spontaneous response to large deviation from thermodynamic equilibrium. Such fluctuations trigger the appearance of

organizations whose probability of occurrence at equilibrium would be negligible."

The key point is that fluctuation can trigger the appearance of new structures. In the Martinez [71] model, a system of cells can evolve by a succession of instabilities through a set of distinct states. The important point to realize is that in order to regulate such a passage, not only must the system be unstable, but also the instabilities must in some way regulate the boundary conditions of the system.

Prigogine and Lefever [68, p.19] state:

An important feature of self-organization and development, viewed as a succession of instabilities, which must be stressed, is the fundamentally irreversible character of the whole process: Each time the system reaches a point of instability it spontaneously and irreversibly evolves toward a new structural and functional organization; furthermore, these jumps can occur only at given time instants after the beginning of the whole process; in other words, the system has a natural time scale of irreversible gain associated with its own internal properties.

In layman's language, "you can't go home again." A question for future research is whether or not this Martinez model is applicable to social and economic systems as well as biological and chemical systems.

Margalef [89] expressed the opinion, based on his model of diversity and stability, that species with a higher turnover react more quickly to environmental change. This suggests future research to see if business systems exhibit this same relationship.

Another interesting question is whether or not firms that operate in rapidly changing environments, such as high technology firms, demonstrate a higher degree of resiliency than do firms in less rapidly changing environments. An investigation could also be designed to determine whether or not regulated industries demonstrate a significant difference

from non-regulated industries in terms of the degree of stability and resilience exhibited and their relationship to rate of return and risk.

Oscillations occur in many systems and especially in social or business systems where mutual interaction exists. Milsum [65, p.217] has found that as ecologies become more mature, the magnitude of oscillatory behavior decreases. This may be pertinent for many of our contrived systems. Future empirical research may answer the question as to whether more mature business firms experience less oscillation in rates of return than do less mature systems, analogous to ecological systems.

Opportunities for additional research exist in the application of the concepts of stability and resilience to disciplines other than financial management. The choice of time periods, different from those of this research report, longer time periods and shorter time periods suggest another avenue of extension of this research.

A final suggested project would be an Equivalent Stability Hypothesis analogous to the Equivalent Risk Hypothesis which postulates that firms in the same industry have similar risk profiles. The hypothesis would be that firms in the same industry class exhibit similar stability profiles.



## APPLICATIONS

Possible applications of the ideas and empirical results introduced in this research report are presented in terms of the concepts of relative business risk, stability and resilience.

The relative business risk surrogate proposed in this research report encompasses the relative fluctuations in the rate of return expressed as the ratio of earnings before interest and taxes to total assets, EBIT/TA. This makes it unnecessary to differentiate between firms of different size, in terms of total assets, and permits us to compare financial performance based on relative fluctuations in rates of return rather than absolute fluctuations as currently practiced by many financial managers.

As an example to help clarify this approach, consider two firms, A and B. Firm A exhibits a rate of return of ten percent, an absolute risk (standard deviation of rates of return) of five percent and a relative risk (coefficient of variation of rates of return) of twenty percent. Firm B exhibits a rate of return of fifteen percent, an absolute risk of five percent and a relative risk of twenty-five percent.

How would we judge these two firms on the basis of the above data? Firm B is more profitable than firm A. If this were our only criteria, we would choose firm B. The absolute risk levels are identical for each firm, therefore we would again choose firm B as providing a greater return without having to accept a greater risk. If we look at relative risk however, firm B appears to be more risky than firm A. In this case, we must judge whether the higher rate of return

for firm B will compensate for the greater relative risk incurred.

This question does not have a single best answer since each decision maker makes his decision on the basis of a different utility function, thus the choice is subjective, i.e., it is unique to each individual.

Stability reflects the ability of a system to respond successfully to small or temporary disturbances. The stability surrogate proposed in this research report is the ratio of relative fluctuations in sales to the relative fluctuations in rates of return. Consider two firms C and D. Firm C exhibits a relative business risk measure of five percent while firm D exhibits a relative business risk measure of ten percent. With this information only, we might conclude that firm C is less risky than firm D. If however, we specify that firm C is operating in an environment that exhibits a five percent variability and that firm D operates in an environment that exhibits a twenty percent variability, then we might conclude that firm D is less risky than firm C in that it is less sensitive to small or temporary environmental disturbances.

While the relative business risk measure indicates fluctuations only in rates of return, the stability measure indicates fluctuations in the rate of return in relation to environmental perturbations. Thus the stability measure provides more information for decision makers.

The resilience surrogate proposed in this research report quantifies the ability of the firm to respond successfully to large or permanent changes in the environment. Resilience measures the degree to which the amount of invested capital is adequate for responses to

major environmental disturbances with minimal changes in invested capital. The resilience surrogate is the ratio of relative sales fluctuations to relative invested capital fluctuations.

As an example, firms E and F both operate in similar environments, they are both exposed to the same environmental variability. The variation in invested capital for firm E is fifteen percent and for firm F is twenty percent. We might conclude that firm E is more resilient than firm F because it was able to absorb the environmental variability with less fluctuation in its capital structure. If we were anticipating major environmental changes, we would prefer firm E over firm F if our goal was to minimize changes in our capital structure or changes in the corporate asset structure.

