MUTIPLE POINT COMPETITION AS A PREDICTOR OF
STRATEGY, STRUCTURE, AND ECONOMIC PERFORMANCE

by

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This dissertation proposes a set of axioms that a measure of relatedness should satisfy, develops a measure of relatedness of two businesses based on the probability of a firm not being in only one of the two, and demonstrates that this measure satisfies the proposed axioms. This measure also yields a theoretically more justifiable measure of diversification.

Analysis of data relating to over 8,000 business segments reported by nearly 7,000 firms in the COMPUSTAT database reveals systematic differences across industries in the association between diversification and profitability. A strong negative association exists between diversification and profitability in industries which are highly profitable but not in industries that are less profitable.

According to Arrow and Radner's model diversified firms should design their structure by putting related businesses in the same division. A logit model using the above measure of relatedness for a sample of fifty of the Fortune 500 companies provides support for the model.
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PREFACE

The subject matter of this dissertation is diversification strategy, divisional structure, and economic performance of large firms in the U.S.—the theme of Rumelt’s (1974) *Strategy, Structure and Economic Performance*. However, this dissertation extends Rumelt’s work by developing theoretically more justifiable measures of relatedness and firm diversification based on multiple point competition, by investigating the relationship between firm diversification and economic performance in a large sample of 7,000 firms in the U.S., and by using the multiple point competition based measure of relatedness to predict the divisional structure of firms. After the studies by Wrigley (1970) and Rumelt (1974), this is among the first to investigate the diversification strategy and the divisional structure of firms simultaneously.

Diversification is an area of research peculiar to strategic management (SM). Though diversification is the single most common strategy characterizing large business firms in the US, it has largely been ignored by the Industrial Organization (IO) economists, who had been more concerned with interindustry differences in rates of returns than with intraindustry differences. The few economists who ventured into a study of diversification generally reported no clear relationships between diversification and either profit rates or growth (Gort, 1962; Mueller, 1986), no harmful effects on competition (Goldberger, 1965), and no increase in market share (Berry, 1975)—an altogether uninviting, inconsequential phenomenon from the point of view of the economist.

As a result, most of the significant work in this area has been done by SM researchers. But despite a number of studies, contradictions abound. For instance, while Rumelt found a positive association between related diversification and economic performance in the U.S., Luffman and Reed (1984)
reported higher performance associated with unrelated diversification in the U.K. Another area of concern in this stream of research has been the lack of satisfactory measures of relatedness and diversification. According to Pitts and Hopkins (1982), the results of the past studies on diversification and economic performance were dependent upon the type of measure of diversification they used. Chapter II of this dissertation proposes a set of axioms that a measure of relatedness should satisfy, demonstrates that a measure of relatedness between two businesses based on the probability of a firm being in only one of the two satisfies these axioms, and develops an index of diversification using this measure of relatedness. Chapter III reports results from a study of the profitability of over 8,000 business segments reported by nearly 7,000 companies in the COMPUSTAT data base that reveals systematic differences in the association between profitability and diversification across industries.

Like research on diversification strategy, research on divisional structure has also been central to the area of SM as organization theory (OT) researchers have chosen to ignore the divisional structure of the firm in favor of studying the Weber's (1947) model of structuring of organizations. But SM researchers in the past had been concerned more with whether "structure followed strategy" than with the design of the divisional structure. As a result, past research provides no help in designing the multidivisional structure of a firm.

In Chapter IV we use a model of large teams developed by Arrow and Radner (1979) in which productivity losses due to incomplete sharing of information among team members are minimized if the economic environments of the team members are statistically independent. The optimal structure of a multidivisional firm is therefore one in which businesses in a division are
related more to those within the division than to those across. Estimation of a logit model of the divisional structure of fifty of the Fortune 500 companies using the above measure of relatedness based on multiple point competition provides support for the model. It appears that the divisional structure of most large diversified firms conforms closely to the structure of their multiple point competition. However, some firms seem to choose to organize differently. We therefore also propose two alternative models of divisional structure that appear to account for these deviations. One of these is based on the problem of incomplete information while the other allows a divisionalized firm to maintain entrepreneurial vigor.
CHAPTER I

INTRODUCTION:

A REVIEW OF RESEARCH ON DIVERSIFICATION
Diversification and divisionalization have been among the most common resource allocation and organizational strategies followed by firms in the U.S. during the last four decades (Wrigley, 1970; Rumelt, 1974; Chandler, 1975). Accordingly, researchers in disciplines as diverse as business history (Chandler, 1962), law (Davidson, 1981; 1985), marketing (Capon et. al., 1989), finance (Reid, 1968; Weston and Mansingka, 1971), economics (Berry, 1975; Gort, 1962; Markham, 1973; Mueller, 1986; Williamson, 1975; Armour and Teece, 1982; Teece, 1988) and strategic management (Rumelt, 1974; Christensen and Montgomery, 1981; Bettis and Hall, 1982) have studied the phenomenon of diversification and divisionalization of firms—their motives and consequences—from a variety of perspectives. For simplicity, we will restrict our discussion in this chapter to the extensive literature on diversification and defer a discussion of the literature on divisionalization to Chapter IV.

Research on diversification can be categorized into three broad streams that stem primarily from the areas of finance (this includes the studies that are primarily informed by corporate law), industrial organization (IO) economics, and strategic management (these include the studies that incorporate the marketing perspective). The studies in these streams of research reflect the objectives, methodologies, and perspectives unique to the three primary disciplines that inform their research. Table 1.1 shows summary findings from several studies of diversification.

**DIVERSIFICATION RESEARCH IN FINANCE**

Research on diversification in the area of finance differs from that in the areas of IO and SM on at least two counts. First, it is generally limited to the study of the conglomerate form of diversification—or to the study of
the unrelated diversification. Second, much of this research is premised on
the belief that the rationale for such diversification is either the
divergence of the goals of owners and managers, or reduction of risk.

Divergence of the Goals of Shareholders and Managers

The first rationale rests on the belief that in large corporations the
interests of the shareholders and those of the managers are not congruent.
Mueller (1969) has a model of diversification based on the pursuit of growth
maximization rather than shareholder wealth maximization by a firm's managers.
To a firm's managers interested in maximizing the growth rate of the firm, the
opportunity cost of funds invested in the firm will equal the return on
marginal projects within the firm, rather than the rate of return on the
highest yielding investment projects in other firms, which is the opportunity
cost of funds invested in the firm by the shareholders. Then the managers'
discount rate will be lower than that of the shareholder, resulting in higher
levels of investment in productive activities than if managers were to pursue
shareholder wealth maximization. This will raise the optimal level of
investment in horizontal, vertical, and diversified activities. If public
policy constraint prevents vertical and horizontal investments then it will
raise optimal level of investment in diversification. According to this story,
diversification is in the interest of managers and is counter to the interests
of the shareholders.

However, recent theoretical work on the principal agent relations
indicates that diversification may be in the interest of shareholders (Aron, 1988). The problem of moral hazard in agency relationships arises because the
principal (shareholders in this case) can not observe the effort of managers,
because managers are risk averse, and because the managers' utility function is different from that of the shareholders. To induce managers to exert optimum effort the shareholders must pay them more than the wages corresponding to the reservation utility of managers. But now suppose there are two products in place of one, in two industries where profits in any period are statistically independent. The value of the additional information that the shareholders receive from the profitability of this new product is always positive. That is, if the cost of optimal contract is C and the number of products is N, then $\frac{\Delta C}{\Delta N} < 0$. So, in this case the shareholders have an incentive to diversify. If Aron's model were correct, however, then the best form of diversification would be that into unrelated areas where profits would not be correlated. Berry (1975), however, found that most firms in the U.S. had diversified into areas closely related to their original activities.

Reid (1968) evaluated a sample of conglomerate firms during the period 1951-1961. He used three measures each to represent the interests of managers and stockholder, and found that the firms more active in acquisitions and mergers during the period scored higher on the criteria related to managers' interests. These findings, however, were not supported by Weston and Mansingka (1971, p. 933) who found that the "conglomerate firms outperformed samples of other firms or broad groups of firms on all of the growth measures." The earnings performance of conglomerates as measured by the ratio of net income to net worth was higher but statistically not significant.

Reduction in Risk

Like Aron's model, reduction in risk or uncertainty as rationale for diversification would also favor diversification into unrelated areas. It has
been suggested that firms tend to diversify into areas where profit streams are negatively correlated over time with their primary products. In this way firms can avoid the secular variability associated with business cycles and demand and cost shocks, thereby lowering the risk facing shareholders. But, several finance theorists (Brealey and Myers, 1984) have claimed that portfolio diversification by the investors can perfectly replicate these benefits at a lower cost. Diversification by firms therefore would appear to be an inefficient method of reducing this risk. Others have pointed out that this would be the case only if the costs associated with bankruptcy were ignored. Brealey and Myers (1984) also provide instances where firms could diversify away the risk more cheaply. Suppose somebody bought $100 worth of IBM stock in 1950 as part of a diversified portfolio. By 1970 the value of that IBM stock was well above $2,000 and the original portfolio was no longer diversified. Now, in 1970 there were two ways of diversifying away the risk on this holding. First, the investor could sell his or her stock of IBM and buy a diversified portfolio of stocks. But then he or she would have to pay taxes on the capital gains. The other and perhaps cheaper way to diversify away investor's risk in this case would be for IBM to diversify.

Smith and Shreiner (1969) compared the efficiency of portfolio selection of conglomerates with that of investment companies. The investment companies in their sample had superior portfolio performance. Weston, Smith and Shriever (1972) also report that conglomerates were less effective than mutual funds at diversifying risk. A recent study by Michel and Shaked (1984), however, questions these findings as in their sample conglomerates outperformed other firms in return to shareholders for a given level of risk. In other words, for a given level of return, conglomerates in their sample had a lower risk.
profile.

In an interesting variation of the above theme, Amihud and Lev (1977) suggest that through mergers and acquisitions managers diversify the risk of their losing jobs. They also report empirical support for their model.

DIVERSIFICATION RESEARCH IN IO

Research on diversification in IO too differs from that in SM in two respects. First, given the primary interest of IO researchers in interindustry rather than intraindustry differences in profitability, several researchers in this stream have studied diversification at the level of industry rather than at the level of the firm (see for instance, Caves, 1975). We do not review the industry level studies in Table 1.1.

Second, the chief objective of diversification research in IO appears to have been the search for the effect of diversification on market power. "Market power is the ability of a market participant or group of participants (persons, firms, partnerships, or others) to influence price, quality, and the nature of the product in the market place" (Shephard, 1970:3). Market power is believed to reduce competition and could lead to risk free profits. If diversification could be shown to be associated with market power then it would have strong public policy implications.

There are two ways in which diversification may lead to increased market power and reduced competition. First, if economies of scope exist then the diversified firm with multiple products has advantage over the single business (product) firm in terms of cost and it enjoys positive profits. Second, if several large conglomerates face each other in many markets then they have less incentive to compete in price as a price cut in one market would invite
retaliation in several other markets (Miller, 1973).

The case of economies of scope being a rationale for diversification is weak. According to Baumol, Panzar and Willig (1982, p. 71) economies of scope are the "necessary and sufficient condition for the existence of multiproduct firm in perfectly contestable markets." That is:

"If $C(y_1, y_2) < C(y_1, 0) + C(0, y_2)$, any market structure involving specialty firms would be unstable in that it would be profitable for them to merge." (Baumol, Panzar and Willig, 1982, p. 71)

An example of such a multiproduct firm would be a firm in the otter trawl industry producing cod, haddock, flounder, and other fish (Squires, 1987). There are economies of scope in producing these species of fish together. No firm exists that produces only flounder, for instance, or only haddock. But firms producing these species of fish are not diversified firms. Among diversified firms we include a company like Morton Thiokol which produces table salt on one hand, and propulsion fuel for space vehicles on the other.

Bernheim and Whinston (1990) have shown that multi market contact by diversified firms may facilitate collusion. In a single market the substantial lag between cheating and detection because of slow diffusion of information about prices makes it difficult to enforce collusion. But if the firms meet across many markets and the price information diffuses more rapidly in some markets than in others, then a firm will be deterred from cutting price. The multi market contact of diversified firms therefore facilitates collusion by reducing the information lag. However, in a study of Savings and Loans in California, Mester (1987) found that multi market contact by firms was beneficial to consumers.
Williamson (1975) once called the diversified firms "miniature capital markets" able to allocate resource internally among businesses based on better information than that available to the capital market. Williamson's hypothesis has never been directly tested. However, Hambrick, Day and Macmillan's (1982) inability to verify in the PIMS database the cash flow pattern across 'stars,' 'cash cows,' 'dogs,' and 'question marks' predicted by the Boston Consulting Group indicates that the flow of resources across businesses for the purpose of investment is not very significant among diversified firms in the U.S.

The 'long purse' story of diversification also relies on imperfection in the capital market and assumes that the diversified firm has greater access to (internal) sources of funds than has the undiversified firm. These funds can see a diversified firm through a protracted period of predatory pricing. The 'multi market reputation' story also hypothesizes predation as the rationale for diversification. Hilke and Nelson (1988), on the other hand, suggest that diversification by firms may result in diversified firms facing diversified rivals that would discourage predation. Moreover, for a story of predation to be credible, firms must be able to charge high prices in periods when they are not preying. Diversified firms, therefore, should exhibit high profits and industries with several diversified firms in them should exhibit high concentration.

In reality, IO economists have generally reported no clear relationships between diversification and either profit rates or growth (Gort, 1962:65; Caves, 1977; Berry, 1975:156), no harmful effects on competition and no increase in market share (Goldberg, 1965). In fact, Berry (1965:143-144) found that diversification by the Fortune 500 companies often led to significant entries into high concentration industries with consequent reduction in
concentration ratios which had benign influence on competition. Entry by smaller firms in similar industries did not have much impact on the concentration ratios in these industries.

DIVERSIFICATION RESEARCH IN SM

The most important study in the area of diversification remains the one by Rumelt (1974) who had examined the profitability of 246 of the Fortune 500 companies in the U.S. between the years 1949-1969 and had found a positive association between related diversification and profitability. In his sample firms that obtained over 70% of their revenue from businesses which shared a common skill, resource, market, or purpose exhibited higher profitability. Firms that had diversified into unrelated areas had lower profitability.

Broadly, much of the research on diversification in SM supports Rumelt’s (1974) results that diversification into related areas is associated with superior performance, while firms diversifying into unrelated areas are found to perform poorly. Some indirect evidence from IO and finance substantiates these results. In Berry’s (1975:105) sample diversification within 2-digit SIC categories had a marginally higher impact on asset growth than diversification across 2-digit SIC categories. Earlier, Weston, Smith and Shrieveres (1972) had found that conglomerates performed worse than the firms in the control group.

Rumelt’s findings have been questioned by Christensen and Montgomery (1981) and Bettis and Hall (1982) who incorporated industry effects into Rumelt’s database and found that the high profitability of related diversifiers was largely due to their presence in high concentration and high profitability industries. However, most other recent studies on diversification have corroborated Rumelt’s findings. Notable exceptions are
two studies of British firms by Luffman and Reed (1984) and Grant and Jamine (1988). The latter, for instance, found higher performance associated with diversification with no significant differences across related and unrelated diversifiers, while the former found high performance associated with unrelated diversification.

While most of the above studies investigated linear relationships between diversification and profitability, Grant, Jamine, and Thomas (1988) estimated a quadratic model for firms in the U.K. They found that diversification was positively associated with performance and the square of diversification was negatively associated with performance, implying that a little diversification was beneficial but too much of it could impair performance.

Most studies of diversification in SM reviewed above had been primarily empirical in nature with no claim to testing formal models. Wernerfelt and Montgomery’s (1988b) study differs from others in this respect in that they use the utilization of excess capacity as a rationale for diversification (Penrose, 1959) and argue that firms appropriate Ricardian rents if they have access to non-imitable factors. If the firm has an excess capacity of these factors then it would first use them for expansion of existing business in the domestic and overseas markets, and if excess capacity is still left, then it would diversify. But the wider a firm diversifies the lower the average rents would be because a given factor will lose value when transferred to markets that are less similar to that in which it originated. Using Tobin’s q, they find support for the idea that diversification is prompted by excess capacity in rent yielding factors.

Extrapolating from their study, Wernerfelt and Montgomery (1988b) claim
that the average rent of a firm would decline as the firm diversified into more and more new and unrelated businesses. But, in a study of 61 conglomerates during the years 1958-1968, Weston and Marsingka (1971) found that while the earnings rates of the conglomerate firms in the late 1950s or the early 1960s were significantly lower than the earnings rates for other groups of firms, by 1968 no significant differences in earnings performance were observed.

LIMITATIONS OF RESEARCH ON DIVERSIFICATION

As the above review suggests, the major strength of past research on diversification had been its diverse origin, its multiple perspectives, and its plurality of approaches. These strengths, however, also give rise to a major weakness as no attempt has been made to integrate the often apparently contradictory findings from previous research on diversification. For instance, while Rumelt (1974) found that related diversifiers were more profitable in the U.S., Luffman and Reed (1984) reported that unrelated diversifiers were more profitable in the U.K. This lack of integration is even more apparent in the dichotomy that exists between theoretical and empirical work on diversification. The predictions from a variety of theoretical models (for instance, Mueller, 1965; Aron, 1989) appear to be completely divorced from the results reported by the empirical studies of Berry (1975), Rumelt (1974), and others.

A second limitations to this stream of research has been the lack of causal analysis. While investigating the association between diversification and performance, these studies fail to indicate the direction of causality between the two. Rumelt (1974:156) had been careful to qualify his findings by
divesting them of all causal implications. His results were insufficient to conclude whether differences in economic performance were a cause or a consequence of different diversification strategies. Subsequent researchers not only failed to address the issue of causality but also abandoned the caution shown by Rumelt. Lack of time series data on diversification is a major reason why the issue of causation has not been addressed by researchers so far.

A third limitation of research on diversification had been pointed out by Pitts and Hopkins (1982) who had observed that the results obtained by empirical studies on diversification had been dependent upon the measure of diversification used. While studies using a categorical measure of diversification of the type used by Rumelt (1974) found a positive association between related diversification and profitability in the U.S., those using a Hirschman-Herfindahl type index of diversification (Berry, 1975; Mueller, 1986) have generally failed to find any statistically significant relationship between diversification and performance. In Chapter II we address this limitation of research on diversification by proposing a theoretically more justifiable measure of firm diversification based on a measure of relatedness which is a metric. Then, in Chapter III we use this measure of diversification for investigating the relationship between firm diversification and economic performance.
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<td>Smith and Shreiner</td>
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<td>Christensen and Montgomery (1981)</td>
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<td>Bettis (1982)</td>
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<td>Bettis and Hall (1982)</td>
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<tr>
<td>Grant and Jamine (1988)</td>
<td>304 large U.K. manufacturing firms, 1972-1984</td>
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W-R: Wrigley-Rumelt categories of diversification

HHI: Hirschman-Herfindahl index type measure of diversification
The words "relatedness" and "diversification" [or "diversity" as it is called by Pitts and Hopkins (1982)] are used in a variety of contexts in the area of management in general and in the area of strategic management in particular, whenever there is need to classify firms and businesses or to discuss some sort of relationship between the activities of a firm. Indeed, it would be difficult to pursue any stream of literature in the area of strategic management for long without encountering the concept of relatedness and diversification in one guise or other. The full scopes of the two terms therefore can possibly best be defined extensionally by indicating the major areas of research where they have been used as important variables. In addition to their use in the extensive literature on diversification (Rumelt, 1974; Christensen and Montgomery, 1981), relatedness and diversification feature prominently as key variables in studies on mergers and acquisitions (Porter, 1987), divestment and restructuring (Allen, 1979), strategic alliances (Koh, 1989), international ventures (Bane and Neubauer, 1981), determinants of organizational performance (Springate and Hill, 1978), organizational structure (Child, 1972), divisionalization (Wrigley, 1970), managerial decision making (Donaldson and Lorsch, 1973), organizational interdependence (Springate and Hill, 1978), and the like.

