USING A CORPORATE SYSTEM MODEL OF A FIRM TO INVESTIGATE THE FEEDBACK DYNAMICS LEADING TO GROWTH, DECLINE AND BANKRUPTCY

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ABSTRACT

This paper presents the outline of a system dynamics corporate model of a representative manufacturing firm to be used to study the feedback dynamics leading to growth, decline and the likelihood of going bankrupt. The model comprises human resource, customers and sales, operations, budget, accounting, cash flow, finance, shares and bankruptcy propensity sectors that are heavily interactive. The driving forces of growth or decline are related to the ability of the firm's management to raise the necessary resources for working capital, capital equipment, human resource training and etc. that will ensure its long term viability. Viability is measured by Altman's 'Z' composite score based on financial ratios that has been shown to reliably indicate the likelihood of bankruptcy. The ability of the firm's management to negotiate bank loans and raise capital through shares offers is governed by the owner's, banker's and shareholder's perceptions of the viability of the firm. The 'Z' score is used as a surrogate measure of this. Trials will be run to investigate effects of management interventions on the feedback dynamics causing growth and decline.

Keywords: Bankruptcy, growth, viability, feedback dynamics, system dynamics modeling

INTRODUCTION

The study of the causes of company failure remained a neglected area until the ninteen-sixties. One of the earlier works on failure by Smith (1966), reviewing the history of a number of failures.and listed the causes as *diversification, decentralization and centralization*. Ross and Kami (1973) proposed the *ten commandments of management* and suggested that companies will fail if they break a number of these commandment. These included *strategic planning, control systems, recognition that customer is king*, and so on. Barmash (1973) identified only one cause *greed*. Argenti (1976) blamed *creative accounting* by companies that disguised the fact that they were in trouble. He identifies three lethal management defects (*inadequate budgetary control systems, defective cash flow plans and deficient cost systems*), three fatal mistakes (*leverage, overtrading and big projects*) and four categories of symptoms (*financial, creative accounting, non-financial and nose dive*).

The ability of financial ratios and models based on these ratios to predict bankruptcy has been studied (see Beaver 1968, Altman 1968, Altman and Lavallee 1980). More than 65 possible ratios have been identified as having varying predictive ability (Boritz, 1991). Predicting failure depends on the ratios selected according to Hamer (1983) and Karels and Prakesh (1987). Later, researchers developed alternative models based on cash flows, market returns and return variation. For example, a cash flow model was developed by Aziz, Emanuel and Lawson (1988). It is based on the fact that the value of a firm is the sum of the streams of discounted cash flows to and from operations, government, lenders and shareholders. Beaver (1968) suggested a market return model which considers the impact of firm bankruptcy on stock returns. He concludes that the market generally anticipates bankruptcy sooner than financial ratios do. This is consistent with market efficiency theory,

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since risk of bankruptcy perceptions shape the expected returns before investors can react to alternative information sources. Aharony, Jones and Swary (1980) suggested a bankruptcy prediction model based on the variance of market returns. It reveals the behaviour of total and firm specific variances in returns four years before bankruptcy is announced. A comparison of discriminatory power of these model are available in Mossman et al.. (1996).

Such studies are mostly reported in financial and accounting journals. This has benefited auditors and investment analysts as it enables them to estimate the probability of bankruptcy of a firm on behalf of their clients such as lenders and investors. What is lacking in these studies is the dynamic interplay of operations and external environment giving rise to viability or vulnerability. This could provide the forewarning to management about the weak areas requiring rectifying to reverse the deleterious trends. Management requires this information to be able to correct it before the trends become obvious to external interest groups that might affect the chances of recovery.

The dynamic interplay among company operations, market, competitors, suppliers, and labor force is complex. The System Dynamics methodology can be used very effectively in such studies. For instance, Shehata (1975) analyzed the cause-effect mechanisms of a cash system to study the influence of cash control policies on the other organizational subsystems, and vice versa. The latest study by Doman et al. (1995) reports the findings of an internal McKinsey research where System Dynamics was used to compare the growth policies of two life insurance companies. The research shows how attempts to exceed the maximum sustainable growth rate specific to any individual company can lock it into a slow but relentless decline from which there is little hope of escape. They have identified a number of long range warning signs.

More recently Hurst (1995) compared a cross section of enterprises from hunter-gatherers of the Kalahari and Quakers of the Industrial Revolution to contemporary organizations such as 3M and Nike to explain how even successful organizations become systematically vulnerable to catastrophe. He argues that there are times when managers must deliberately create crises by committing acts of 'ethical anarchy' in order to break the constraints and renew their organizations. Hall (1976 and 1984) has suggested that a SD corporate system model could be used to simulate crises and provide the wake up call to management to prevent the failure from happening.

In this paper, an attempt is made to develop a representative corporate system model describing the interactions of the major organizational functions and to study their dynamic interrelationship causing changes to the firm's bankruptcy propensity. Experiments with policy changes can be used to trace the impacts on the bankruptcy propensity and learn about strategies for avoidance. The purpose here is to try to detect impending failure well in advance to be able to do something about it.