The use of stability and resilience surrogates as proposed in this research thus offer additional measures of corporate performance that extend beyond the usual risk measures of traditional financial management theory. If more and better information permits better decision making and provides greater insight into corporate behavior, then the concepts of stability and resilience and their respective surrogates introduced in this research report will be of value to each of our major groups.

Extrapolation of past trends into the future is usually based on the assumption that the driving forces and the relationships among the variables will continue to remain the same. If a different future is predicted that requires changes in the causal forces and their interrelationships, then extrapolation of past trends could be misleading.

The use of the risk concept alone does not explicitly address

the impact of a different future on an organization. The empirical use of the concepts of stability and resilience can provide estimates of the sensitivity of an organization to environmental change. By using the methodology of this research project, decision makers can make quantitative estimates of the effects of predicted environmental change on both corporate profitability and risk levels.

Of special significance is the hope that this research is a step forward in filling the compelling need for empirical verification of theoretic systems hypotheses with real organizational phenomena.

The scholarly value of this research project should lie in the research questions posed for future study. Is there a proper balance of stability and resilience that contributes to long-range profitability? Does this balance differ among firms and industries? What are the causal factors that contribute to organizational stability and resilience? How can an organization create change in the degree of stability and resilience exhibited by the firm? Do these concepts help explain the past financial behavior of organizations? Can sophisticated forecasting techniques be combined with the concepts of stability and resilience to enhance strategic and tactical planning? Do government agencies need to regulate stable industries? Are these concepts applicable to non-profit institutions? Can these ideas be applied to national economies?

These and many other questions could be posed as natural extensions of this research. It is hoped that the introduction of these concepts of stability and resilience will provide the initial impetus to other scholars to pursue these ideas within the context of both business and non-business systems.

As a business organization grows to extreme levels of scale, complexity and interdependence, then the relative ability of any individual to comprehend the system will tend to diminish. To manage a socio-economic system effectively, a decision-maker must acquire knowledge as well as information.

Emery and Trist [81] discuss the dilemma created by conditions of growing complexity and proposed a classification system of environments, interrelationships between the system and the environment.

Emery and Trist's thesis is that much of the behavior of both organisms and organizations is a function of the gross overall characteristics of their environment. Their approach is to obtain knowledge of these behaviors by identifying the properties that best characterize the overall environment and the system behavior necessary for adapting to the environment.

They identify these environmental properties with the term "causal texture." Causal texture defines the components of the system and their interrelationships. The relevant components are restricted to goal objects and noxiants. Goal objects are those things which contribute to the survival of the system. These goals and noxiants are located within the environment such that organizational efforts are required to obtain or avoid them.

Emery and Trist proposed an overall characterization of the environmental properties which can be categorized into four ideal types; placid random, placid clustered, disturbed reactive and turbulent.

This last type, turbulent, is presenting new and different problems of adaptation.

A brief description of each type of these four environments follow, however, the main thrust of this paper focuses on the turbulent environment and organizational strategies and indicators for dealing with turbulent environments.

In the placid random environment, the goals and noxiants are randomly and independently distributed. This is the simplest form of environment. Strategy reflects immediate gratification, a short-range local point of view.

In the placid clustered environment, environmental information is limited to the relative probabilities of co-occurrence of goals and noxiants. Strategy focuses on optimal location since the location of goals and noxiants is not random. Certain positions can be described as potentially richer than other positions. Survival is dependent upon knowledge of the environment.

The disturbed reactive environment is similar to the placid-clustered environment in that the goals and noxiants are non-randomly distributed. The major difference is the presence of another system of the same kind within the environment. Co-presence requires strategy as well as tactics to achieve survival. Game theory, conflict and optimization are tools for survival in this environment.

In the turbulent environment, the dynamic properties arise both from the interaction of the competing systems and from the field itself. Emery and Trist [82,p.21] state, "these fields are so complex, so richly textured, that it is difficult to see how individual systems can, by their own efforts, successfully adapt to them. Strategic planning and

collusion can no more ensure stability in these turbulent fields than can tactics in the clustered and reactive environments. If there are solutions they lie elsewhere."

Even though the organizations of the future may strive for stability and certainty, they may find it impossible to achieve. In a turbulent and uncertain environment, the organization will have to be adaptive, resilient. When the organization cannot achieve and maintain stability because of future uncertainty, it must emphasize dynamic flexibility and responsiveness to change, resilience. Organizational change is largely induced by external environmental influences or disturbances. Adaptability, resilience, is a function of the ability to learn and perform according to the changing contingencies. The successful organization of the future must be able to cope with its turbulent field.

The concepts of stability and resilience presented in this research project are an attempt to address the problem of business systems operating in turbulent environments.

Investors, debtors, business executives, government regulatory agencies and business system scholars must concern themselves with the unfolding future, with the impact of environmental change on business systems, with the responsive capabilities of organizations and with the discovery of parameters that can be used to monitor these system-environment relationships.

### Epilogue

Knowledge is often achieved in sporadic spurts and the route is strewn with many false paths. The aim of this research effort was to

achieve a sporadic spurt, rather than a minimal, albeit safer, extension of some limited portion of a common subject and hopefully has avoided the many false paths. If this research study encourages others to criticize or extend the ideas presented, then it has succeeded in maintaining the dialogue essential to the discovery of new knowledge.



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