Given the key role played by the concepts of relatedness and diversification in so many streams of research central to the area of strategic management, it is not surprising that several SM scholars have devoted effort to developing objective measures of relatedness and diversification (Rumelt, 1974; Montgomery, 1982). Without such measures ex post facto arguments about the behavior of firms would only too readily be possible. In this section we will critically evaluate these measures from the
points of view of their content validity and suitability for use in empirical research and propose alternative definitions along with certain axioms that any measures of relatedness and diversification should satisfy to be of use in theory building and empirical research. We will then suggest certain measures based on these definitions that satisfy the axioms.

ON THE MEASUREMENT OF RELATEDNESS

Following Gregson’s (1975) definition of psychological similarity, we will define relatedness at three different levels—at normative, objective, and empirical levels. Each of the three different levels of definition has a different domain of applicability. Researchers in the area of strategic management in the past have not been very clear about the level of definition they have used in different contexts [compare, for instance, the definitions of relatedness used by Rumelt (1974) and Christensen and Montgomery (1981) with those proposed by Prahalad and Bettis (1986) and Kazanjian and Drazin (1987)]. This may in part be responsible for Marshall’s (1987:139) criticism that "work on relatedness and profitability has suffered from weak theory as well as weak data. Vague concepts such as ‘shared experience,’ ‘core skills,’ and ‘stick to your knittings’ have constituted explanations of why the two (businesses) might be related."

A Normative Definition: Relatedness as Distance along Cost

The purpose of a normative definition of relatedness is to provide an ideal measure of relatedness with a view to classifying businesses or activities of firms. Such a definition will make no presupposition about being a classification of an actual judge, rather it is one that can be used to
measure relatedness by a rational, consistent, and ideal judge. Actual human judges can only aspire to close approximation to the normative measure. All other measures of relatedness at different levels of definition must therefore be judged by how closely do they approximate measures of relatedness based on the normative definition. A normative definition of relatedness therefore will be useful primarily for the purpose of theory building and for the purpose of validating measures of relatedness based on the two other levels of definitions.

In the past literature, the closest thing to a normative definition of relatedness that exists is Baumol, Panzar, and Willig's (1982) definition of economies of scope:

"If $C(y_1, y_2) < C(y_1, 0) + C(0, y_2)$, any market structure involving specialty firms would be unstable in that it would be profitable for them to merge." (Baumol, Panzar and Willig, 1982:71)

According to Baumol, Panzar and Willig (1982:71) economies of scope are the "necessary and sufficient condition for the existence of multiproduct firm in perfectly contestable markets." However, this definition does not explain the existence of diversified firms operating in related and unrelated businesses.

We define the opposite of relatedness as the distance $d \in (0, 1)$ between two businesses $i$ and $j$ along the dimension of cost:

$$c_i^o = c_i (1-d) + C.d$$ (2.1)

where $C$ is a random variable with mean $c$ and variance $s^2$. This definition is based on the assumption that the marginal cost of a firm diversifying into an industry at distance $d$ comprises two components—a component linked to its cost in the existing industry, and another component that is drawn from a random lottery. As the firm diversifies away from its existing business into
an unrelated area, the proportion of the new cost that is linked to its existing cost decreases while the proportion linked to the random lottery increases. In our opinion, this cost function gives rise to a pattern of correlated returns across businesses for firms diversifying into related areas in which a low cost firm can expect high returns if it enters businesses that are related to its existing operations, while a high cost firm can expect low returns if it enters related businesses (Sinha, 1990).

However, since segment cost data of firms diversifying from business i into business j are not readily available, equation (2.1) can rarely be directly used for the purpose of estimating the distance \( d \) between businesses i and j. This definition of relatedness will therefore remain a normative one so long as information on the cost of firms' businesses remains elusive and will perhaps be used for the purpose of validating measures of relatedness based on the two other levels of definitions.

**Axioms for measures of relatedness:** Since relatedness, according to our normative definition, is the opposite of distance, any measure of relatedness must be based upon a measure of distance that would satisfy certain axiomatic properties required of such measures. Ideally, a measure of distance would be a metric \( d \) that would satisfy the following conditions (Bryant, 1985):

\[
[R1]. \quad d(p,q) = 0 \text{ if } p = q \\
[R2]. \quad d(p,q) > 0 \text{ if } p \neq q \\
[R3]. \quad d(p,q) = d(q,p) \text{ for all } p, q \\
[R4]. \quad d(p,r) \leq d(p,q) + d(q,r) \text{ for all } p, q, r \text{ (triangle inequality)}.
\]

[R1]–[R4] constitute the four axioms a measure of relatedness should satisfy. Conceptually it is possible to have a one way relatedness between two industries. An automobile firm may find it easier to enter into the area of
financial services, while it might be more difficult for a financial services firm to enter into automobiles. In this case [R3] above will not be satisfied as \( d(p,q) \neq d(q,p) \). Such a measure of one way relatedness would merely be a pseudo metric. But a pseudo metric can always be transformed into a metric. For instance, in the above case \( [d(p,q) + d(q,p)] \) would be a metric.

According to the above axioms the distance \( d_{ij} \) between two businesses \( i \) and \( j \) depends upon the characteristics of the two businesses. The distance (or the relatedness) between two businesses \( i \) and \( j \) is same for all firms, it does not depend upon the context or logic of particular firms or managers. These axioms therefore rule out definitions of relatedness offered by Kazanjian and Drazin (1987) and Prahalad and Bettis (1986). We are not, however, discounting the importance of individual insight and vision. To be able to see patterns and linkages across businesses not visible to others is the essence of creative corporate strategy. But the patterns and linkages always exist, though they might be beyond the ability of others to see, and are the same for all firms.

Two Objective Definitions

Because of problems of operationalization, normative definitions are often unsuitable for use in empirical research. Most disciplines therefore use definitions at the two other levels for empirical research. Two of the most commonly used measures of relatedness in the area of SM are both based upon objective definitions of relatedness that rely upon a procedure of measurement designed to make the relationship between two businesses independent of the subjective judgements of researchers. However, as objective definitions they are somewhat less useful for the purpose of theory building [see Gregson
(1975) for a criticism of objective definitions as means for theory building and testing] and, as we will demonstrate later, some of these also do not fulfill the axiomatic properties ([R1]–[R4]) required of measures of relatedness.

Measurement along resources, markets, and products: One of the earliest objective definitions of relatedness that we have been able to find occurs in the McKinsey & Co.'s report to General Electric (GE) in 1970 (Hamermesh, 1986) McKinsey & Co., however, were not formally defining relatedness but were recommending to GE a way of designing Strategic Business Units (SBUs). A similar definition of relatedness in the context of the design of SBUs is also provided by Patel and Younger (1977). According to them two businesses are related if

1. a price reduction in one business affects prices in the other,
2. they have the same set of customers,
3. they share common resources in manufacturing, marketing, and R&D,
4. and they have common competitors.

Rumelt (1974) who classified businesses into two categories—related and unrelated—was probably the first to provide a more formal definition of relatedness. His definition is a slight variation on the McKinsey theme and is also the definition that is most commonly used in the area of SM. According to Rumelt (1974:29), two businesses are related to one another when a common skill, resource, market, or purpose applies to each.

Two businesses are, therefore, related if they are similar in skills, markets, resource requirements, and the like. In mathematics similarity and dissimilarity are expressed in terms of distances. If dissimilarity is represented by a distance d on a scale of 0–1, then (1 – d) represents the
similarity. According to Rumelt's definition of relatedness, the distance \( d_{ij} \) between two businesses \( i \) and \( j \) is a monotonically increasing function of the differences between their skills \( |s_i - s_j| \), markets \( |m_i - m_j| \), resource requirements \( |r_i - r_j| \), and the like. Expressed mathematically,

\[
d_{ij} = f(|s_i - s_j|, |m_i - m_j|, |r_i - r_j|)
\]

(2.2)

The relatedness of the businesses \( i \) and \( j \) is \((1 - d_{ij})\).

Rumelt operationalized this measure of relatedness by putting all businesses of a firm on a chart in the form of boxes and drawing links that connected two boxes if the two businesses either required similar skills or resources or had similar markets. For instance, Carborundum's businesses of abrasives, high temperature ceramics, and resistors, and heating elements were related to its silicon carbide and aluminium oxide business. On the other hand, GAF's asphalt roofing, siding, and sheet floor covering businesses were clearly unrelated to any of its other businesses of dyes and pigments, industrial chemicals, photographic equipments and chemicals, and business machines and forms.

Rumelt's definition of relatedness is extremely insightful and conceptually sound, and he indicates that he achieved general agreement about which businesses were unrelated to any other activity of the firm (Rumelt 1974:15-16). However, while his measures of firm diversification have been validated by Christensen and Montgomery (1981), his measure of relatedness of businesses is yet to be validated by other researchers. Moreover, even though Rumelt's classifications of businesses into related and unrelated categories are remarkably consistent, they violate [R4] for several businesses. For instance, he classifies the magazine publishing and cable TV businesses of Time as related, and the newspaper publishing and the magazine publishing
businesses of Time Mirror as related, but the newspaper and the cable TV businesses of Time Mirror are classified as unrelated (Rumelt, 1974:174).

Thus, Rumelt's measures do not satisfy the axiomatic properties required of measures of relatedness. Their usefulness in theoretical or empirical research therefore is limited. This should not, however, detract us from the quality of Rumelt's classifications. Rather, this illustrates the value of rigor in theory building as provided by an axiomatic approach such as the above. Had Rumelt conceived of his measure of relatedness formally as distance and applied [R1]-[R4] for the purpose of validating the resulting classifications, perhaps he would have been even more consistent.

*SIC Code Based Measures of Relatedness:* Several researchers (Berry, 1975; Palepu, 1985; Montgomery, 1992) have used an SIC code based measure of relatedness. Under this scheme businesses falling within the same 2-digit SIC categories are considered related while those falling across 2-digit SIC categories are considered unrelated. Caves, Porter, and Spence (1980) and Wernerfelt and Montgomery (1988a) use a variation of the above in which they assign a distance of zero to businesses within the same 3-digit SIC category, a distance of one to businesses within the same 2-digit SIC category, and a distance of two to businesses across 2-digit SIC categories.

Like Rumelt's measure of relatedness, the SIC code based measure of relatedness can be considered an objective measure, independent of researchers' subjective judgement. But, unlike Rumelt's measure, an SIC code based measure of relatedness satisfies [R1]-[R4] and is a metric. However, such a measure of relatedness is less defensible on conceptual grounds. Under this scheme crude oil production (SIC 1311) and refining (SIC 2911) are unrelated businesses.
An Empirical Definition: Relatedness as Distance along Competition

An empirical definition is one that a real human observer (a researcher
or a manager) actually uses as a rule when making a judgement on the
relatedness of two businesses. Ideally, an empirical definition should be as
close to the normative definition as possible. If the variables in the
normative definition of relatedness could be operationalized empirically then
the two levels of definition would coincide. However, as the variables in the
normative definition are difficult to measure empirically, an empirical
definition will actually measure a surrogate of relatedness. Since an
empirical definition of relatedness is supposed to yield measures to be used
in empirical studies for the purpose of theory building and testing, it must
be based upon variables that can be numerically represented and will ideally
be built around explicit axiomatic expressions.

We will now describe what we consider to be a more promising approach
towards measuring the relatedness of two businesses. The measure is based on
multiple point competition (Wernerfelt and Karnani, 1985), i.e., common
competitors across businesses. In a mature economy such as the U.S., where
most large and medium size firms have diversified into more than one business,
and where most firms have indeed diversified into related areas (Berry
1971:383; Needham 1978:210), the probability of a firm being in two businesses
i and j simultaneously can be considered to be a function of the distance d_{ij}
between the two businesses in terms of skills, markets, resources, and the
like.

\[(1 - P_{ij}) = F(\vert s_i - s_j \vert, \vert m_i - m_j \vert, \vert r_i - r_j \vert) \]  \hspace{2cm} (2.3)

It follows from (2.2) and (2.3) that the distance between two businesses is a
function of the probability of a firm being in both simultaneously.

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\[ d_{ij} = f[F^{-1}(1 - P_{ij})] \]

Lemelin (1982) empirically tested the above proposition with success. He used a probit regression to test the hypothesis that the probability of a firm in industry \( i \) also operating in industry \( j \) was high if the two industries were related. He used five relatedness variables—a correlation coefficient across industry input structures from the input-output tables of Canada, a dichotomous variable that assumed the value of 1 if both industries \( i \) and \( j \) were either producer goods, or convenience goods, or consumer goods, two variables reflecting the amount of input bought by the industries from each other, and a dummy variable for science based industries which are likely to have wide linkages. His results were statistically highly significant, with all coefficients in the expected direction and established that the relatedness of two businesses across the multiple dimensions of markets, technologies, and resources was fully captured by the single dimension of the probability of a firm being in both businesses simultaneously.

A probability based measure of relatedness has other advantages. It is continuous, and a measure of distance or diversity could be constructed from it that would be a metric. Unfortunately, the measure of relatedness that Lemlin had used does not directly result in a metric measure of distance between two businesses. Lemlin had used the probability of a firm being in two businesses simultaneously as a measure of relatedness. The conjugate of that probability—the probability of a firm not being in two businesses simultaneously—does satisfy [R2]–[R3], i.e., it satisfies the triangle inequality and two other axioms, but does not satisfy [R1] and is not a metric.

To see this consider the multiple point competition matrix shown in
Table 2.1. Let there be ten firms operating in one or more of three businesses. Firms 1 and 2 are operating in all three businesses 1, 2, and 3, while the other eight firms are operating in business 3 only. Businesses 1 and 2 have identical competitor profiles and should be considered highly related. But according to this measure, the distance between them is 0.8.

Fortunately, a modification of the above concept results in a proper metric. Consider the distance between two businesses given by the probability of only one firm operating in any one of the two businesses. This distance is a metric. We express this in the following theorem:

**Theorem 1:** In a given sample of companies the probability of a firm operating in only one of the two businesses 1 and 2 constitutes a metric.

**Proof:** Consider again the matrix of multiple point competition for three businesses 1, 2, and 3 shown in Table 2.1. The number of companies in the sample is m. The distance between any two businesses is given by

\[
d_{12} = \frac{(\Sigma |x_{11} - x_{12}|)}{m}
\]

\[
d_{13} = \frac{(\Sigma |x_{11} - x_{13}|)}{m}
\]

\[
d_{23} = \frac{(\Sigma |x_{12} - x_{13}|)}{m}
\]

If \(d_{12} = 0\) then we assume that the two businesses are not different [R1]. If \(d_{12} \neq 0\) then the two businesses are not the same [R2]. Also, \(d_{12} = d_{21}\) [R3]. We write the triangle inequality [R4] as

\[d_{12} \leq d_{23} + d_{13}\]

or, \(\frac{(\Sigma |x_{11} - x_{12}|)}{m} \leq \frac{(\Sigma |x_{11} - x_{13}|)}{m} + \frac{(\Sigma |x_{11} - x_{13}|)}{m}\)

or, \(|x_{12} - x_{13}| + |x_{11} - x_{13}| - |x_{11} - x_{12}| \geq 0\)

If \(|x_{11} - x_{12}| = 0\) then the above is obviously true. If \(|x_{11} - x_{12}| \neq 0\) then either \(x_{11} = 0\) and \(x_{12} = 1\), or \(x_{11} = 1\) and \(x_{12} = 0\). In the former case, if \(x_{13} = 0\) then \(|x_{12} - x_{13}| = 1\), and if \(x_{13} = 1\) then \(|x_{11} - x_{13}| = 1\), so the inequality is
satisfied. A similar reasoning applies in the latter case. So, in all cases the above inequality is true. Q.E.D.

The conjugate of this metric would give us a measure of relatedness of two businesses in terms of the probability of a firm not being in only one of the two businesses. Because of the binary nature of the data this metric is proportional to the squared Euclidean metric [i.e. \( \sum (x_{ij} - x_{kl})^2 \)]. As we will demonstrate later, this metric is generalizable to the case of more than two businesses for the purpose of measuring the total diversification of a firm and is therefore also suitable for use in empirical studies on firm diversification.

ON THE MEASUREMENT OF DIVERSIFICATION

Pitts and Hopkins (1982) have pointed out that the results obtained by empirical studies on diversification had been dependent upon the measure of diversification used. Most studies using the categorical measures of diversification of the type used by Rumelt (1974) found a positive association between related diversification and profitability in the U.S. On the other hand, studies in the area of IO (Berry, 1975; Mueller, 1986), most of which used a Hirschman-Herfindahl type index of diversification, generally failed to find any statistically significant relationship between diversification and performance. It appears, therefore, that the results from these studies are measure specific. The question of measurement of diversification is, therefore, not one of researcher's choice, but must be justified on axiomatic grounds if we are to have any confidence in the results based on these measures. Following the framework developed earlier, we will present
definitions of firm diversification also at three different levels—normative, objective, and empirical.

A Normative Definition of Firm Diversification

In case of a firm operating in n businesses, the analogous form of equation (2.1) will be:

\[ c_i^d = C_i (1-D) + C_i D \]  \hspace{1cm} (2.4)

where \( c_i^d \) denotes the cost of firm i diversifying into an industry at distance d from origin. \( C_i = [c_1, \ldots, c_n] \) is the vector of firm i’s costs in its n existing businesses, and D is the vector of distances of firm i’s existing businesses from the industry at distance d from origin. For each of the n businesses of firm i we can construct a vector \( D_i = [d_{i1}, \ldots, d_{in}] \) comprising distances of business j from each of the other businesses of the firm along the dimension of cost. These vectors taken together form a matrix D that represents the diversification strategy of firm i.

\[
D(j,k) = \begin{bmatrix}
d_{11} & d_{12} & d_{13} & \ldots & d_{1,n-1} & d_{1,n} \\
d_{21} & d_{22} & d_{23} & \ldots & d_{2,n-1} & d_{2,n} \\
d_{31} & d_{32} & d_{33} & \ldots & d_{3,n-1} & d_{3,n} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
\vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
d_{n1} & d_{n2} & d_{n3} & \ldots & d_{n,n-1} & d_{n,n}
\end{bmatrix} \hspace{1cm} (2.5)
\]

If a firm is operating in highly related areas then all elements in the D matrix will be close to zero. On the other hand, if the firm is diversified into unrelated areas then all elements in the D matrix will be close to 1. A summary measure of firm diversification can now be constructed by averaging the elements in the D matrix. Thus, a normative measure of firm diversification will be the average distance between any two businesses of a firm measured along the dimension of cost. This is a continuous measure
according to which firms operating in a set of closely related businesses will have lower indices of diversification, while those operating in highly unrelated areas will have higher indices of diversification.

Unlike other continuous measures of diversification which treat single business firms as highly related diversifiers (for instance, the HHI type index of diversification of a single business firm is defined as zero which is the lowest value of diversification on a continuum of 0-1), this measure of diversification is undefined for a single business firm. Thus, our measure of firm diversification, in fact, comprises an initial classification of firms into single and multiple business firms and then a continuous measure of diversification for those firms that operate in multiple businesses. In this sense this measure of diversification is nearer to Rumelt’s classification than to the continuous measures of diversification used in the literature.

*Axioms for Measures of Firm Diversification*: Our normative measure of diversification is given by the average element \( d_{ij} \) of the D matrix in (2.5) above, i.e., by the average distance between two businesses of the firms along the dimension of cost. Ideally, any surrogate measure of diversification \( d \), therefore, should correlate with \( d_{ij} \), (i.e., \( \partial d_{ij}/\partial d > 0 \)). However, the need for a surrogate for \( d_{ij} \) arises because we cannot measure it directly. For the same reason we will not be able to directly observe the correlation between \( d_{ij} \) and a proposed measure of diversification \( d \). But we do know that \( d_{ij} \) is a function of the characteristics of firm’s businesses. Therefore, any measure of diversification \( d \) must be a function of the characteristics of firm’s businesses, i.e., \( d = d(a_i, a_j) \), where \( a_i \) and \( a_j \) are the relevant characteristics of businesses \( i \) and \( j \). Again, we may not be able to know the exact nature of \( a_i \) and \( a_j \), but the above reasoning does suggest that \( d(a_i, a_j) = d(a_p, a_q) \) if the set of businesses \( i \) and \( j \) is identical to the set of
businesses $p$ and $q$, i.e., if $\{i, j\} = \{p, q\}$.