The other side of the coin is sustained growth. Achi et al. (1995) have examined forty-one companies with sustained growth of over 20 percent. They advise management to forget diminishing return and classical economics and instead focus on the reinforcing feedback loops driving the growth. They suggest that if several reinforcing loops are active in the right direction and in unison, then growth is unstoppable. The corporate system model we are proposing could also be used to explore this issue. The purpose here is to discover the reinforcing feedback loops and strategy for getting them to work in unison and maintaining the momentum.

STRUCTURE OF THE MODEL

It was aimed to develop a corporate model of a representative manufacturing firm incorporating the law of parsimony with the fewest parameters and initial values to be supplied by the users and having mostly endogenous interrelations. To build the model we consulted and brainstormed with a number of experts in manufacturing, operations, marketing and finance both from academics and industry. This is helpful in calibrating the

model to a specific industry and employing actual industry data to validate the model. The major organizational functions useful in the study of growth, viability and bankruptcy propensity are identified below. They each form a sector in a Stella programmed model.

i) Human Resource: This sector deals with major processes related to hiring, training, skill obsolescence, layoff and quitting and their effects on supply of the human resource and its productivity for production operations.

ii) Customers and Sales: This sector describes the relationships of variables affecting the level of regular and trial customers and in turn the total sales. Trial customer are first inducted and then convert to regular buyers if satisfied with quality and price of the product or they quit. Variations in quality and price and delivery affect the decisions to become regular customers or quit. Total sales is affected by the stocks of trial and regular buyers, and the average sales of these customers.

iii) Operations: This sector describes the flows and accumulations of orders, inventories and plant capacity. Change in plant capacity is governed by capacity acquisitions based on sales forecasts and the availability of funds. The production rate is limited by orders and/or human and/or physical capacities. It then influences the inventory levels in plant and warehouse locations while the combined order backlog and work-in progress accounts for the delivery delays that in turn influence customer satisfaction and sales, and so forth.

iv) Accounting: This sector deals with keeping track of accounts receivables and payables, depreciation, profit, taxes, labor payments, costing of goods sold and cost of acquiring capacity . Sales revenue depends upon the shipping, price mark up and bad debts fraction. Cost of goods sold accounts for the various expenses such as labor payments, material cost, manufacturing overheads and selling and promotional expenses. Gross profit is the difference of sales revenue and cost of goods sold. Advantage of depreciation and interests in tax estimation are taken care of. Assets build up as new capacity is acquired.

v) Budget: This sector describes the dynamics of the budgeting process in a firm. Here projections for cash required is made on the basis of projected cost of acquiring capacity, projected retained earnings and working capital. Working capital required is determined by projected cost of goods sold, average collection period and average delivery delay. Sales revenue is projected on the basis of price mark up and forecast sales. Selling and promotion budget is primarily influenced by relative change in market share. Retained earning projection considers the issues such as taxes, depreciation and dividends. It is itself a simplified model of the accounting process.

vi) Cash Flow: This sector models the cash inflows and outflows, and the resulting cash balance. Sales revenue as well as long and short term borrowings largely contribute to Cash inflows. The receipts of accounts payable depends on delays in payments after billing. Cash outflow accounts for the expenditure of the firm on materials purchases, labor cost, capacity acquisition, payment of interest and maturing principals (repayment of debt), taxes, overhead expenditure and etc. in the current financial year.

vii) Finance: This sector models the important accumulations of long and short term debt resulting in the maturing obligations in the current year. Long and short term borrowings are undertaken to finance working capital and capacity acquisitions. Repayments due for the year are the maturing debt and the interest payments due on the balance of the debt. A major assumption is that the maximum debt load is geared to the debt-to-equity position that is itself a function of the firm's viability as measured by the 'Z' bankruptcy score (a surrogate for the banker's perceptions) as described below.

viii) Shares: This sector describes the activities related to raising capital through equity shares. Shares are issues at an interval to meet the investment requirements. Earning per share is determined from the earning after taxes and outstanding shares. This also keeps account of dividend and earnings retained for use. A major assumption is that shares issued only if long-term loans cannot be secured because of the firm's debt-to-equity position.

ix) Bankruptcy propensity: The probability of bankruptcy is, other things held constant, higher for a firm with a low current ratio than a high one. Similarly, the

probability of bankruptcy is higher the higher the growth rate of equity less growth rate of total assets, or lower the net profit to total debt ratio or net profit to total assets ratio or sales to total assets and so on. Altman and Lavallee (1980) applied multiple discriminant analysis (MDA) to establish a relationship linking these ratios to obtain a composite index (Z) that measures the likelihood of bankruptcy. The study was made using a sample of 42 Canadian firms, 21 of which were declared bankrupt between 1970 and 1979. This sector computes the 'Z' score from the accounting ratios in the Accounting sector using Altman and Lavellee's formulation.

x) Policy decisions: In this sector the major policy processes are collected into categories of decisions made by *management fiat* (e.g., fraction of earnings to be distributed as dividends) and decisions determined by *standard practice* (e.g., sales mark-up adjusted to maintain current profitability but constrained by the need to maintain market share) (after Hall, 1976).

CONCLUDING REMARKS

Since this is a project in process, a review of the model and the results to date will be presented.

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