Second, in our opinion, in equilibrium, the profit maximizing strategies for firms with low and high costs are different—it is too costly for a high cost firm to diversify into a related area and it is generally not a profit maximizing strategy for the low cost firm to diversify into an unrelated area—diversification is associated with and is an important indicator of the profitability of the firm (Sinha, 1990). In this sense, Jervis (1989) would consider a measure of diversification $d$ an index of corporate profitability. According to Jervis (1989:18), "indices are statements or actions that carry some inherent evidence that the image projected is correct because they are believed to be inextricably linked to the actor's capabilities or intentions. Behavior that constitutes an index is believed by the perceivers to tap dimensions of characteristics that will influence or predict an actor's later behavior and to be beyond the ability of the actor to control for the purpose of projecting a misleading image."

Spence (1974:10) also reserves the word index for "observable unalterable characteristics," and uses the word "signal" to indicate the characteristics within the control of a person. The primary distinction between an index and a signal is between manipulable and non-manipulable characteristics, attributes, or activities. Interestingly, companies do try to manipulate their image as a diversified firm outside by sending signals that are within their control. In the U.K., for instance, where conglomerate diversification had been more profitable, the chairman of one of the leading confectioners boasted of the "bold new diversification the company had made by successfully launching chocolate-coated wholemeal snack biscuits. It mattered not that the company drew a substantial portion of its income from an existing range of chocolate covered snack biscuits, it simply mattered that
diversification—the thing to do—should be linked with the company name” (Luffman and Reed, 1986:30). In the U.S., on the other hand, where related diversification is generally more profitable, companies take pains to explain to the public the synergy that exists between their current businesses and the new acquisition (see for instance, the annual reports of Xerox Corporation, explaining its entry into the financial services business).

And finally, a measure of diversification should be such as to separate out the less profitable firms from the more profitable ones in a profitable industry (Rumelt, 1974; Christensen and Montgomery, 1982). A measure of diversification must maintain this nature of the equilibrium at least analytically. Diversification can not be measured by a variable that may have one single value for all profit maximizing firms in equilibrium under all conditions.

Based upon the above we now propose a set of axioms that a measure of diversification suitable for theory building and empirical investigation into the association between firm diversification and profitability must satisfy.

[D1]. A measure of firm diversification should result in identical values for two firms having identical sets of businesses. That is,

\[ d(a_i, a_j, a_k) = d(a_p, a_q, a_r) \text{ if } \{i, j, k\} = \{p, q, r\}. \]

[D2]. A firm must not be able to change its measure of diversification costlessly. That is,

\[ \Delta C(\Delta d) > 0 \]

where \( \Delta C(\Delta d) \) is the cost of any change in diversification.

[D2]. For the symmetric case, that is, for the case where all businesses of a firm are equally related or unrelated to each other, a measure of firm diversification should not decrease with the number of businesses. That is:

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\[ \frac{\partial d}{\partial n} \geq 0 \text{ if } d_{ij} = d_{jk} \text{ for all } i, j, k. \]

Though the above axioms are largely self explanatory, because they represent a break from tradition in the area of SM, some explanation seems necessary.

First, we conceive of a measure of firm diversification as a measure of firm's strategy [hence the title of Rumelt's (1974) *Strategy, Structure and Economic Performance*]—its relatively long term decisions to be in certain businesses (Andrews, 1975)—that could be changed by the firm only in the medium to long term through entry into or exit from certain businesses. In particular, this means that a measure of firm diversification should not depend upon the shares of different businesses in firm's revenue that change every year depending upon external factors and without any strategic action on the part of the firm. The first axiom is a formal expression of this simple fact and means that a measure of firm diversification, \( d \), should only be a function of the characteristics of businesses the firm is in. In our normative definition the measure of diversification depends only upon the distances, \( d_{ij} \)  

\[ (i, j = 1, \ldots, n), \text{ between the businesses the firm is in. That is,} \]

\[ d = d(d_{i2}, \ldots, d_{in}, d_{n-1,n}) \]

Since the elements (\( d_{ij} \)'s) of the matrix \( D \) in (2.5) depend only upon the characteristics of the two businesses, the above measure of firm diversification is completely determined by the businesses a firm is in and can not be changed in the short term without entering into a new business or exiting from an existing one. In particular, the value of \( d \) does not depend upon the share of different businesses in firm's revenue (or assets), i.e.,

\[ \frac{\partial d}{\partial p_i} = 0 \text{ where } p_i \text{ is the share of business } i \text{ in firm's revenue (or assets).} \]

A corollary of the above can be stated as follows:

*Corollary: A measure of firm diversification should not increase if the*
firm acquires another firm whose products are identical to the firm's existing products.

This corollary is a formalization of the idea that capacity expansion is not diversification. Since a firm can expand its capacity through acquisition, such acquisition should not result in changes in its diversification status.

The third axiom is a simple statement of the fact that, other things being equal, a firm with more number of businesses is more diversified. This axiom is satisfied by the above measure in the limit.

Two Objective Definitions of Diversification

In Table 1.1 we had summarized the various measures used by researchers to operationalize the concept of firm diversification. Here we will restrict our discussion to two of these measures frequently used by researchers in SM and IO. Both can be called objective definitions of firm diversification as they are based on detailed procedures that eliminate the element of subjectivity and make the measures independent of the judgement of the researchers. However, as we will demonstrate below, these measures do not satisfy the axioms [D1]-[D3] proposed above and their suitability for the purpose of theory building and empirical research is therefore limited.

Categorical Measures: The most frequently used measure of firm diversification in the area of SM is one by Rumelt (1974) who had refined a categorical measure of diversification earlier used by Wrigley (1970). He arrived at nine categories of diversification by charting technological, marketing, and economic links between various businesses of a firm and by assessing three ratios that he called specialization ratio, related ratio, and vertical ratio that reflected the percentages of firm's revenue attributable to a specialized area, to related areas, and to vertically linked areas.
Rumelt's procedure for classifying firms into nine categories is time consuming, but quite objective. Christensen and Montgomery (1981) validated his categories with a correlation of over 0.9. Rumelt's categories also capture the essence of diversification strategy well and that has been the reason for their repeated use by other researchers. Montgomery (1982) criticised Rumelt's measure of diversification for being categorical rather than continuous. However, we do not consider this a disadvantage as, in our opinion, in equilibrium firms are likely to diversify into either highly related or highly unrelated areas (Sinha, 1990). The real problem with Rumelt's measure of diversification lies in its being based primarily upon his measure of relatedness which, as we have seen earlier, is not a metric.

**SIC code based indices:** The generic form of such an index is:

\[ d = 1 - \sum p_i u_i \]

where \( p_i \) is the share of the \( i \)th business in firm's total sales, and \( u_i \) is a weight assigned by the researcher. Following the Hirschman-Herfindahl index of industry concentration, Berry (1975) weighted each business share by itself:

\[ d = 1 - \sum p_i^2 \]

When there is one firm in an industry, the HHI index of concentration is 1. But for a single product firm the index of diversification is zero. Hence the subtraction from 1 above. No such subtraction was needed when Jacquemin and Berry (1979) used \( \log(1/p_i) \) as weight to obtain the entropy index:

\[ d = \sum p_i \log(1/p_i) \]

Palepu (1985) used the additivity of the entropy measure to decompose the total diversification into two indices of diversification—within and across 2-digit SIC categories—that served as proxies for related and unrelated diversification.

Unlike Rumelt's categories, the SIC code based indices yield continuous
measures of diversification and are based on a measure of relatedness that is a metric. But the decomposition of the entropy measure into two indices measuring related and unrelated diversification is less defensible on conceptual grounds. As we pointed out earlier, under this scheme crude oil production (SIC 1311) and refining (SIC 2911) are unrelated businesses.

The above indices are based on the indices of industry concentration. Encoua and Jacquemin (1980) give an axiomatic derivation of "allowable" concentration indices. They require a concentration index \( R(a_1, \ldots, a_n) \) to satisfy the following properties:

1. it must be symmetric between firms (invariant to permutations of market shares between firms).
2. satisfy the Lorenz condition that a mean preserving spread increases \( R \).
3. the concentration for symmetric firms decreases when the number of firms grows from \( n \) to \( n + 1 \).

They show that a family of concentration indices satisfying these properties takes the form \( R = \sum a_i h(a_i) \) where \( h \) is an arbitrary non decreasing function such that \( a_i h(a_i) \) is convex. The HHI and the entropy indices satisfy these properties. Moreover, these indices have been shown to be related to the Lerner index, and in the case of symmetric Cournot oligopoly, the profits of a firm are directly proportional to the HHI.

But if the above indices are to be used as measures of diversification, then they must also conform to our idea of diversification. The first axiom [D1] proposed earlier for measures of diversification rules out measures based on any scheme for weighting the businesses of the firm such as the entropy or the HHI type index of diversification. If firm diversification is measured by any of the above indices then a firm can increase its index of diversification
without entering into a new business, and can reduce its index of diversification without exiting from any business. In fact, if sales revenues were used then firm’s diversification index could change overnight due to (oil) price changes without any change in its product mix. Such a measure of diversification measures anything but the strategy of the firm.

Another problem with the indices of diversification of the type that use some scheme of weighting of firm’s businesses is that, for the purpose of studying the association between diversification and profitability, these measures could systematically underestimate the level of (unrelated) diversification of less profitable firms, and thereby fail to uncover any association between profitability and diversification. To illustrate this we will consider a hypothetical example.

Consider two firms A and B. A is highly profitable, B is not. B diversifies into an unrelated area, draws a bad lottery, diversifies into another unrelated area, and draws another bad lottery, ..., its tenth attempt at diversification is somewhat successful. Now it has eleven businesses, it has not divested any. As the eleventh business is more profitable than the rest, it puts more money in this business. After some time this business comes to account for 60% of its sales, the other ten businesses account for the rest 40%. Its HHI type index of diversification is 0.62. Firm A, on the other hand, diversifies into a related area in which it remains profitable. Then it diversifies into another related area in which it again remains profitable. It has three highly profitable businesses. So, it invests highly in all three. At a point of time, let us assume that the first business accounts for 50% of its revenue, the second business accounts for 30% of its revenue, and the third business accounts for 20% of its revenue. Its HHI type index of diversification is 0.62.
According to the Wrigley-Rumelt categories of diversification, firm B is an unrelated diversifier, while firm A is a related diversifier, and the case of the above two firms supports the notion that related diversification is associated with higher profits. But if we use the HHI type index of diversification then there is no association between diversification and performance. In fact, the less profitable firm is more likely to put even greater percentage of its resources in the businesses that are relatively more profitable while maintaining a minimum level of presence in other businesses, perhaps waiting to sell out. Such a strategy would result in a small HHI index of diversification for the less profitable firms and a positive association between an HHI type index of diversification and profitability. These observations mean that the axioms indicated by Encoua and Jacquemin above are not suitable for a measure of diversification.

An Empirical Definition of Diversification

We now demonstrate that a measure of diversification derived from the probability based measure of relatedness that we discussed earlier would satisfy [D1]–[D3]. This concept of probability accords closely with our notion of diversification. Most people would consider a firm that produces laundry detergents and dishwasher liquid, both accounting for equal shares of its revenue, much less diversified than another obtaining half of its revenue from table salt and the other half from rocket fuel—though both will have the same HHI type index of diversification. There are many firms producing both laundry detergents and dishwasher liquid—these are highly related businesses. There is only one firm producing both table salt and rocket fuel.

The metric measure of distance based on multiple point competition is readily extended to the case of n businesses and can be shown to satisfy [D1]–
[D3]. Consider a firm operating in n businesses. The distance between its businesses i and j is given by \( d_{ij} \), which is the probability of a firm operating in only one of the two businesses. As demonstrated earlier, this distance measure is a metric. For the n businesses of the firm there are \( n(n-1)/2 \) unique pairs of businesses and \( n(n-1)/2 \) distances. A measure of total diversification of the firm then can be expressed as

\[
D = \frac{2}{n(n-1)} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} d_{ij}, \quad i \neq j.
\]

This D depends only on the characteristics of the businesses \( \{i, j, \ldots, n\} \) the firm is in [D1] and, in particular, is independent of the shares of different businesses in firm's revenue (or assets). A firm can not change D without incurring the cost of entering into or exiting from a business [D2]. If all the \( d_{ij} \)s for a firm are same then its measure of diversification, D, will remain unchanged as it acquires a new business, i.e., \( \partial D/\partial n = 0 \). Thus, D satisfies [D3] in the limit.
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CHAPTER III

THE RELATIONSHIP BETWEEN DIVERSIFICATION AND PROFITABILITY
DIVERSIFICATION AND PROFITABILITY

Even though the association between firm diversification and economic performance represents a major stream of research in the area of SM, most researchers have typically estimated largely similar models with simple effects without interaction terms that could be written as

\[ r_i = \mu + \alpha_j + \beta D_i + \varepsilon_i \]

where \( r_i \) represents a measure of the profitability of firm \( i \), \( \mu \) is the mean profitability of firms, \( \alpha_j \) is the effect of industry \( j \) which the firm \( i \) belongs to on the profitability of the firm, \( \beta \) is the overall effect of firm diversification on profitability, \( D_i \) is a measure of diversification for firm \( i \), and \( \varepsilon_i \) is the random error term for the firm. Since our measure of diversification also includes a separate classification for single business firms, our analogue to the above model will be:

\[ r_i = \mu + \alpha_j + \beta D_i + \gamma + \varepsilon_i \]  

(3.1)

where \( \gamma \) is the effect on profitability of firm's status as a single business firm.

The Model

For the sake of comparison with earlier research, we will estimate equation (3.1) above. However, as there are several reasons to expect systematic differences in the relationship between diversification and performance across industries (Christensen and Montgomery, 1982), we will investigate the interaction between diversification and industry and estimate separate slopes for diversification in different industries. For ease of interpretation of the effects of various interactions, we will concentrate on segment level profitability of firms in the manner done by Schmalensee (1986).

Following Schmalensee (1986), we will use an analysis of (co)variance
framework. Let the profitability of a segment of a firm be expressed as:

\[ r_{ij} = \mu + \alpha_j + \beta D_i + \gamma + (\alpha \beta)_j D_i + (\alpha \gamma)_j + \epsilon_{ij} \]  \hspace{1cm} (3.2)

where \( r_{ij} \) is the profitability of firm \( i \)'s operations in industry \( j \), \( \mu \) is the average profitability of all business segments of firms in the sample, \( \alpha_j \) is the effect of industry \( j \) on the profitability of firm \( i \)'s operation in that industry, \( \beta \) is the impact of firm diversification on the profitability of its segment, \( D_i \) is a measure of firm diversification, \( \gamma \) is the effect on profitability of a firm's status as a single business firm, \( (\alpha \beta)_j \) is the impact of firm diversification on profitability specific to industry \( j \), \( (\alpha \gamma)_j \) is the impact on profitability of firm's status as a single business firm specific to industry \( j \), and \( \epsilon_{ij} \) is the random error term for firm \( i \)'s operations in industry \( j \).

If our analysis does indeed result in statistically significant interaction terms \( (\alpha \beta)_j \) and \( (\alpha \gamma)_j \), and statistically insignificant \( \beta \) and \( \gamma \), then we will estimate a reduced model of the form:

\[ r_{ij} = \mu + \alpha_j + (\alpha \beta)_j D_i + (\alpha \gamma)_j + \epsilon_{ij} \]  \hspace{1cm} (3.3)

Model (3.3) is the nested analysis of covariance model that estimates separate slopes of diversification in each industry. Statisticians consider interpretation of nested models such as (3.3) above, in general, difficult and are particularly suspicious of analysis of variance designs with unequal cell sizes as is the case with most studies of firm profitability across industries (for instance, Schmalensee, 1986). A model as complex as (3.3) would pose special problems of interpretation, more so because we would also like to test specific hypotheses relating to the correlations between parameters across segments.

For the profitability of the firm, a model analogous to (3.2) would be:

\[ r_i = \mu + \sum \alpha_j p_{ij} + \beta D_i + \gamma + \sum (\alpha \beta)_j D_i \cdot p_{ij} + (\alpha \gamma)_j + \epsilon_{ij} \]  \hspace{1cm} (3.4)
where \( p_{ij} \) is the share of firm's operations in industry \( j \) in firm's total revenue. The weighted parameters add greatly to the complexity of this model. While the parameters can be estimated and hypothesis relating to correlation between them can be tested, the increased complexity is not warranted for the purpose of investigating hypotheses that can also be tested with a simpler model such as (3.2). For this reason, we will concentrate our effort on estimating model (3.1), (3.2) and (3.3) above with segment level data on firm profitability.

The Hypotheses

Rumelt (1982) and Christensen and Montgomery (1981) earlier had reported statistically significant industry effect. They had tested the hypothesis that, in a model such as (3.1), the coefficient \( \alpha_i \) for at least one industry \( k \) was significantly different from that for some other industry, i.e.,

\[
\alpha_i \neq \alpha_j \text{ for some } k \neq j.
\]

In their research, low firm diversity overall was associated with higher economic performance, but after partitioning out the effect of industry on firm's economic performance, the relationship between diversification and firm profitability was only weak. Their results, therefore, were not entirely inconsistent with a hypothesis that there was no appreciable difference between the performances of related and unrelated diversifiers within an industry. Since we expect that the relationship between diversification and profitability will vary systematically across industries—a negative association between diversification and performance in highly profitable industries, and no association between diversification and performance in less profitable industries—we can formally state the first hypothesis from the model as:
Hypothesis 1: The association between profitability and diversification will be different for different industries:

\[(\alpha^*\beta)_j \neq (\alpha^*\beta)_k\] for some \(j \neq k\);

where \((\alpha^*\beta)_j\) represents the regression coefficient of the interaction term of diversification and industry \(j\).

We also expect that the coefficient of diversification will be large and negative for profitable industries and non-negative for the less profitable ones. This allows us to express our second hypothesis:

Hypothesis 2: The regression coefficients of diversification \((\alpha^*\beta)_j\) and industry dummy \((\alpha_j)\) will be negatively correlated.

In addition, firms that diversified into related areas were to be found in highly profitable industries (Christensen and Montgomery, 1982). We can now state this formally as our third hypothesis:

Hypothesis 3: Firm diversification \((D_j)\) and industry profitability \((\alpha_j)\) will be negatively correlated.

In Rumelt's (1982) and Christensen and Montgomery's (1981) studies of the Fortune 500 firms, after controlling for industry, the single product firms were among the most profitable. However, the sample of firms in both these studies had been limited to the Fortune 500. In a large sample, single business firms are likely to be among the new entrants who may have to incur expenses relating to formation of an organization and the like. Their expected profit therefore may be lower than that of established diversified firms.
(Sinha, 1990). Hence our fourth hypothesis:

_Hypothesis 4:_ Single product firms will earn low expected profit in their industries, i.e., \( \gamma < 0 \).

In addition, in the absence of entry barriers, the single business firms will enter businesses with high expected profits only to see the expected profits go down as a result of such entry. Ultimately, the expected profit of all single business firms then will be the same across all industries. This hypothesis can be written as:

_Hypothesis 5:_ \((\alpha^*\gamma)_{j} = (\alpha^*\gamma)_{k} < 0\) for all \(j \neq k\).

Finally, we have claimed that an HHI type index of diversification may exhibit a non negative association with profitability. We express this formally as

_Hypothesis 6:_ There will be a non negative association between the HHI type index of diversification and firm profitability.

The Data

The data for our analysis come from Standard and Poor's COMPSTAT for the year 1986 that contains time series financial information from the annual reports of all NYSE and AMEX companies. There are over 7,000 companies in this database whose average sales during the years 1982-1986 ranged from less than $1 million to over $86 billion. Of these companies, over 5,700 operated in two or more 4-digit SIC industries. Table 3.1 shows some characteristics of this
sample of companies.

In addition to reporting overall financial information, these companies are required by the Securities and Exchange Commission (SEC) to report summary financial information for each distinct business segment that accounts for more than 10% of their revenue. In 1986, the over 7,000 companies in the COMPUSTAT database reported financial information relating to over 10,000 business segments. SEC, however, does not require the companies to report financial information by SIC codes. Standard and Poor's assigns a primary and a secondary 4-digit SIC code to each business segment reported by the firms.

We used a one year (1986) ratio of operating profit to sales as a measure of segment profitability of the firms. This is similar to the return-on-sales measure used by Ravenscraft (1981; 1982) in his study of the FTC data on the profitability of lines of businesses. Schmalensee (1986), on the other hand, used a return-on-total-assets measure in a similar study of the profitability of lines of businesses, arguing that it was superior on theoretical grounds. In the COMPUSTAT database, however, the operating-profit-to-sales ratio is the only clean measure of profitability available at the segment level. Though several companies report identifiable assets for the segments, in general, these do not add up to the total assets of the firm and their use for calculating the profitability of segments therefore is not advisable.

We used the metric measure of distance between two businesses defined earlier as the probability of a firm being in only one of them. The average distance between any pair of businesses of the firms gave us a measure of firm diversification. To calculate this we created a multiple point competition matrix of the type shown in Table 2.1 for each firm using data from Standard and Poor's COMPUSTAT which also provides up to ninety 4-digit SIC codes for
all of the over 7,000 companies in the database. In 1986, the maximum number
of 4-digit SIC codes a firm was operating in was 49. The multiple point
competition matrix of a firm was a binary matrix with about 5,700 rows
representing the diversified companies in the database and up to 49 columns.
Because of the large number of companies in the dataset, the distance between
any two businesses measured as the probability of a firm being in only one of
these was small. We therefore normalized the diversification indices of firms
in the range (0, 1) by dividing them by the largest value for the index for a
firm in our sample. In addition, because this index of diversification is not
defined for single business firms, we created a dummy variable to represent
the single business firms to which COMPUSTAT had assigned only one 4-digit SIC
code.

Following Schmalensee (1986), we used dummy variables to represent
industry effects. King (1979) had earlier shown that the profitability
differences that exist across 2-digit SIC categories are much larger than
those that exist within. In their study of diversification and profitability,
Wernerfelt and Montgomery (1988a), also used industry dummies at the two digit
level. For these reasons, we considered the creation of dummy variables at the
level of 2-digit for the primary SIC codes of the business segments
sufficient.

In an analysis of variance design with unequal cell sizes, cells with
very few entries can result in inflated F-statistics (Tabachnik and Fidell,
1983). We therefore eliminated cells with four or fewer business segments. We
also eliminated segments with sales of less than $1 million in 1986. In
addition, we discarded four outliers that had operating profitability beyond
the 5σ range. As a result of these deletions, we were ultimately left with a
sample of 8,449 business segments in 67 industries.
Table 3.2 shows the descriptives statistics for variables in our sample. The average normalized diversification index for a firm in our sample was 0.21, indicating that most firms had diversified into highly related areas. This is quite in accordance with Berry's (1975) finding.

The Results

Figure 3.1 shows the summary results from the estimation of equation (3.3) and the restricted models in a manner similar to that used by Schmalensee (1986) and Wernerfelt and Montgomery (1988a). Each node in this figure corresponds to a model the predictor variables in which are listed at the node along with the resulting R², adjusted R², and the estimates for β and γ. Arrows pointing away from a model lead to a reduced model with one restriction imposed in the form of removal of one variable or effect. The p-value associated with the effect removed appears as the label for the arrow.

An inspection of Figure 3.1 reveals that industry is the predominant effect on the profitability of firm's businesses, alone explaining over 18% of the variability in the profitability of business segments of firms. Even the most general model in Figure 3.1 with three main effects and two interaction terms [equation (3.2)] had an adjusted R² just a little over 19%. This result is broadly in agreement with those obtained by King (1966), Schmalensee (1986) and Wernerfelt and Montgomery (1988a). In Schmalensee's study industry accounted for 18% of the variance in the return on assets of the lines of businesses of firms while in Wernerfelt and Montgomery's (1988a) study industry explained 19% of the variance in Tobin's q of firms. King (1966) had found that the industry effect accounted for 20% of the variance in firms' stock prices.

Diversification alone, by comparison, accounts for just over 1% of the
variability in profitability in Figure 3.1 [equation (3.1)] and is negatively associated with operating profit of segments. The size of this effect is broadly comparable with that obtained by Wernerfelt and Montgomery (1980a). In their study diversification accounted for 2% of variability in Tobin's q. Model (D) in Figure 3.1, however, is based on a reduced sample (n = 7,591) of multi-business firms and does not include single business firms. Single business firms form a separate category of diversification for which the metric measure of diversification is undefined. We should therefore look at the models that include the dummy for single business firms.

In Figure 3.1, model (D, S, I) comes the closest to the equations estimated by earlier researchers such as Rumelt (1982) and Christensen and Montgomery (1981). The value and the sign of the regression coefficient of diversification remains about the same even after incorporating industry effect into the model. The sign of the coefficient for the single business firm dummy is negative which provides support for our hypothesis [H4] and is in direct contrast to the high profitability of single business firms in Rumelt's and Christensen and Montgomery's samples.

Table 3.3 shows the variance decomposition for the model in equation (3.1). In this table, because of the unequal number of companies in different industries, we used the regression (or unique sum of squares) approach to the decomposition of variance in which the sums of squares attributed to each variable are calculated after adjusting for all other variables—the so-called Type II sums of squares (Searle, 1988:462). Because of unequal cell sizes, the sums of squares explained by different variables in this approach when added to the residual sum of squares, in general, do not add up to the total sum of squares and the resulting F-statistic for each variable is therefore conservative. For reporting results from analysis of unbalanced data this
approach of partitioning the sum of squares is usually preferred (Bernstein, 1988:145).

With the above in mind, we can now examine the relative importance of industry, diversification, and single business firm dummy effects in Table 3.3. According to this table, if the variance in segment profitability attributable to industry is partitioned out first then the other two variables account for less than 0.5% of the remaining variability in performance. However, if we partition out the variance accounted for by the two other variables (diversification and single business firm dummy), then industry seems to account for only 16% of the variance in the profitability of business segments.

On the right hand side of Table 3.3 we have shown the hierarchical (or Type I) sums of squares with the order of adjustment for variables being diversification, single business firm dummy, and industry. In this method of partitioning the sums of squares do add up to the total. As discussed above, industry in this method of partitioning the sum of squares appears to account for 16% of the variability in our data and diversification accounts for 1.1% of the variability. The single business dummy accounts for only 0.03% of the variability and its regression coefficient is statistically not significant.

At the bottom of Figure 3.1 is the most general model [relating to equation (3.2)] possible with three variables and two interaction terms. The resulting R² of 0.205 and the adjusted R² of 0.19 are the largest in this Figure for any model. The F-statistics relating to both interaction terms—between diversification and industry and between single business firm dummy and industry—were significant at p = .000. The high statistical significance of the effect of interaction between diversification and industry means that the regression coefficient for diversification in at least one
industry i is significantly different from that in some other industry j (H1). However, the high statistical significance for the effect of interaction between single business firm dummy and industry indicates that the profitability of single business firms varied from one industry to another. Thus our hypothesis (H5) does not appear to be valid for our data.

The coefficients of diversification and single business firm dummy were statistically not significantly different from zero in this model after the estimation of the coefficients for their interaction terms with industry. Removal of these two terms brought us to the separate slopes or nested model of equation (3.3) without loss in explanatory power (R² = 0.205; adjusted R² = 0.19). This model comprises three effects—the industry effect, the effect of diversification nested within industry (i.e., separate slopes for diversification for each industry), and the effect of single business firm dummy within each industry. All three effects are statistically significant at p = .000 (Table 3.4). The high level of statistical significance of the effect of diversification within industry means that the regression coefficient for diversification in at least one industry j is significantly different from zero. Similarly, the high level of statistical significance for the effect of single business firm dummy within industry indicates that the profitability of single business firms in at least one industry j is significantly different from the mean profitability for all business segments of firms in the sample.

Table 3.4 shows the variance decomposition for equation (3.3) using the method of unique sum of squares. Even though industry continues to remain the single most important effect, after accounting for the effects of diversification and single business firms within all industries, the industry effect is reduced to only 3% of the total variance. On the other hand, after accounting for industry effect, the separate slopes for diversification and
single business firm dummy together would account for 4% of the variance in segment profit. This reduction in the contribution of industry effect to total variability in firm performance after partitioning out the effect of variability due to certain industry specific effects is consistent with previous research. In Wernerfelt and Montgomery's (1988a) study, while industry effect accounted for 19% of the variation in the model with market share and diversification, it accounted for only 12% of the variation after adjusting for industry R&D and advertising intensities.

We now round up our analysis with the investigation of the correlation between estimated parameters across segments. According to Christensen and Montgomery (1982), related diversifiers were to be found in more profitable industries. This would mean that we could expect a negative correlation between our measure of diversification and industry profitability [H3]. Also, since profitable firms in profitable industries diversify into related areas (Christensen and Montgomery, 1982; Sinha, 1990), we would expect a negative correlation between industry profitability and the regression coefficient of diversification within the industry [H2]. Table 3.4 shows the correlations between the relevant parameters across segments. Both the correlations are negative and statistically significant at p < .000, lending strong support to our hypotheses. The first result is broadly in agreement with results obtained by Christensen and Montgomery (1981) and the second extends their findings in significant ways.

Profitability and HHI-type Index of Diversification

From the above analysis it may appear that our results are no different from those reported earlier in the literature where several other researchers found similar effects of diversification on firm profitability using the HHI
type indices of diversification (Palepu, 1985; Wernerfelt and Montgomery, 1988a). However, we earlier claimed that a profit maximizing firm with high cost may diversify into unrelated areas in search of profitable opportunity. If it does not have any highly profitable businesses then it might concentrate most of its resources in one area that is relatively more profitable, while maintaining a minimum level of presence in other areas, perhaps waiting for an opportunity to sell out. In such a case, an HHI type index of diversification will have only a small value for the unprofitable unrelated diversifier. The profitable firm, on the other hand, might invest heavily in several of its profitable and related businesses, but will have a high HHI-type index of diversification. In such a case, we hypothesized a non negative association between HHI type index of diversification and firm profitability which was the opposite of that reported by earlier researchers.

Figure 3.2 shows the summary results from the estimation of a model similar to one that had been estimated earlier by other researchers:

\[ r_{ij} = \mu + \alpha_i + \beta D_i + \epsilon_{ij} \]

The results in this figure relate to segment profits of firms and \( D_i \) is the HHI-index of diversification given by:

\[ D_i = 1 - \Sigma p_i^2 \]

The effect sizes are similar to those in Figure 3.1. Industry is the dominant influence, but even after controlling for industry the coefficient of diversification is statistically significant. The size of the beta coefficient is also comparable to that obtained for our metric measure of diversification, but its sign is positive. Diversification, as measured by the HHI-type index, appears to have a positive effect on firm performance after controlling for industry. This is quite in accordance with our hypothesis (H6) and is the opposite of the results reported by some other researchers in this stream. We
discuss the implication of this and other findings below.

DISCUSSION OF RESULTS

The results from our analysis vindicate five of the six hypotheses stated earlier. Hypotheses 1, 2, 3, 4, and 6 have all received support at high level of statistical significance, while hypothesis 5 has not received support from the data. The results relating to H1, H2, and H3 had earlier been either reported by other researchers or had been anticipated by them in some form or other (Rumelt, 1982; Christensen and Montgomery, 1981). However, the results relating to H4, and H6 are directly opposite to those obtained by some researchers in the past and deserve explanation. In addition, we will discuss some possible reasons for lack of support for H5, and for the relatively small size of the effect of diversification on firm profitability.

The Profitability of Single Business Firms

In some of the most widely cited previous studies of diversification (Rumelt, 1982; Christensen and Montgomery, 1981), after controlling for industry, the single product firms were among the most profitable [Rumelt’s (1982) study also found the dominant constrained firms profitable in addition to the single product firms]. We, on the other hand, conceived of single business firms as new entrants or fringe firms who were, on an average, less profitable than other firms. We accordingly hypothesized that single business firms will be less profitable than other firms and found support for the hypothesis in the data.

There are several possible reasons for the difference between our results relating to single business firms and those obtained by Rumelt and others. The sample of most of the previous studies on diversification had been
limited to the five hundred largest firms in the country. Rumelt’s sample comprised 246 of the Fortune 500 companies, while Christensen and Montgomery (1981) had used a subset of Rumelt’s sample. In our opinion, the single product firms in their samples were not representative of the population of single product firms in the economy. These firms had survived, achieved success, and made it to the Fortune 500. They were elites among single product firms and results based on their profitability could hardly be extended to single product firms in the rest of the economy.

Since our sample included all firms listed with NYSE and AMEX, the extent of the above bias is much reduced in our analysis, though it is perhaps not completely absent. Our results indicate that single business firms overall are more profitable than other firms. But after controlling for industry, the operating profit of single business firms as a percentage of their sales was 5.26 points below that for all firms. Single product firms in this sample appear to operate in highly profitable industries. This is as it should be because the purpose of fringe firms is to equalize profits across industries through entry into industries with higher profitability.

However, the widely varying profitabilities of single business firms across industries is not strictly in accordance with our hypothesis (H5). The lack of support for this hypothesis indicates a possible lack of equilibrium, as a result of which the expected profitability of a new entrant is higher in some industries than in others. Such a situation could also arise because of entry barriers in some industries or because of differences in fixed costs across industries. Industries differ in the stage of evolution they are passing through. Since competitive equilibrium in an industry may be achieved only over time, it would have been surprising indeed if we would have found the profitability of single business firms equal across industries.
Nevertheless, the lack of support for this hypothesis might have had impact on the choice of related or unrelated diversification by multi business firms and could have been responsible for diluting the relationship between diversification and profitability in the data.

In addition to the disequilibrium story, there are two other possible reasons for the observed differences in the profitabilities of single business firms across industries in our sample. First, our use of operating profit to sales ratio as a measure of profitability of firms could have contributed to the differences in the profitability of single business firms across industries by preserving industry specific idiosyncracies in depreciation rates and advertising and R&D intensities. The force of this effect is much reduced for the multibusiness firms. This indicates the need for validation of our results by the use of other measures of economic performance of businesses.

And second, in analysis of variance designs with unequal cell sizes the test statistics for effects with small cell sizes are known to be inflated (Tabachnik and Fidell, 1983). In fact, we had deleted cells with four or fewer single business firms to guard against this possibility. Still, there were several industries with only five single business firms. This explanation appears all the more credible when we recall that the coefficient of the single business firm dummy was statistically not significant at the $p = .01$ level in three of the models without interaction terms in Figure 3.1.

HHI-type Index of Diversification

Several researchers in the past used an HHI-type index of diversification for the purpose of investigating the relationship between firm diversification and profitability. Some reported no statistically significant
association between the two (Berry, 1975; Mueller, 1986), while others reported a negative association (Wernerfelt and Montgomery, 1988a). We, on the other hand, hypothesized a non-negative association between the HHI-type index of diversification and found support for our hypothesis in the data.

At a first glance this appears to be a counterintuitive result. Actually it is not for two reasons. First, while our multiple point competition based measure of diversification is not defined for a single business firm, the HHI-type index of diversification is defined for a single business firm as zero. According to the HHI measure, a single business firm is the most highly related diversifier. As indicated above, in the samples used by earlier researchers the single business firms were among the most highly profitable because their samples had been limited to large (typically the Fortune 500) companies. This is a sample of elite firms and any single business firm participating in this sample is an exception among single business firms. The high profitability of single business firms in their sample perhaps gave rise to a negative association between diversification and profitability in these studies. In our sample of 7,000 companies, on the other hand, the single business firms were less profitable after controlling for industry. Grant, Jamine, and Thomas (1988), who estimated a quadratic relationship between diversification and profitability of 350 firms in the U.K. using an HHI-type index of diversification, had found that a little diversification was positively associated with profitability, i.e., the firms which were the least diversified (single business firms) were less profitable.

And second, the studies that reported the strongest negative association between profitability and the HHI-type index of diversification in the past nearly always used the distinction between related and unrelated diversification either through partitioning the HHI-type index of
diversification within and across 2-digit SIC codes (Palepu, 1985) or through a scheme of weighting businesses differently within or across 2-digit SIC codes (Wernerfelt and Montgomery, 1988a). In our opinion, the negative association between diversification and profitability in these studies was the result of the differential weighting of businesses and not of the HHI-type index. The two studies of diversification (Berry, 1975; Mueller, 1986) that used an HHI-type index of diversification without using the distances, in fact, found a positive coefficient of diversification similar to ours, though their results were statistically not significant.

Wernerfelt and Montgomery (1988a), in support of their use of the concentric index of diversification, cite Caves, Porter, and Spence (1980), who report that the HHI index of diversification correlated highly with the concentric index. However, for the purpose of studying the relationship between diversification and profitability Caves, Porter, and Spence (1980) used the Wrigley-Rumelt categories of diversification strategy and not the concentric index. The HHI type indices of diversification in a way measure the variance of firms' revenue across businesses rather than their entry and exit strategies. For this reason, perhaps they may be more useful for investigating the differences in firms' cash flow variability, annual and seasonal patterns of their income, and the like.

Diversification and Profitability

The overall relationship between diversification and profitability in our study was statistically significant and negative. After controlling for industry, the segment operating profit as a percentage of sales was 12.23 points higher for firms that had diversified into highly related areas compared to the average segment profitability of firms in the sample. Though
such difference in profitability attributable to diversification is by no means small, we believe that this effect could have been even stronger but for the following reasons.

We have already pointed out one factor diluting the relationship between profitability and diversification—namely, the difference in the profitability of single business firms across industries indicating differences in expected profits of entrants. If the expected profit of a new entrant is higher in some industry than in others then even less profitable firms in related businesses might prefer to enter this business rather than into an unrelated one. This effect could either be the result of an industry still being in the process of moving toward competitive equilibrium, or of differences in entry barriers and cost of entry across industries.

But even if the profitability of single business firms was same across industries, there would still remain a factor that would have impact on the relationship between diversification and profitability. This factor is information. All firms do not have knowledge about all industries. In particular, a firm may have greater knowledge of entry costs in highly related businesses, perhaps because of its knowledge of customers and suppliers in those industries. This firm may consider the cost of collecting information about the cost of entry into an unrelated business prohibitive. In such a case, even if the firm is less profitable and would have chosen to diversify into an unrelated area in case of full information, it might want to diversify into a related area.

Limitations of the Study and Suggestions for Research

For the purpose of simplicity, we used the segment as the level of analysis in this study. There is need, however, to extend this study to the
level of the firm. Such an extension will achieve two objectives. First, results from such a study will allow more direct comparison with the results from previous studies of diversification which had all been done at the firm level.

And second, firm level studies could be extended to a variety of measures of economic performance such as growth in sales, growth in profitability, price to earnings ratio, and such other. Christensen and Montgomery (1981) had claimed that related diversifiers operated in industries with higher growth rates. We could not test this hypothesis in this study because in COMPUSTAT only one clean profitability ratio—namely, the operating profit to sales ratio—is available for segments. Certain performance figures such as earnings per share, return on equity, and Tobin’s q are available only at the firm level.

Another direction in which this study needs to be extended is the use of more direct measures of diversification. The measure of relatedness we used here is merely a surrogate. Since not all firms diversify into related areas, a measure based on multiple point competition may not be an ideal measure of relatedness. A better measure of diversification could be obtained by measuring the relatedness between businesses along the dimension of cost. The COMPUSTAT data in which firms, on an average, report profitability of only one and half segments each, are not very good in this respect. The line of business data of the Federal Trade Commission could prove more suitable for this purpose. The FTC data could also be used for the purpose of validating the multiple point competition based measure of relatedness.

However, even a cost based measure of relatedness may not be able to overcome the problem of endogeneity in this study that arises because we use the same set of companies for calculating relatedness and for studying the
relationship between diversification and profitability. In Chapter V we
discuss some other methods of relatedness that may allow a way out.

Because of lack of data, we could not include variables such as market
share, advertising and R&D intensity, and the like in this analysis which are
known to affect the economic performance of firms. As a result of such
omissions the models estimated by us could be overstating the effect of
diversification in our sample. Since Wernerfelt and Montgomery (1988a) had
found the relationship between diversification and firm profitability
statistically significant even in the presence of market share, and
advertising and R&D intensity variables, we have greater confidence in our
results. Still, we consider it highly desirable to estimate models
incorporating the variables omitted in this study.
Table 3.1

Characteristics of the Sample
(Number of companies with sales over $1 million = 6,888)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales ($ million)</td>
<td>622</td>
<td>3,223</td>
<td>1</td>
<td>86,630</td>
</tr>
<tr>
<td>Assets ($ million)</td>
<td>959</td>
<td>5,210</td>
<td>-</td>
<td>157,015</td>
</tr>
<tr>
<td>Employees</td>
<td>5,500</td>
<td>23,400</td>
<td>-</td>
<td>757,000</td>
</tr>
<tr>
<td>Return on assets (%)</td>
<td>-1.25</td>
<td>20.21</td>
<td>-99</td>
<td>422</td>
</tr>
<tr>
<td>Return on investment (%)</td>
<td>5.97</td>
<td>47.62</td>
<td>-99</td>
<td>903</td>
</tr>
</tbody>
</table>

All figures are arithmetic averages for five years (1982-1986)
Table 3.2

Correlations and Descriptives Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
<th>Mean</th>
<th>S.D.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HHI&lt;sub&gt;i&lt;/sub&gt;</td>
<td>1.000</td>
<td>0.518</td>
<td>8,809</td>
</tr>
<tr>
<td></td>
<td>D&lt;sub&gt;i&lt;/sub&gt;</td>
<td>-0.058***</td>
<td>0.210</td>
<td>7,951</td>
</tr>
<tr>
<td></td>
<td>r&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>0.013</td>
<td>-0.117***</td>
<td>6.627</td>
</tr>
</tbody>
</table>

** p < .01; *** p < .001
Table 3.3

Variance Decomposition From Estimation of Equation (3.1)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Type II or adjusted sum of squares*</th>
<th></th>
<th></th>
<th>Type I or hierarchical sum of squares**</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of squares</td>
<td>% of Total</td>
<td>Degrees of Freedom</td>
<td>Mean sum of squares</td>
<td>F</td>
<td>Probability</td>
</tr>
<tr>
<td>Diversification</td>
<td>20,431</td>
<td>0.39</td>
<td>1</td>
<td>20,431</td>
<td>41.04</td>
<td>.000</td>
</tr>
<tr>
<td>Single Business</td>
<td>13,938</td>
<td>0.27</td>
<td>1</td>
<td>13,938</td>
<td>28.00</td>
<td>.000</td>
</tr>
<tr>
<td>Industry</td>
<td>831,543</td>
<td>15.86</td>
<td>66</td>
<td>12,599</td>
<td>25.31</td>
<td>.000</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>4,351,067</td>
<td>82.01</td>
<td>8,740</td>
<td>498</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,241,765</td>
<td>100.00</td>
<td>8,808</td>
<td>595</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* These sums of squares are adjusted for all other variables and do not add to the total because of unequal cell sizes.
**The variables enter the equation in the order listed.
Table 3.4

Variance Decomposition From Estimation of Equation (3.3)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Type II or adjusted sum of squares*</th>
<th></th>
<th></th>
<th>Type I or hierarchical sum of squares**</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of squares</td>
<td>%</td>
<td>Degrees of</td>
<td>Mean</td>
<td>F</td>
</tr>
<tr>
<td>Diversification</td>
<td>73,810</td>
<td>1.41</td>
<td>67</td>
<td>1,102</td>
<td>2.28</td>
</tr>
<tr>
<td>Single Business</td>
<td>73,578</td>
<td>1.40</td>
<td>31</td>
<td>2,373</td>
<td>4.92</td>
</tr>
<tr>
<td>Industry</td>
<td>161,256</td>
<td>2.08</td>
<td>66</td>
<td>2,443</td>
<td>5.07</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>4,167,867</td>
<td>79.51</td>
<td>8,644</td>
<td>482</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,241,765</td>
<td>8.808</td>
<td>595</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* These sums of squares are adjusted for all other variables and do not add to the total because of unequal cell sizes.

**The variables enter the equation in the order listed.
Table 3.5

Correlations between Parameters of Equation (3.3) Using metric measure of Diversification
\((N = 7,951)\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>(D_i)</th>
<th>(\alpha_j)</th>
<th>((\alpha j_1))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D_i) (Metric measure of diversification for firm i)</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\alpha_j) (Regression coefficient for industry j)</td>
<td>-0.027***</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>((\alpha j_1)) (Regression coefficient of diversification in industry j)</td>
<td>-0.092***</td>
<td>-0.515***</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**p < .001**
Figure 3.1

Summary Results Indicating the Effect of Industry and Diversification on Segment Profitability

Legend:
N = Null model
D = Diversification effect
S = Single business firm effect
I = Industry effect
D*I = Interaction between diversification and industry effects
S*I = Interaction between single business firm and industry effects
D(I) = Diversification within industry
S(I) = Single business within industry
Sample size = 8,809 for all models except two.
Sample size for models D and D,I = 7,951
Summary Results Indicating the Effect of Industry and Diversification on Segment Profitability Using HHI-index of Diversification

Legend:
N — Null model
D — Diversification effect
I — Industry effect
Sample Size = 8,809
CHAPTER IV

MULTIPLE POINT COMPETITION AS A PREDICTOR OF DIVISIONAL STRUCTURE
Researchers in the areas of sociology, organization theory (OT), and strategic management (SM) have been studying the structure of organizations for decades. Moore, Johns and Pinder (1980:9) reviewed some of this research and observed: "the knowledge we have gained about organizational phenomenon over the past fifteen years has been far from commensurate with the energy expended. During that time the incremental gain in knowledge about how organizations should be structured and designed, has been modest."

Moore et al were speaking of research in the area of OT, but their criticism applies with even greater force to the work done by SM researchers who have been more concerned with whether "structure follows strategy" than with the ways in which business divisions are and should be organized. In this chapter we seek to rectify the situation by discussing a model for the design of divisional structure of firms, and by empirically verifying it with data from some of the largest, most complex business organizations in the world.

This chapter is divided into four parts. The first part briefly reviews the literature on the structure and the structuring of organizations. The second part describes a model for the design of divisional structure of large business organizations. The third part comprises methodology, analysis of data, and results; while the fourth and final part presents discussion of findings, alternative models, and proposals for extending this line of research.

THE MULTIDIVISIONAL STRUCTURE IN THE LITERATURE

The literature on organizational structure in recent decades has shown a clear dichotomy between two streams of research arising from Weber's (1947) and Chandler's (1962) models respectively. Following Galbraith (1972), we
will call the former the study of the structuring of organizations, and the latter the study of the structure of organizations.

Sociologists and OT researchers studying organizations have largely adopted Weber's model in which the structuring characteristics of the organization—specialization, formalization, centralization, and standardization—are considered to be the all important variables. These variables represent the policies and activities occurring within the organization which, according to them, prescribe and restrict the behavior of members more than do formal organization structures and hierarchies.

Most OT researchers have, therefore, chosen to ignore the study of formal structure (hierarchies) of organizations even when studying large business organizations as if it lacked substantive content, while the few who have written about the divisional structure of large corporations sound strangely removed from reality. Mintzberg (1983:252), for instance, while agreeing that most Fortune 500 firms have adopted a divisional structure, goes on to add that "the divisionalized form has the narrowest range of all configurations. It has no real environment of its own; at the best it piggybacks on the Machine Bureaucracy in the simple, grated structural form. The pure Divisionalized Form may prove inherently unstable, in a social context a legitimate tendency but not a legitimate structure. The economic advantages it offers over independent organizations reflect fundamental inefficiencies in capital markets and stockholder control systems that should themselves be corrected. And it creates fundamental social problems."

Following Weber's approach Burns and Stalker (1961) reported a mechanistic-organistic continuum of organizational structure contingent upon environment. Woodward (1962) showed that different technologies imposed
different demands on individuals. Organizations whose subjects dealt with routine processes and technologies tended to have greater formalization and centralization than did their counterparts whose subjects dealt with non routine processes and technologies. Lawrence and Lorsch (1967) substantially refined the contingency approach by demonstrating that styles of subunits within an organization could vary because of the differences in their subenvironment.

Later Mohr (1971) and Pennings (1975) failed in their attempts to replicate the results of Woodward and of Lawrence et al. But, instead of beginning to think of alternative perspectives, this was seen as a reason to intensify the search for a series of moderators that could somehow explain the data. Subsequent research has therefore greatly expanded the list of contingencies to include those of size (Blau and Schoenherr, 1971; Blau, 1972; Hinings and Lee, 1971; Child and Mansfield, 1972), public versus private ownership (Pugh and Hickson, 1976), and democracy (Donaldson and Warner, 1974). This lack of parsimony, however, has not been compensated for by any increase in predictive ability as sophisticated research designs have typically produced $R^2$ around 0.10 leaving large amount of variance unexplained (White, 1978). Perrow (1973:11) says: "As the growth of the field has forced ever more variables into our consciousness, flat claims of predictive power are beginning to decrease and research has become bewilderingly complex."

Child (1973) has argued that much of the above research is based upon static, statistically derived associations, and fails to inform us about the process through which the observed structural configurations had been achieved. In proposing strategic choice as a critical determinant of structure, Child established the much needed link between two streams of
research—the one based on Weber's model and the other based on Chandler's. However, despite his attempt and those of Grinyer and Yasai-Ardekani (1982) researchers in the area of OT have generally ignored the phenomenon of the multidivisional structure.

Nevertheless, OT researchers have proposed several theories of organizational change—the organizational power perspective (Perrow, 1970; 1972; Fliqstein, 1985), the population ecology model (Hannan and Freeman, 1984), and the theory of organizational homogeneity (Dimaggio and Powell, 1982)—to name but a few. Since the multidivisional structure represents the single most important instance of organizational change among large firms in the U.S. during the last century, it will be instructive to investigate the applicability of these theories to the phenomenon of the multidivisional structure.

The organizational power perspective of Perrow (1971; 1972) and Fliqstein (1985) argues that the multidivisional structure is the result of the action of certain players who stand to gain from its implementation. Since the multidivisional structure can aid in the process of growth through diversification, sales and marketing and finance personnel are likely to favor its implementation. Fliqstein (1985) studied the adoption of the multidivisional structure by the largest 100 firms in the U.S. during the years 1929–1979. In his study sales and marketing presidents appeared to have significant influence on the firm's decision to adopt a multidivisional structure during only one of the five decades studied. Diversification strategy alone consistently appeared to be the greatest influence on the adoption of the multidivisional structure, thus vindicating Chandler's "structure follows strategy" assertion.
In Hannan and Freeman’s population ecology model (1984:150) organizational changes such as that represented by the multidivisional structure occur through the creation of new organizations and organizational forms and the replacements of old ones. This is because the older organizations have come to occupy niches, are performing reliably, and tend towards structural inertia. In this sense Hannan and Freeman’s model is a strong statement of the selection argument and differs from those of other population ecologists such as Aldrich (1979) who emphasize adaptation to environment as much as selection. Hannan and Freeman’s viewpoint seems to be contradicted by Chandler’s (1962) finding that the multidivisional structure emerged as an innovation of the large established firms such as General Motors, Dupont, Sears, and Standard oil of New Jersey rather than of new firms. In Fligstein’s (1985) study cited above, the large firms underwent substantial organizational changes, a phenomenon that argues against Hannan and Freeman’s concept of structural inertia.

Dimaggio and Powell’s theory of organizational homogeneity would hold that the multidivisional structure spread through imitation. Such imitation might occur because of the cultural expectations of buyers, suppliers, competitors, government, and other stakeholders that create pressure on the firm to conform to the prevalent modal form of organizational structure, because of the firm’s desire to mimic its more successful rivals, and because of the professionalization of managers who come to share a common world view, perhaps acquired at the business schools.

Such a theory can provide a partial explanation at test for the spread of the multidivisional structure for two reasons. First, if extrapolated backwards, the theory of organizational homogeneity literally leads one into a

82
chicken and egg situation. If firms design their organizational structure through imitation then whom did the first few firms to divisionalize imitate? And second, Westney (1987), in her study of imitation of institutional forms in Japan, has shown that such imitation is nearly always accompanied by modifications to meet the special needs of the imitator. These modifications are often important enough to be called innovations in their own right. A theory of imitation that fails to recognize the importance of such modifications can not be a complete explanation for the phenomenon of the multidivisional structure. However, despite these weaknesses, Dimaggio and Powell’s theory deserves greater attention and we will consider a restatement of their theory of organizational homogeneity again later during this chapter.

The Structure of Organizations

Chandler (1962) in his Strategy and Structure describes organizational changes at GM, Du Pont, Sears, and Standard Oil. The success of these companies allowed them continuous expansion and diversification into new geographic and product market areas. But such growth rendered their functional organizations ineffective. Each of these companies struggled with difficulties of coordination and then developed the multidivisional form independently. As Chandler (1962:15-16) put it, "A new strategy required a new or at least refashioned structure. ...growth without structural adjustment can only lead to economic inefficiency."

Chandler’s work was followed by a most productive stream of research in the area of SM in which the link between strategy and structure was established time and again, but not the direction of causation. Wrigley (1970) found that in 1967 while no single product firm in his sample of the Fortune
500 had a divisional structure, all of the conglomerates, 95% of the firms diversified into related areas, and 64% of those with a little of diversification had adopted a divisional structure. Rumelt's (1974) results supported the "structure follows strategy" thesis, but he also found "the possibility that structure affects strategy" (p. 76) and was forced to add that "structure also follows fashion" (p. 149). Evidence from Europe was also generally supportive, though with some qualifications. Channon (1973) found that in U.K., because of the holding companies and family ownership, firms divisionalized often 20 years after diversification. Dyas and Thanheiser (1976) reported that regulatory restrictions in France forced even diversified firms to maintain highly centralized structure.

Thus, SM researchers had been concerned with whether "structure followed strategy" rather than with the design of divisions. Such knowledge is, of course, important, but fails to inform us about how divisions are or should be organized. The actual design of the multidivisional structure of a firm is a non-trivial task. For even the relatively tiny problem of putting 25 businesses into five divisions, the number of possibilities is 2,436,684,974,110,751. Each of these designs is unlikely to be equally efficient. Past research in the areas of OT and SM is of no help in the choice from among them.

There is also a normative literature arising out of the consulting firms that, though addressing the issue of the formation of Strategic Business Units (SBUs), is not entirely irrelevant for the purpose of the organization of the divisional structure of a company. Recommendations from various consultants on how SBUs should be organized do differ in detail, but are similar in essence. The earliest such recommendation is by McKinsey & Co. who advised General
Electric on the design of SBUs as early as 1970. According to them, the
general characteristics of an SBU were defined as follows: "a unique set of
competitors, a unique business mission, a competitor in external markets (as
opposed to an internal supplier), the ability to accomplish integrated
strategic planning, and the ability to 'call the shots' on the variables
crucial to the success of the business" (Hamermesh, 1986:190). Patel and
Younger (1977) of Arthur D. Little, Inc. also provide a similar set of
recommendations:

1. Price: If the prices of two products are linked—a price reduction
   for one affects the price of the other—then the products should
   probably belong to the same SBU.

2. Customers: If two products have the same set of customers then
   perhaps they should be amalgamated in one SBU for the purpose
   of strategic planning.

3. Shared experiences in R&D, manufacturing, and marketing: If two
   products have a number of manufactured components in common, if
   their R&D requirements are similar, and if their marketing
   strategies are related, then they should preferably belong to the
   same SBU. (Patel and Younger also speak of common
   competitors—a point that we will discuss shortly).

If we read SBUs in place of products, and divisions in place of SBUs,
then the above translates into recommendations for the organization of
divisions. Two SBUs should be part of the same division if they are similar in
technology, markets, resource requirements, and the like, or in other words,
if they are related. The above criteria of Patel and Younger follow closely
the definition of relatedness by Rumelt (1974:29).
The economists, once criticized for ignoring organizational factors (Cyert and March, 1963), have, in fact, given the greatest amount of attention to the problem of designing the multidivisional structure. Williamson (1975:149), for instance, stated that optimal divisionalization involved the identification of separable economic activities. However, he did not indicate why the divisional boundaries should coincide with separable economic activities within the firm.

There are subtle differences among the statements of Williamson and those of Patel and Younger. According to Williamson the economic environment of businesses in different divisions should be independent. Patel and Younger, on the other hand, assert that businesses which are economically dependent upon each other should form a division. Neither Williamson nor Patel and Younger have formal models, and both refrain from giving reasons for their assertions.

A MODEL OF THE MULTIDIVISIONAL STRUCTURE

Arrow and Radner (1979) have a model of teams that has some implications for the design of the multidivisional structure. They prove that the maximum production level that could be achieved by a team under complete information sharing could also be achieved by it asymptotically under a regime of incomplete information sharing if the environment of each team member was independent. In the context of the multidivisional structure, this model implies that the economic environments of different divisions should be independent and provides theoretical support for Williamson’s suggestion.

Because Arrow and Radner’s model of large teams is the only formal model that we have come across in our survey of the literature in the areas of
sociology, OT, SM, and economics that appears to have relevance for the design of the multidivisional structure, we will discuss this model in some detail before its operationalization, though we will exclude all formal proofs that are available in the original references.

Consider a firm with a multidivisional structure. The firm has \( n \) divisions \((i = 1, \ldots, n)\), and a center. We assume that the total output of the firm is the sum of the outputs of all divisions. The output of the firm is maximized when the average output of the divisions reaches a maximum.

There are two types of resources, say, capital and labor. The center allocates the total supply of capital, \( K (= n, \text{say, as the unit of capital is arbitrary}) \), among the divisions, so that

\[
\sum K_i \leq K; \quad K_i \geq 0; \quad i = 1, \ldots, n.
\]

The availability of total capital, \( K \), depends on the state of the environment.

The divisions determine the quantity of labor input \((L_i \geq 0; \ i = 1, \ldots, n)\) themselves. The wage rate of labor, \( w \), is constant across the divisions. The output of each division is given by

\[ F_i = F(K_i; \ L_i; \ \theta_i) \] \hspace{1cm} (4.1)

where \( \theta(\theta_1, \ldots, \theta_n) \) is a vector of parameters characterizing the production function of the divisions. We assume that the \( \theta_i \)'s are independently and identically distributed. The theoretical probability distribution \( P \) of \( \theta \) in the population is common knowledge. \( \theta_i \in (0,1) \), and the maximum possible value of \( \theta_i \) is 1. The average output per division is

\[ 1/n(\sum F(K_i; \ L_i; \ \theta_i)) \]

For simplicity we will use the Leontief production function, so that

\[ F_i = F(K_i; \ L_i; \ \theta_i) = \min(\theta_i K_i; \ L_i) - wL_i \] \hspace{1cm} (4.2)

Radner (1972; 1987), Groves and Radner (1972), and Groves and Hart
(1986) consider four different regimes of information sharing among the center and divisions, viz., Complete Communication (CC); Complete Exchange with the Center (CEC); one stage Lange-Lerner [following the literature on market socialism, see Groves and Hart (1986)]; and no communication. The four regimes denote progressively reduced sharing of information, and therefore correspond to progressively lower levels of output. Here we will be concerned only with the first two information structures, namely, the CC, and the CEC.

In the case of CC each division communicates its production parameter ($\theta_i$) to the center and to every other division. The center then communicates to each division the allocation of capital ($K_i, \ldots, K_n$), and the divisions then decide on the quantity of labor input, $L_i$. The expected average output of the divisions in this case is

$$F_{cc} = \frac{1}{n}[\sum F(K_i(\theta_1, \ldots, \theta_n); L_i(\theta_1, \ldots, \theta_n; K_i, \ldots, K_n); \theta_i)]$$

(4.3)

Because all decisions in this information regime are based on all information that is ever likely to be available to anyone, this regime results in the maximum output. In particular, all divisions use only the amount of labor that corresponds to their allocation of capital, i.e., $L_i = \theta_i K_i$. In addition, to maximize production, center allocates capital only to those divisions which have the maximum value of the production parameter, $\theta_i = \theta_{max}$. Therefore,

$$F_{cc} = (1 - w) \theta_{max}$$

(4.4)

In CEC, on the other hand, each division chooses the quantity of labor input ($L_i$) and communicates to the center its production parameter ($\theta_i$). The center then communicates to each division the allocation of capital ($K_i$). The average output of the divisions under such an information structure is

$$F_{cec} = \frac{1}{n}[\sum F(K_i(\theta_1, \ldots, \theta_n); L_i(\theta_i); \theta_i)]$$

(4.5)

While none of the four information regimes discussed by Radner (1986)
may have an exact counterpart in the real world, there are remarkable
similarities between the CEC information structure and the process of planning
and resource allocation in firms with a multidivisional structure. In this
regime divisions do not communicate with each other, and are required to
commit resources (for instance, place orders for equipments, supplies, and the
like) in advance of knowing their share of the capital allocated by the
center.

As the class of decision functions available to the firm under CEC is
contained within that available under CC, $F_{cr}$ can not exceed $F_{cc}$. But Arrow
and Radner (1979:366) demonstrate that for a sufficiently large number of
divisions, the loss in expected average net output per division "due to
incompleteness of information in CEC can be made negligible by a suitable
choice of CEC team decision function."

By way of motivation, Arrow and Radner (1979, section 2) show this in a
simple case when the probability distribution $P$ of the production parameter $\theta_i$
is concentrated on a finite number of distinct values, $\theta_1, \ldots, \theta_n$. The
maximum value of $\theta_i$ is $\theta_{\text{max}} = \theta_n$. As $n$ increases to infinity $E[\max \theta_i (i = 1, \ldots, n)]$ converges to $1$. Hence,

$$F_{cc} = 1 - w \quad (4.6)$$

In the case of CEC, let the decision rule of each division be

$$L_i(\theta_i) = \frac{1}{p_n} \text{ if } \theta_i = 1$$

$$= 0 \text{ if } \theta_i < 1 \quad (4.7)$$

where $p_n$ is the theoretical probability of a firm having the highest value of
the production parameter $1$ and is common knowledge, though the actual value of
$p_n$ in the particular sample of firms is not known.

The center's decision rule is to divide the total amount of capital $K$
equally among those divisions for which \( \theta_i = 1 \). If there are no such firms then the resource is thrown away. That is,

\[
K_i = \frac{1}{q_n} \text{ if } \theta_i = 1 \\
= 0 \text{ if } \theta < 1
\]  

(4.8)

where \( q_n \) is the proportion of divisions in the sample with \( \theta_i = 1 \). Then each of these firms receive \( K_i = \frac{1}{q_n} \) amount of capital, while each firm with \( \theta_i < 1 \) receives \( K_i = 0 \). The average output of a division in this case is

\[
F_{ccc} = q_n \{ \min \{(1/q_n), (1/p_n)\} - w/p_n \} \\
= \min (1, q_n/p_n) - w q_n/p_n
\]  

(4.9)

As \( n \) increases, \( q_n \) approaches \( p_n \), and in the limit,

\[
F_{ccc} = 1 - w = F_{cc}
\]

Thus, "if the environments of the team members are statistically independent, and if certain regularity properties are satisfied (including concavity of the production function and symmetry of the divisions), then the optimal expected output per division will approach the maximum possible under Complete Communication as the number of divisions increases. Roughly speaking, in a 'large' team with statistically independent environments, CEC is almost as good as CC, i.e., almost first best efficient." (Radner, 1987:13).

Earlier Radner (1972) and Groves and Radner (1972) proved the above in case of a quadratic production function, but Arrow and Radner's results are more general. Though Arrow and Radner speak of teams of firms, their results translate to divisions of a firm. The way CEC information structure works is as follows: "If the production parameters are independently distributed, then, for large teams, the empirical distribution is effectively known a priori, and the firm's knowledge of its own parameter, \( \theta_i \), defines its place in the general distribution, hence supplies all the information that could possibly
be obtained. However, if the $\theta$'s are correlated but not perfectly, then the inference of any one firm as to the empirical distribution of the other's parameter is less certain, it knows that they are drawn from the conditional joint distribution given its own parameter value, but since the latter is a random variable, so is the empirical distribution." (Arrow and Radner, 1979:383).

Arrow and Radner's model provides a way of designing the divisional structure of the firm. According to this model, firms should design their divisions such that its businesses are more related to other businesses within the division than to businesses across the divisions.

Operationalization of the Model: Measuring Relatedness

In Chapter II we argued that the probability of a firm not being in only one of two businesses is an excellent measure of relatedness between the two businesses. This measure is based on the idea that most firms in the U.S. have diversified into related areas. According to Arrow and Radner's model, firms put related businesses together in a division (or unrelated businesses in different divisions). So, if Arrow and Radner's model is correct then it appears that multiple point competition is a key predictor of structure. The divisional structure of a firm should conform to the structure of its multiple point competition.

This argument, however, should not be confused with the 'competition imperative' of Scott (1971:141) who had proposed competition as a mediator of the relationship between strategy and structure by suggesting that "the divisional structure appears to be the most effective way to manage the strategy of diversification under highly competitive conditions." Galbraith
and Kazanjian (1986:24) also suggest that structure follows strategy only when competition threatens a deterioration in performance. In his study of European multinationals, Franko (1974; 1976) found that firms that had a holding company or functional structure in the sixties divisionalized by the early seventies in the wake of increased competition with the removal of tariff barriers within the Common Market and with the entry of American and Japanese firms.

We propose to extend the scope of the above 'competition imperative' by demonstrating that not merely does the extent of competition mediate the adoption of multidivisional form as suggested above by others, but the structure of multiple point competition may also be a predictor of the divisional structure of firms. A normative implication of the model would be that the structure of competition could also be used to design the divisional structure of firms.

ANALYSIS AND RESULTS

We analyzed data from COMPUSTAT of Standard & Poor's COMPUSTAT Services Inc. which provides up to ninety 4-digit SIC codes for all NYSE and AMEX companies. Our data relate to the year 1986. In that year the maximum number of 4-digit SIC industries a company operated in was 49 (only 47 after deleting SIC codes that were not related to meaningful businesses). There are over 7,000 companies in this database, of which over 5,000 operate in more than one 4-digit SIC category. Our analysis is based on this latter set of companies.

We analyzed the correspondence between the divisional structure and the structure of multiple point competition for fifty of the Fortune 500 companies. The managers of most of these companies cooperated with us in the
study. We will present detailed results for four companies and summary results overall. The companies that we will discuss below in detail—American Standard, Morton Thiokol, Rockwell International, and Westinghouse—differ in size, operate in different industries, and have different degrees of diversification.

Choice of Analytic Technique

We used two different analytic techniques for the purpose of analyzing the data at two different levels. For analysis at the firm level, we used clustering techniques such as hierarchical cluster analysis and factor analysis, and for the purpose of analyzing the overall fit of the model to the data for fifty firms, we used a logit model. We will discuss results from the logit model for the overall sample after discussing the results from cluster analysis for four firms.

We used cluster analysis at the level of firms as it appeared to be intuitively more appealing and provided greater insights, both for theory and practice, into the problem of designing the multidivisional structure. Cluster analysis uses distances among objects to cluster them into groups which are relatively homogeneous (whose members are similar). The technique has been used widely by taxonomists in the area of biology for decades for the purpose of classifying living beings. In a way, the problem of designing the divisional structure of an organization too can be viewed as a problem in systematics (taxonomy or classification). When managers put certain products and businesses together in one division they are making a decision that these products and businesses are similar in some way.

The data we wanted to cluster analyze were in the form of binary (0-1)
rectangular arrays with up to 47 columns (of businesses) and up to about 5,000 rows (of companies). We used Pearson's product moment correlation as the similarity measure in two of the clustering procedures in SPSS® (SPSS Inc., 1986). Though the Pearson's correlation coefficient is not a metric (Aldenderfer and Blashfield, 1985), Mezzich (1978) reports that algorithms using the correlation coefficient outperformed Euclidean distance and city block metric in recovering the underlying structure in his data set. Edelbrock (1979:381) found algorithms using correlation as a measure of similarity to be "more accurate than those using Euclidean distance, regardless of the amalgamation rule." The correlation coefficient, in his study, was particularly robust against outliers.

We first present results for three companies using the (between group) average linkage method of clustering. Edelbrock (1979) reports that this method was significantly more accurate than single, complete, and centroid linkage algorithms. Milligan (1980) found that this method was the best among 30 algorithms investigated by him for widely varying error (outlier) conditions.

**American Standard:** In 1986 American Standard (AS) operated in 12 four digit SIC categories. In that year AS was organized into four divisions (Figure 4.1): air conditioning products, building products, transportation products, and automotive products. Air conditioning was its largest business.

Figure 4.2 shows results of cluster analysis of the businesses of AS. There is a striking correspondence between its divisional structure and the clustering pattern of its businesses. The four businesses in its Building Products Division form a compact cluster. Of all its businesses, vitreous china and plumbing fixtures appear to be the most highly related. Air
conditioning—its largest business—is more related to automotive products and rail road equipment businesses than to the businesses in the Building Products Division. The Transportation Products Division of AS comprises six businesses, five of which form a compact cluster, while the sixth, the rail road equipment business, appears to be more related to the motor vehicle parts and air conditioning businesses. The automotive products business appears to be nearer to the air conditioning products business than to the transportation products business.

**Morton Thiokol:** In 1986 Morton Thiokol (MT) operated in seventeen 4-digit SIC categories and its operations were organized into three groups (see Figure 4.3), viz., Aerospace, Specialty Chemicals, and Salt.

Figure 4.4 shows the results of cluster analysis of the multiple point competition matrix of MT for its seventeen businesses. The correspondence between its divisional structure and the clustering pattern of its businesses, which form four clusters, is remarkable. Nine of its businesses comprising the Specialty Chemicals Group form one compact cluster. Two businesses that form its Salt Group also appear in a separate cluster. The six businesses in its Aerospace Group, however, have split to form two separate clusters. Four businesses relating primarily to defense, viz., ammunition, ordnance and accessories, training equipments and simulators, and guided missile and space vehicle propulsion, form one cluster, while MT’s automotive air bags business along with miscellaneous business services forms another cluster.

**Rockwell International:** In 1986, Rockwell operated in 34 four digit SIC categories and was organized into four groups (see Figure 4.5)—Aerospace, Electronics, Automotive Products and Services, and General Industries.

Figure 4.6 shows results of cluster analysis of the multiple point
competition matrix of Rockwell. The correspondence between the pattern of clustering and organizational structure of Rockwell is quite close. The six businesses in its Aerospace Group clearly belong to one cluster. The Automotive Products and Services Group comprising six businesses forms a separate cluster along with two businesses of the General Industries Group. The nine remaining businesses of the General Industries Group cluster together.

The Electronics Group appears to be made of two somewhat unrelated sets of businesses. In particular, while the defense and commercial electronics businesses do cluster together, the computer and office automation businesses that Rockwell bought recently with the acquisition of Allen Bradley do not appear to be highly related to the other businesses in this Group.

Allen Bradley is a separate division within the Electronics Group. So, perhaps being within this Group is not a great handicap for Allen Bradley. However, by pointing out a possible weakness in the existing organizational arrangement of Rockwell, we have demonstrated the usefulness of our analysis in diagnosing organizational problems and the feasibility of this approach towards designing the multidivisional structure of organizations.

Though computers and office automation equipments are generally considered electronic products, not many manufacturers of these equipments appear to be operating in the areas of defense and commercial electronics. If Allen Bradley had been put into the Electronics Group for the realization of some supposed synergies with other electronics businesses of Rockwell without giving a thought to what those specific synergies were, then perhaps Rockwell should take a hard re-look at its existing Group structure.

Westinghouse: In 1986 Westinghouse operated in 36 four digit SIC
categories and was organized into four groups, viz. Energy and Advanced Technology; Industrial and International; Commercial; and Westinghouse Broadcasting (see Figure 4.7).

By now it should be apparent that the dendogram becomes progressively difficult to interpret as the number of 4-digit SIC businesses of a firm increases. Even more difficult is a comparison with the organization structure of the companies reported in their annual reports. In case of Westinghouse the hierarchical clustering procedure resulted in ten clusters, but Westinghouse had only four groups in 1986. When a low dimensional solution is required, i.e., when a large number of entities are required to be partitioned into a very small number of groups, then the techniques of ordination are more useful (Lorr, 1983:45-46).

Principal component analysis is one of the most widely used techniques of ordination (Digby and Gower, 1986). While the techniques for principal component analysis for interval data are well established, there appears to be some controversy on the choice of the correlation coefficient for the analysis of binary data. Bartholomew (1987:115-117) recommends the use of either the tetrachoric correlation or a correlation coefficient based on the cross product ratio. Harman (1976:24), on the other hand, prefers the Pearson’s product moment correlation coefficient for such analysis as the matrix of tetrachoric correlation coefficient may not be positive semi-definite. McDonald (1985:201) considers any type of factor analysis of binary data as heuristic analysis in which the estimates are adequate but not "best."

Following Harman, we used the FACTOR procedure in SPSS* for principal components analysis with varimax rotation for the data on multiple point competition for Westinghouse. The principal components method first produced
17 sets of closely related businesses from 36 four digit SIC categories. This method could be very informative for the purpose of designing compact divisions, but certainly did not produce any resemblance with Westinghouse's organization structure which had only four groups. So, we did factor analysis again but restricted the number of factors to four.

Table 4.1 shows the results of factor analysis with four factors. All businesses belonging to the Industrial and International Group loaded heavily on Factor 1, while the businesses belonging to Westinghouse Broadcasting loaded heavily on Factor 2. Businesses belonging to the Energy and Advanced Technology Group split and loaded on Factors 3 and 4, indicating that this Group comprises two sets of businesses. Alarm and signaling products, measuring instruments, and semiconductor businesses are related to the search, navigation, and guiding systems—now Westinghouse's largest business. The turbines, plate fabrication, and heavy construction business are linked, but are not related to the other businesses of this Group. Search, navigation, and guiding systems, however, loaded somewhat highly on Factor 3 along with turbines, plate fabrication, and heavy construction. With the exception of installation and erection of building equipments which loaded heavily on Factor 3 (Energy and Advanced Technology), businesses belonging to the Commercial Group did not load on any of these factors. Apparently (and also, as indicated by Westinghouse in its annual report) this Group is made of several unrelated businesses.

A Measure of Correspondence

While clustering procedures do not result in any test statistic, several recovery measures have been proposed to assess the validity of data partition.
The Rand (Rand, 1971), Jaccard (Anderberg, 1973), and kappa (Edelbrock, 1979) indices are among the most commonly used external criteria measures of recovery (Milligan, 1981). However, both Edelbrock and McLaughlin (1979) and Milligan and Isaac (1980) found that the Rand and kappa indices correlate at above 0.975. Hence, the two indices are essentially identical for practical applications. We therefore used the Rand and the Jaccard indices as measures of recovery (or as measures of correspondence of organizational structure with the structure of competition).

The two indices are computed as follows (see Table 4.2). For \( n \) businesses there are \( n(n - 1)/2 \) pairs of comparisons possible. Let \( a \) be the number of pairs of businesses which are together both in the organization structure of the firm and in the classification done by the clustering procedure; let \( b \) represent the pairs that are not together in the organization structure of the firm but are classified together by the clustering procedure, \( c \) is the number of pairs of businesses that are in the same division of the firm but are put in different clusters by the clustering algorithm, and \( d \) represents the number of pairs of businesses that are not in the same division of the firm nor are put together in a cluster by the algorithm. \((a + b + c + d)\) equals \( n(n - 1)/2 \). Then the Rand index is given by \((a + d)/(a + b + c + d)\).

The Jaccard index is \( a/(a + b + c) \).

In the case of Westinghouse (Table 4.1), there are (\( n \) =) 36 businesses. So that, the possible number of pairs is \( n(n - 1)/2 = 630 \). If we consider the 4 businesses under factor 3 (Advanced Technology Group) as misclassifications, then \( a = 172; b = 6; c = 33; \) and \( d = 419 \). The Rand index is 0.94 and the Jaccard index is 0.82. The two indices are not test statistics and no statistical significance can be attached to their values. However,
under random clustering they exhibit opposite tendencies—as the number of clusters increases the Rand index approaches the value of 1 while the Jaccard index approaches the value of 0 (Milligan, 1981). Chance could be ruled out if the values of both indices were high. Since in the case of Westinghouse, both Rand and Jaccard indices were high, according to Milligan (1981), they would represent good correspondence between the organizational structure of Westinghouse and the structure of its multiple point competition.

Rand and Jaccard indices do not give any information about the overall fit of the model to the data. To investigate statistically the validity of the hypothesis that companies do organize their divisional structure by putting related businesses together in a division, we used a logit model with a pair of businesses of a firm as the unit of analysis. The dependent variable in this case was dichotomous and assumed the value of one if both businesses were in the same division of the company and of zero if they were not. The independent variables were the distance between the two businesses, the company dummies, and the interaction terms.

Though it was possible to analyze such a dichotomous dependent variable within the frameworks of discriminant analysis, probit, and linear probability models, we preferred the logit model because it makes far fewer assumptions (Press and Wilson, 1978). Unlike discriminant analysis, for instance, the logit model makes no assumption about multivariate normality of predictor variables. Lachenbruch, Sneringer, and Revo (1973) report poor performance of the discriminant analysis estimates in certain non-normal models. Further, even when all the assumptions of discriminant analysis hold, a logit model is virtually as efficient as discriminant analysis (Harrell and Lee, 1985). The linear probability model, in either the least square or the weighted least
square version, has the obvious disadvantage that the estimates are not constrained to lie between 0 and 1. According to Amemiya (1981:1887), in the univariate and dichotomous case such as ours "it does not matter much whether one uses a probit model or a logit model." Because of the close similarity of the two distributions, it is difficult to distinguish between them statistically (Charles and Cox, 1987).

Because in our data if two businesses i and j were in the same division and businesses j and k were in the same division then businesses i and k were also in the same division, the observations relating to each pair of businesses were not independent. We therefore report results from the estimation of the model after deletion of non-independent observations. These results were similar to those obtained from the full data set.

We estimated a univariate independent logit model based on the following: Let $Y_{ij}$ denote the dependent variable that takes two values:

$Y_{ij} = 1$ if businesses i and j of company n are in the same division;

$= 0$ otherwise.

Then, the logit model is based on the assumption that the probability $P(Y_{ij} = 1) = 1/(1 + e^{\alpha - \beta d_{ij} - \gamma_n})$

where $\alpha$ is the intercept parameter, $\beta$ is the coefficient of the distance $d_{ij}$ between the two businesses i and j, and $\gamma_n$ is the effect of the company n. The company effect in the model takes into account the fact that a firm does not operate in all businesses in the economy and has to design its divisional structure from the businesses that it has. Two businesses i and j may be considered related enough to be put into one division by one firm and not related enough to be so clubbed together in a division by another firm depending upon which other businesses the two firms are in. Consider, for
instance, the businesses of motors and transmission gears which are highly related businesses and firms do put these two businesses together in a division so long as they are not operating in the business of industrial control as well, in which case the motor business usually is grouped together with the industrial controls business. Moreover, different companies have different number of groups or divisions. As before, we estimate several variations of the above model in a hierarchical fashion including the nested model given by

\[ P(Y_{ij} = 1) = \frac{1}{1 + e^{-a - \gamma_n \cdot (\beta)_{ij}}} \]

where \((\beta)_{ij}\) is the coefficient of the distance within company \(n\).

Table 4.3 shows the results from the estimation of a set of hierarchical logit models containing various combinations of distance and the company dummies, including the nested model for the reduced data set after elimination of non-independent observations. Since these are logit models with only one observation per cell, the usual goodness-of-fit criterion of minimum \(\chi^2\) is not applicable as the \(\chi^2\) is known to be monotonically increasing in sample size (Knoke and Burke, 1980). In stead, we will rely on the goodness-of-fit criteria suggested by Amemiya (1981). For nested models with only a few observations per cell, Amemiya recommends the use of the likelihood ratio test which is based on the difference between the likelihood functions of the model and the null model that has only a constant term in it. The likelihood ratio has a \(\chi^2\) distribution with the degrees of freedom equal to the number of additional parameters in the model. According to this criterion, one should choose the unconstrained model only if the likelihood ratio \(\chi^2\) is greater than the critical value of \(\chi^2\) at the chosen level of probability. In Table 4.3, the \(\chi^2\) statistic in column 5 is the likelihood ratio \(\chi^2\) with respect to the null
model.

For non-nested models, Amemiya suggests the use of the Akaike Information Criterion (AIC) [see Akaike, 1973]. In Table 4.3 we report a variation of the AIC given by

$$R = \left( \frac{\text{model } \chi^2 - 2p}{-2L(0)} \right)^{-2}$$

where $p$ is the number of variables in the model excluding intercepts and $L(0)$ is the maximum log-likelihood with only intercept in the model. $R$ is related to both Akaike's information criterion and Mallow's $C_p$ (see Atkinson, 1980). In case of logit models, $R$ has an interpretation analogous to the multiple correlation coefficient in regression analysis. If the $2p$ correction is ignored then $R$ has a value of 0 if the model is of no value and 1 if the model predicts perfectly. $R^2$ is the proportion of log likelihood explained by the model. The $R$ statistic is shown in column 8 of Table 4.3.

In addition to the above criteria, Amemiya also suggests the use of the number of wrong predictions as a criterion for evaluating models. This criterion is frequently used in discriminant analysis to compare the predictive ability of the model against null models such as the proportional chance model or the maximum chance model (Morrison, 1981). The percentage of correct predictions by the different models is shown in column 9 of Table 4.3.

An inspection of the statistics displayed in Table 4.3 reveals that the full nested model with company and the separate slopes of distance within each company is the best of the models estimated. Though the model with only the distance term in it is also statistically significant at $p = .000$, its predictive ability improves significantly when the parameter of distance is estimated separately for each company. The company dummies also have statistically significant parameters.
The statistically significant results in Table 4.3 indicate that the distance between two businesses along the single dimension of competition which captures the distance between the two along the multiple dimensions of skills, resources, and technology, is a strong predictor of whether the two are in the same division of a firm. The signs of the coefficients of distance were negative in models without interaction terms (not shown).

Because of possible differential effect of company on the distribution of error term, we also estimated logit models for each company separately. For 38 of the fifty companies in our sample the coefficients are negative, fifteen of these are statistically significant at the level of p < .01. This may be regarded as evidence in support of Arrow and Radner’s model of the divisional structure.

DISCUSSION AND PROPOSALS FOR RESEARCH

Our analysis showed that the formal divisional structure of large business organizations appears to conform closely to the structure of their competition. However, there were also a few exceptions in our sample. In case of 23 companies the coefficient of distance was negative but statistically not significantly different from zero. The coefficient of distance was positive in case of twelve of the fifty companies, and for one of these companies, was even statistically significant at p < .01. These figures indicate two possible types of deviations from the previous model of divisional structure. First, some companies perhaps design their divisional structure by putting related businesses in different divisions; we will call this over-divisionalization as it would result in larger than optimal number of divisions. And second, some firms perhaps design their divisional structure by putting even unrelated
businesses in one division. We will call this under-divisionalization as it may result in fewer than the optimal number of divisions. Both these are extremes and in reality companies may use some combination of the two design strategies. We now discuss two models of divisional structure that provide insights into conditions that might favor over- or under-divisionalization by firms.

Incomplete Information and the Design of Divisional Structure

We first propose a model of the divisional structure of a diversified firm based upon the problem of incomplete information. The model is similar in structure to the model of acquisition by Aron (1980). In his model of firm size and managerial wages, Rosen (1982) had shown that firm size was an increasing function of the ability of managers. Large diversified firms therefore have an interest in recruiting managers with claim to higher ability, in nurturing them, and in taking pains to separate out the most able among them from the rest for the highest positions. Ability of managers, however, is hidden and can only be measured with error. Profit performance is an imperfect indicator of ability.

Let us consider the manager of Division 1 in Figure 4.8. This manager has responsibility for two businesses, 1 and 2. The profit ($\Pi_i$) of a business is a function of the ability ($a$) of the manager and of a random component that depends upon the business:

$$\Pi_i = \Pi_i(a, \theta_i); \quad \theta_i \sim N(0, \sigma_i^2)$$  \hspace{1cm} (4.10)

The CEO can not observe $a$ or $\theta_i$, but only $\Pi_i$. From the two observations of $\Pi_i$s he or she has to make the best inference about the ability of the manager. The problem is not trivial. It would decide who among the division
managers would be promoted and who could be the next CEO.

For simplicity we will assume that the functions in (4.10) are linear, i.e.,

\[ \Pi_h = a + \theta_1 \]
\[ \Pi_b = a + \theta_2 \]

We further assume that \( \theta_1 \) and \( \theta_2 \) are bivariate normal, and the correlation between the two is \( r \). This correlation \( r \) is a measure of the relatedness of the two businesses. A high \( r \) would indicate that the two businesses are highly related, while a low \( r \) would indicate that they are not so highly related.

The maximum likelihood estimate of \( a \) when \( \Pi_h \) and \( \Pi_b \) are observed is:

\[ a = \left[ (\sigma_y/\sigma_1) \Pi_h + (\sigma_y/\sigma_1) (\Pi_h + \Pi_b) \right] / \left[ 1 + (\sigma_y/\sigma_1)^2 - 2(\sigma_y/\sigma_1)r \right] \]

\( \hat{a} \) is unbiased, is normally distributed, and is complete sufficient statistic for \( a \) (Lehmann, 1983). The variance of \( \hat{a} \) is:

\[ \text{var}(\hat{a}) = \sigma_y^2 (1 - r^2) / \left[ 1 + (\sigma_y/\sigma_1)^2 - 2(\sigma_y/\sigma_1)r \right] \quad (4.11) \]

The CEO's problem is to minimize \( \text{var}(\hat{a}) \). However, equation (4.11) is difficult to sign unambiguously. The numerator in (4.11) takes the minimum value of 0 for \( r = 1 \) and \( r = -1 \), and is maximum for \( r = 0 \). The denominator is decreasing in \( r \). Except for \( r = 1 \) for which \( \text{var}(\hat{a}) = 0 \), for every positive value of \( r \) there is a corresponding negative value for which \( \text{var}(\hat{a}) \) is smaller. That is, in the absence of businesses with perfect correlation, the CEO can not do better than put businesses with negative \( r \) together in a division. But negative correlation may not mean statistically independent environment. For certain values of \( \sigma_1 \) and \( \sigma_2 \), however, we can demonstrate that the best strategy for the CEO is to put businesses with \( r = 0 \) together. This is the case, for instance, when \( \sigma_1 \) and \( \sigma_2 \) are both equal, in which case (4.11) reduces to
\[ \text{var}(\hat{\alpha}) = \sigma^2 (1 + r)/2 \]

which is minimum when \( r = 0 \). For similar but stronger results see Mehta (1989).

The phenomenon captured in this model is often seen in action. A promising executive, before being moved to a senior position, is often asked to take charge of two or more relatively unrelated businesses for some time. More often, however, companies make a compromise between the need for an optimal divisional structure and that for assessing the ability of their managers by rotating the managers through divisions. Assuming that time does not affect the two businesses differently, this strategy yields the same result as above.

Entrepreneurial Vigor and Divisional Structure

We now propose the preservation of entrepreneurial vigor as a motive for over-divisionalization. Such a structure is often called the flat structure and anecdotal evidence about the entrepreneurial vigor of this form of organization abounds. However, no formal model exists to explain why such an organization would be more entrepreneurial. In this section we present a model that shows that a diversified 'entrepreneurial' firm will tend to over-divisionalize by putting even related businesses into separate divisions.

To prove this we will compare the R&D investment decisions in a diversified 'entrepreneurial' firm that is over-divisionalized with that in another diversified firm operating in the same set of businesses but which has fewer divisions, each comprising several related or unrelated businesses, and demonstrate that the latter will invest less in R&D.

Consider two diversified firms A and B in an industry in which they are
the only competitors. Both firms operate in identical sets of businesses, but firm B has more divisions than firm A. The manager of a typical division in firm A is a relatively older person with several years of experience who draws a large salary $S_A$. This salary reflects the length of his service with the firm, perhaps through bonuses and stock options tied to the number of years of service with the firm. If he or she were to leave the firm then he or she will command a much smaller salary in a firm outside. The manager of a typical division in firm B is younger with fewer years of experience, who draws a relatively smaller salary $S_B$ such that $S_B < S_A$. If he or she were to leave the firm then he or she will command the same salary in any other firm outside.

There is an R&D project in the industry that is in the nature of a patent race in which there can be one and only one winner. If firm A is successful then it rewards its division manager with an increase in salary of $\Delta S_A$, and if firm B is successful then it rewards its manager with an increase in salary of $\Delta S_B$, where $\Delta S_B > \Delta S_A$. This would be the case, for instance, if the post-success salaries for both managers are the same.

R&D investment decisions in the two firms are made at the level of division. Following Rasmussen (1989), we assume that the two division managers simultaneously choose to invest $x_A$ and $x_B$ dollars in R&D on the project which results in research achievements $f(x_A)$ and $f(x_B)$ where $f' > 0$; $f'' < 0$. Nature chooses which firm wins the patent using the function $g$ that maps research achievement to a probability of success between zero and one. For instance, the probability of success of firm A is given by

$$p_A = g|f(x_A) - f(x_B)| \tag{4.12}$$

where $g' > 0$; $g(0) = 0.5$; $0 \leq g \leq 1$.

The division managers have a positive utility for their salary and a
negative utility, $R(x)$, for R&D expenditure. The marginal utility of R&D expenditure is constant and same for the managers of the two firms. Table 4.4 shows the probabilities of success for the two firms and the corresponding payoffs for the managers. From Table 4.4 and equation (4.12), the payoff or the expected utility of the division manager of firm A is

$$U_a = p_a[S_a + \Delta S_a - R(x_a)] + (1 - p_a)[S_a - R(x_a)]$$

$$= g|f(x_a) - f(x_b)|\Delta S_a + S_a - R(x_a)$$

(4.13)

And the payoff for the division manager of firm B is

$$U_b = p_b[S_b + \Delta S_b - R(x_b)] + (1 - p_b)[S_b - R(x_b)]$$

$$= [1 - g|f(x_a) - f(x_b)|]\Delta S_b + S_b - R(x_b)$$

(4.14)

Both division managers maximize their expected utilities. Hence,

$$\frac{\partial U_a}{\partial x_a} = g'f'_a\Delta S_a - R'_a = 0$$

Therefore,

$$f'_a = R'_a/g'\Delta S_a$$

(4.15)

and

$$\frac{\partial U_b}{\partial x_b} = g'f'_b\Delta S_b - R'_b = 0$$

from which,

$$f'_b = R'_b/g'\Delta S_b$$

(4.16)

From (4.15) and (4.16),

$$f'_a/f'_b = \Delta S_b/\Delta S_a > 1 \text{ because } \Delta S_b > \Delta S_a.$$ 

This implies that $f'_a > f'_b$. Since $f'' < 0$, $f'$ is decreasing in $x$. It follows therefore that $x_a < x_b$. The division manager of the diversified 'entrepreneurial' firm spends more on R&D than does the division manager of its diversified rival. Thus this model formalizes the common notion that large diversified firms with a tight divisional structure are less entrepreneurial than similar organizations with a flat structure comprising many more
divisions.

The basic result above has been obtained because of the fact that the manager of the 'entrepreneurial' firm expects to gain more from success than does the manager of the diversified firm with the tighter structure. It is not necessary that the manager of firm A have more experience and higher salary. If his division has several businesses and any gain made because of success in R&D has to be shared with the managers of other businesses as well then such sharing would also reduce the incentive for R&D for the division manager.

Johnson & Johnson (J&J) provides an example of a large firm with a flat organization. J&J is an agglomeration of over 150 more or less independent entrepreneurial companies. General Electric, on the other hand, is the arch-typical example of the large diversified firm with a tight divisional structure. Fisher, McKie, and Mancke (1983:192) recount the reason for GE's failure to compete with IBM in the computer industry and its eventual withdrawal:

"The computer department was always buried deep in the organizational structure. In 1963, it had been within the Industrial Electronics Division, which in turn was part of the Industrial Group. In 1968 GE formed the Information Systems Group, one of ten groups containing 50 to 60 divisions, and in turn, 130 or 140 separate departments. Because computers were so far down in its organizational structure and because it had so many other products to attend to, GE failed to mobilize its resources in computer to the extent necessary."

In his testimony in the FTC's case against IBM, Reginald Jones, ex-CEO of GE, confirmed the above, "We never did make the allocation of resources to the business that were warranted" (Fisher, McKie, and Mancke, 1983:193).
The above are only two of the many possible reasons that in reality may give rise to deviations from Arrow and Radner’s model of divisional structure. The ‘entrepreneurial’ model of the divisional structure was driven by the incentive mechanism that rewarded managers in different types of structures differently. The incentive mechanism can influence the design of the divisional structure in other situations as well. For instance, extrapolating from Lazear and Rosen’s (1981) model of rank order tournaments in which top league players do not want to play with bottom league players, it is conceivable that managers of low cost businesses in a firm would not like to be in the same division as high cost businesses, even though the managers of high cost businesses would very much like to be in the same division as the low cost businesses. Such a situation may also result in a flat organization.

A somewhat different mechanism that may also result in a flat divisional structure is the management of businesses solely for the purpose of selling them off. For an example consider the broadcasting industry in the U.S. Because of regulatory restrictions, firms in the U.S. can not own more than a few radio or TV stations. Successful firms in these businesses therefore buy ailing radio or TV stations, turn them around and sell them off at profit. Selling of these businesses is facilitated if they are managed as separate SBUs or divisions. Conglomerates that acquire new businesses and are not sure whether they would keep them for a long time or would divest them use a similar strategy of keeping the new businesses as separate divisions rather than integrating them with other businesses of the firm.

Suggestions for Research

Information and incentives impose opposite specifications on the
divisional structure of firms. A multinational with operations in developing
countries may find information processing costly and choose a flat structure
with greater autonomy to subsidiaries. An assembly shop, on the other hand,
may find it easier to obtain information on the productivity of personnel and
prefer a functional form which, in effect, is only one division. Future
research should attempt to explain the design of the divisional structure of
firms better by incorporating variables that capture the effects of
information and incentives.

Much research on organization structure in the past had been concerned
with the "fit" between strategy and structure. The idea had been that
different strategies required different structure to produce optimal results.
When a match between strategy and structure was achieved it resulted in
increased organizational effectiveness (Williamson, 1975). Empirical support
for this came both from Britain and the U.S. Cable and Steer (1977) studied 82
British firms and found that the optimal organizational form (the
multidivisional structure or M-form in the case of diversified firms, and the
unitary or functional structure or U-form in the case of single business
firms) accounted for 7 to 9% difference in returns on equity and asset. Armour
and Teece (1978) found that the existence of M-form resulted in a 2% higher
return to the shareholders of 28 oil companies between the years 1955-1968.
The performance difference later disappeared as all firms in the sample
adopted the multidivisional structure. In a study with matched pairs of firms
across twenty industries, Teece (1981) found that the early adopters of the M-
form outperformed their rivals, though the difference narrowed over time. A
computer simulation study by Burton and Obel (1980) also suggested benign
influence of "fit" on performance.
The above studies conceptualized "fit" as a dichotomous phenomenon. It either did (for instance, in the case of diversified firms with divisional organization) or did not exist. But it is unreasonable to assume that mere existence of the M-form would guarantee optimal organizational configuration to a diversified firm. The M-form permits a large number of combinations of businesses across divisions, (as we indicated earlier, for even the relatively tiny problem of putting 25 businesses into five divisions, the number of possibilities runs into quadrillions, or 2,436,684,974,110,751 to be exact) and the degree of effectiveness of each configuration could quite conceivably be different.

Our study points to the possibility of the existence of "fit" along a continuum. All companies in our sample were diversified firms with multidivisional structure. But the correspondence between their structure and the structure of their competition varied from very low to very high. An obvious extension of this study then would be to investigate the impact of such correspondence between the organizational structure of firms and the structure of their competition on the performance of organizations.

Limitations of the Study

Though our data broadly support Arrow and Radner’s model of divisional structure, other explanations that we did not specifically test for could also account for our results. Perhaps the divisional structure of firms mirrors the structure of multiple point competition because it facilitates collusion. Dimaggio and Powell’s theory of organizational homogeneity would not only be consistent with our data but could also be extended to provide an empirical definition of relatedness. Under this definition, two businesses would be
related if they are put in the same division by several firms. Such a measure of relatedness would be a metric and could also be used for the purpose of studying the relationship between diversification and profitability. However, empirical implementation of such a measure would be relatively difficult and it would depend rather too heavily upon Arrow and Radner’s model of divisional structure.

Population ecologists (Aldrich, 1975) would invoke the natural selection of organizational forms as argument to explain our results. According to them, corporations must either conform to the environment they are facing or die. The environment of a large diversified firm is multifaceted and complex. One way to cope with it is to make the entire organization competent in dealing with every facet of the environment. Another way is to divide the organization into subunits, and let the subunits face homogeneous parts of the environment. "For virtually all competitors their critical environmental constraint is their interface with other competitors" (Henderson, 1983). Homogeneity in competition indicates homogeneity in environment. So, the structure of diversified business organizations conforms to the structure of multiple point competition.

Environmentalists will be quite happy with the above. Lawrence and Lorsch (1967:209), for instance, had argued something similar years ago: "The environment with which a major department engages is decided by the key strategic choice, ‘What business are we in?’ Once that decision is made, whether explicitly or implicitly, the attributes of the chosen environment can be analyzed." They had measured the characteristics of the environment in terms of uncertainty, and the requirements for differentiation and integration.
It may be too early to commit to a single explanation. What is important is the need to study, in a longitudinal setting, the process of change in the divisional structure of companies which reorganized their divisions recently. Westinghouse, for instance, has recently undergone a minor restructuring. It sold off its lighting business and split the Advanced Technology Group into two—Energy and Utility, and Defense Electronics—exactly along the line indicated by factors 3 and 4 in Table 4.1. The present divisional structure of Westinghouse then shows a much better fit with the structure of its competition than did its earlier structure, though Westinghouse did not use a formal model of divisional structure such as ours. It is believed that organizational changes are costly and take time. If the adjustment of structure takes place by trial then it could be very expensive. On the other hand, if we could establish that the organizational structure that conforms to the structure of competition or to any of the above models of divisional structure works better, then businesses could be spared much tribulation. Hence the importance of this line of research.
Table 4.1
Cluster analysis of Westinghouse's businesses using factor method

<table>
<thead>
<tr>
<th>Industrial &amp; International</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ele indl app NEC</td>
<td>.74</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Switchgear &amp; switchboard</td>
<td>.59</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ele trans &amp; distn eqpt</td>
<td>.46</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Power distn &amp; spclty tran</td>
<td>.44</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ele industrial apparatus</td>
<td>.44</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Industrial control</td>
<td>.41</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Motor and generator</td>
<td>.29</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ele lighting &amp; wiring</td>
<td>.25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Westinghouse Broadcasting</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TV broadcasting</td>
<td>-</td>
<td>.87</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Radio broadcasting</td>
<td>-</td>
<td>.85</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Motion picture</td>
<td>-</td>
<td>.38</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy and Advanced Technology</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy construction NEC</td>
<td>-</td>
<td>-</td>
<td>.40</td>
<td>-</td>
</tr>
<tr>
<td>Fabricated plate work</td>
<td>-</td>
<td>-</td>
<td>.35</td>
<td>-</td>
</tr>
<tr>
<td>Steam &amp; hydraulic turbines</td>
<td>-</td>
<td>-</td>
<td>.26</td>
<td>-</td>
</tr>
</tbody>
</table>

| Search, navgn, guide sys          | -        | -        | .25      | .54      |
| Semiconductors                    | -        | -        | -        | .48      |
| Ele meas & control instrmt        | -        | -        | -        | .42      |
| Alarm & signaling products        | -        | -        | -        | .31      |

<table>
<thead>
<tr>
<th>Commercial</th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Instlln/erctn of bldg eqpt</td>
<td>-</td>
<td>-</td>
<td>.34</td>
<td>-</td>
</tr>
<tr>
<td>Air condng &amp; refrigeration</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Optical instruments, lenses</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elevators/moving stairways</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gen indl machnry &amp; eqpt NEC</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indl organic chemicals</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Office furniture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Refuse system</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indl eqpt &amp; machnry whlsln</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Engineers &amp; architects</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bottled &amp; canned beverages</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Patent owners &amp; lessors</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R&amp;D Laboratory</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Adhesives &amp; surfactants</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subdividers &amp; developers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Watches and clocks</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Repair shop &amp; services</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Personnel supply</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ele apparatus wholesale</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Only loadings above .25 shown
Table 4.2

Pairwise classification of businesses by clustering algorithms

<table>
<thead>
<tr>
<th>Relative position of two businesses indicated by the algorithm</th>
<th>Relative position of two businesses in the organization chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both in the same cluster</td>
<td>Both in the same group or division</td>
</tr>
<tr>
<td></td>
<td>In different groups or divisions</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>(a + c)</td>
<td>(b + d)</td>
</tr>
<tr>
<td>In different clusters</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.3

Results from Logit Model after deleting non-independent observations

<table>
<thead>
<tr>
<th>Model</th>
<th>Log likelihood function</th>
<th>Likelihood ratio test</th>
<th>Model R</th>
<th>% of correct predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L^2$</td>
<td>df</td>
<td>$\chi^2$</td>
<td>df</td>
</tr>
<tr>
<td>1. Null</td>
<td>6,164</td>
<td>9,356</td>
<td>114</td>
<td>1</td>
</tr>
<tr>
<td>2. Distance</td>
<td>6,050</td>
<td>9,355</td>
<td>752</td>
<td>49</td>
</tr>
<tr>
<td>3. Company</td>
<td>5,412</td>
<td>9,306</td>
<td>782</td>
<td>50</td>
</tr>
<tr>
<td>3. Distance; Company</td>
<td>5,382</td>
<td>9,305</td>
<td>460</td>
<td>50</td>
</tr>
<tr>
<td>5. Distance(Company)</td>
<td>5,704</td>
<td>9,305</td>
<td>956</td>
<td>99</td>
</tr>
<tr>
<td>6. Company; Distance(Company)</td>
<td>5,207</td>
<td>9,256</td>
<td>956</td>
<td>99</td>
</tr>
</tbody>
</table>
Table 4.4

Payoffs for the Division Managers of Two Firms in an R&D Race

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Probability</th>
<th>Payoff for A’s manager</th>
<th>Payoff for B’s manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>p</td>
<td>$S_a + \Delta S_a - R(x_a)$</td>
<td>$S_b + \Delta S_b - R(x_b)$</td>
</tr>
<tr>
<td>Failure</td>
<td>$(1 - p)$</td>
<td>$S_a - R(x_a)$</td>
<td>$S_b - R(x_b)$</td>
</tr>
</tbody>
</table>
Figure 4.1

American Standard’s organization chart, 1986 (abbreviated)

Corporate office

Senior V.P.
Air conditioning products

Senior V.P.
Building products

Senior V.P.
Transportation products

Senior V.P.
Automotive brake products

V.P. Dealer products

V.P. US Plumbing products

V.P. Railway braking products

Divisional V.P.
Auto products, Germany, Sweden

V.P. Air systems division

V.P. Building specialties

V.P. Signaling products

Divisional V.P.
Auto products, Austria, Belgium, Holland, Italy, Switzerland

V.P. Applied Unitary Refrigeration Sys

V.P. European plumbing products

V.P. Fluid power products

Divisional V.P.
Auto products, England, France

V.P. Light commercial

V.P. Tyler Refrigeration
Figure 4.2

Cluster analysis of American Standard's businesses

Dendrogram using Average Linkage (Between Groups)
Figure 4.3

Morton Thiokol's organization chart, 1986 (abbreviated)

CEO

Group V.P. Specialty Chemicals

Group V.P. Aerospace
  - Propulsion Systems
  - Ordnance
  - Automotive Airbags

Group V.P. Salt
Figure 4.4

Cluster analysis of Morton Thiokol's businesses

Businesses

Paints, varnish, lacquer
Adhesives and sealants
Misc chemical products
Che and chemical prepn, nec
Cyclic (coal/tar) crude, dye
Industrial organic che, nec
Plastic material, syn resin
Inorganic pigments
Industrl inorganic che, nec
Ammunition, ex small arms
Ordnance & accessories, nec
Training eqpt, simulator
Guided missile/sp veh prpln
Prepd food for animals, nec
Food preparations, nec
Motor vehicle parts & acc
Business services, nec

Specialty
Chemicals

Aerospace

Salt

Aerospace
Figure 4.5

Organization chart of Rockwell International, 1986 (abbreviated)

Corporate Office

Aerospace
- Advanced military aircraft
- Aircraft structures
- Space shuttle
- Space systems and vehicles
- Advanced propulsion systems
- Space station design
- Unmanned space system
- SDI R&D contracts
- Operation of DOE facilities

Electronics
- Defense Electronics
- Commercial Electronics
- Allen Bradley

Automotive Products and Services
- Heavy vehicles
- Light vehicles

General Industries
- Graphic Systems
- Energy
- Industrial Sewing Machines
Cluster analysis of Rockwell International's businesses

Businesses

Guided missiles, space veh
Guided miss, sp veh proplsn
Aircraft
Aircraft parts, aux eqp nec
Guided miss, sp veh pts nec
Guided missiles, space veh
Semiconductor related dev
Electronic components nec
Radio, TV, commercial appa
Search, navig, guiding sys
Training eqpt, simulator
Telephone, telegraph appa
Fabricated metal prdts nec
Alarm & signaling products
Motors and generators
Industrial controls
Printing trade mcy/eqpt
Ele eqpts for IC engines
Sewing machines
Industrial measuring instr
Totalizing fluid meters
Engineering lab & res eqpt
Electrical meas/test instr
Valve/pipe ftnng, ex brass
Fabricated pipe/pipe ftnng
Automotive stampings
Steel springs, ex wires
Hardware nec
Motor veh parts/accessories
Steel foundry nec
Misc plastics products
Computers, mini and micro
Office automation systems
Computer equipment nec

Aerospace
Electronics (Defense & Commercial)
General Industries
Automotive Products & Services
Electronics (Allen Bradley)
Figure 4.7
Westinghouse's organization chart, 1986 (abbreviated)

Corporate office

<table>
<thead>
<tr>
<th>Energy and advanced technology</th>
<th>Industrial and international</th>
<th>Commercial</th>
<th>Westinghouse broadcasting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Defense</td>
<td>Westinghouse Elevators Co.</td>
<td>Radio stations</td>
</tr>
<tr>
<td></td>
<td>Water reactors</td>
<td>Distribution and protection</td>
<td>TV stations</td>
</tr>
<tr>
<td></td>
<td>Power generation</td>
<td>Transmission and distribution</td>
<td>TV production company</td>
</tr>
<tr>
<td></td>
<td>Advanced Power System</td>
<td>Electronic measurement &amp; control</td>
<td>Satellite communication</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>Industry Services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advanced production technology</td>
<td>Industrial control</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motors</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Power equipments</td>
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<tr>
<td></td>
<td></td>
<td>Westinghouse Canada Inc.</td>
<td></td>
</tr>
</tbody>
</table>
A Divisional Structure

Figure 4.8
CHAPTER V

IMPLICATIONS FOR THEORY AND PRACTICE
We have discussed some of the implications of the study reported in the three earlier chapters relating to theory building and empirical research in the area of strategic management in general and in the areas of corporate diversification and divisional structure in particular at the end of the chapters. In this chapter, therefore, we will first discuss the implications of our research for practice and then point out some additional implications for theory building and research that were not specific to either Chapter II, or Chapter III, or Chapter IV, and were, for this reason, not discussed earlier.

IMPLICATIONS FOR MANAGERS

Two Strategic Planning Dialogues in 1991

Scene 1: The place is the office of the Vice President, Corporate Planning of General Products, a large diversified Fortune 500 company. Participants in the discussion are Pat, the Vice President of Corporate Planning, and Lisa, the Planning Analyst. The scene begins as Lisa enters Pat's office.

Pat: Hi, Lisa. I called you to discuss our acquisition of this factory automation firm, HI-TECH.

Lisa: Yes. What about it?

Pat: As you know, we do not have a factory automation business. But we are in defense and commercial electronics. In the board meeting yesterday, John had suggested that we should put HI-TECH in the electronics group.

Lisa: Let me see what our organization structure should look like after we acquire HI-TECH.
(Lisa turns to a personal computer and types a few words. The computer dials an on-line database service and she enters the model parameters. Within seconds an organization chart drops out of the printer. She looks at it for a second and then hands it to Pat.)

Pat: Well. HI-TECH is not in the electronics group in this chart.

Lisa: Yes. Though at first a factory automation firm seems much like an electronics firm, actually not many factory automation companies appear to be operating in defense and commercial electronics, and not many defense and commercial electronics firms are in the factory automation business. It might be better if we had a separate group for factory automation.

Scene 2: This time the place is the office of the chairman and CEO of HYCORP, a highly profitable and rapidly growing Fortune 500 firm in the food industry. Mark, the chairman and CEO, takes keen interest in strategic planning for the company. Over the last few years he has diversified HYCORP's single product business through entries into three new but related areas. He is now contemplating entry into a fourth new related business within the food industry. In this scene Mark is discussing the choice of the new business with Anne, the Director of Planning.

Mark: Anne, I would like to talk about our acquisition plans for the next year. Over the last five years we have added the businesses of ice creams, candy, and macaroni to our primary business of chocolate and cocoa products. I think our next acquisitions should supplement these new businesses.

Anne: Do you have any thing in mind?

Mark: Yes. I have three businesses in mind. I think that we could add a
line of dry vegetables and soup to bolster our macaroni business.
Or, we might look for a cookies and crackers firm to add to our
candy business. Better still, we could buy a soft drinks business.
To me that looks like a perfect match for our line of ice creams.

Anne: Actually, I recently did an analysis of the entire food industry
using a new model available on-line. Let me show it to you.

(Anne goes to a personal computer on the table and types some commands. The
computer dials an on-line database. Anne selects the model and the parameters.
After a few seconds a chart comes out of the printer. She reviews it for a
second and then gives it to Mark.)

Anne: Here is the output from the model. According to this, the best we
could do is to acquire a bread and bakery products business or a
shortening and oil business. These would complement our primary
business of chocolate and cocoa products. Several chocolate and
cocoa product firms are already in these businesses.

Mark: What about acquiring a soup company for our macaroni business?

Anne: No. A soup business does not seem to be highly related to the
macaroni business. Very few macaroni firms produce soups.
Similarly very few candy firms produce cookies and crackers.

Mark: O. K. That would mean that ice cream and soft drink businesses
also are not related.

Anne: That is right. Very few ice cream firms are in the soft drinks
business. But we could strengthen our ice cream business by
acquiring a line of frozen fruit, juice, and vegetables, or by
adding another line of condensed and evaporated milk.
A New Generation of Strategy Models

The above two dialogues are, of course, fictitious and have been set in the year 1991. But our research indicates that they are distinctly possible right now. The required databases such as Standard & Poor's COMPSTAT have been available for well over a decade. The absence of the right models, however, had severely limited the use of these databases in the past.

The first dialogue was, as would have been realized, based on our analysis of the organization structure of Rockwell International in Chapter III. We will not repeat that discussion here. In this chapter we will restrict the discussion to an analysis of the multiple point competition matrix of the food industry in the U.S. that was the theme of the second dialogue. This matrix is again drawn from the same database and analyzed with the same technique as in Chapter IV.

Diversifying? Do What Your Competitors Do

When speaking of diversification, nearly everybody advises companies to diversify into related areas—areas where some of the existing assets or resources could be used, or where the existing skills of the company would be of some advantage. The rationale for such diversification was provided by Rumelt (1974) who had found that related diversifiers performed better than the firms that diversified into unrelated areas. But then why do firms which make acquisitions into so called related areas are so often forced to divest them? The evidence of Porter (1987) cited earlier is worth repeating again. In his sample while of the 661 acquisitions made into unrelated areas 60% were divested, 57% of the 2,021 acquisitions made into related areas also had to be divested.
In our opinion, the somewhat larger percentage of divestments of acquisitions made into unrelated areas does not indicate that firms were wrong in diversifying into unrelated areas, as apparently seems to have been inferred by Porter. Rather, there is abundant evidence that, as rational profit maximizers, profitable firms in the U.S. try their best to diversify into related areas. The problem is, they have no means of knowing which business is related unless they acquire it and find that it is (or that it is not). We think that a lot of confusion has resulted from the existing definition of relatedness provided by academicians. They claim that if two businesses have similar customers, or similar technologies, then they are related. According to this, a manufacturer of electronic watches might be tempted to diversify into the area of mechanical watches—the markets are so similar. But a look at competitors would reveal that manufacturers of electronic watches are not producing mechanical watches, they produce calculators in stead. So, calculators appear to be more related to the business of electronic watches than do mechanical watches, and this fact is unambiguously revealed by the definition of relatedness along the single dimension of competition.

The Diversification Decision of HYCORP

In this section we will describe how a profitable firm in the U.S. planning to diversify into a related area could use data on multiple point competition for making its choice of businesses to diversify into. Our example relates to a firm in the food industry that we will call HYCORP. This is the company that was the subject of the second dialogue at the beginning of this chapter. It is a Fortune 500 company that has posted record profits and growth
for fifteen consecutive years while diversifying from its primary business of 
chocolate and cocoa products into the related businesses of candy and 
confectionery, ice cream and frozen desserts, and macaroni, spaghetti, and 
noodles. Table 5.1 shows its existing businesses.

Let us suppose that HYCOPP wants to diversify into another related 
business within the food industry. Conventional wisdom would indicate, for 
instance, that HYCOPP should add a line of dry vegetables and soups to 
strengthen its macaroni business; that it should look for a cookies and 
crackers firm to add to its candy business; and that it might buy a soft 
drinks firm to match its offerings of ice cream. These are exactly the 
businesses Mark, the chairman and CEO of HYCOPP, had in mind while speaking 
with Anne.

To see how related these businesses are to HYCOPP’s existing businesses, 
and to get information on which other businesses within the food industry 
might be related to HYCOPP’s businesses, we did cluster analysis of all 
businesses in the food industry at the level of 4-digit SIC codes. Figure 5.1 
shows the results of the cluster analysis. First, notice that some of the 
results in Figure 5.1 appear very logical, while some others are so counter 
intuitive as to warn us against trusting conventional wisdom. For instance, 
the businesses of cane sugar and beet sugar are highly related. Almost every 
firm which produces cane sugar also produces beet sugar. But the beer and the 
wine and spirits businesses are not related at all. Malt industry appears to 
be highly related to the distillation and refining of liquor, but not to the 
malt beverages industry.

We need not recount the complete list of related and unrelated 
businesses here as the dendogram in Figure 5.1 is self explanatory. We will
merely point out that the ideas of Mark based on conventional wisdom appear to have been all wrong. For instance, the dry vegetable and soup business does not appear to be highly related to the macaroni business, nor is the cookies and crackers business highly related to the candy business. HYCORP's ice cream business is more related to frozen fruit, juice, and vegetables and to condensed and evaporated milk businesses than to the soft drinks business. Also, from Figure 5.1 it appears that of all businesses in the food industry, the businesses of bread and bakery products and shortening and oil are the most highly related to HYCORP's primary business of chocolate and cocoa products.

IMPLICATIONS FOR THEORY AND RESEARCH

Kurt Lewin once said that there was nothing as practical as good theory. Our objective in this dissertation has been to live up to that ideal. We believe that this dissertation provides theoretical integration to diverse and at times contradictory findings from research on strategy, structure and economic performance in the past. By attempting to build theories of diversification and divisionalization on axiomatic foundations our research is also in line with the recommendations of Sneed (1970) and Stegmuller (1976). We have already discussed the major theoretical implications of this research in the earlier essays. Here we will briefly recapitulate the salient contributions of this line of research to theory building and research in the area of SM.

Theoretical Contribution

Unlike most studies of diversification and divisionalization that were
statistically driven, we have empirically investigated formal models of diversification strategy (Sinha, 1990) and divisional structure (Arrow and Radner, 1979). We also developed two alternative models of divisional structure that showed that Arrow and Radner’s was not the only possible model and that other design criteria could result in other forms of divisional structure. In one of the models, lack of information about manager’s ability resulted in under-divisionalization in which firms put unrelated businesses together in a division. The other model demonstrated the appropriateness of the flat organization structure for large firms wanting to maintain entrepreneurial vigor and provided a theoretical justification for the commonly held notion that large diversified firms are not very entrepreneurial. In over three decades of research in the area of SM, very few attempts have been made at expressing strategic phenomenon with the help of such models. We hope that our effort would lead to greater interest in developing formal models of strategy.

Methodological Contribution

In this dissertation we have developed a measure of relatedness of businesses and a measure of corporate diversification which have certain axiomatic properties not possessed by the measures used in the past. Both these measures could also be used by other researchers working on corporate diversification as well as on acquisitions, mergers, divestments, spin-offs, joint ventures, divisional structure, and the like. We also hope that our example will encourage researchers in the area of SM to develop similar measures of other variables in the field that would have certain axiomatic properties.
Empirical Contribution

This dissertation extends research on diversification in the area of SM in the U.S. beyond Rumelt’s sample of 246 of the Fortune 500 companies. Christensen and Montgomery (1981), Bettis and Hall (1982), and several other researchers had confined their researches to subsets of Rumelt’s database. Not surprisingly, except for the effect of the industry, their findings were not much different from those of Rumelt. For instance, single product firms were more profitable in Rumelt’s study as well as in Christensen and Montgomery’s. Rumelt’s single product firms, however, could hardly be called representative of the population of single product firms in the economy. In our sample single product firms are not as profitable as their diversified counterparts.

Even in the area of IO in the U.S., the samples used in previous studies of diversification had been limited to the 1,000 largest firms in the economy (Mueller, 1986). In U.K., Luffman and Reed (1984) had drawn their sample from the 1,000 largest firms in that country. Though these samples were not small, they had two limitations. First, drawn from the largest 1,000 firms, they were not representative of firms in the rest of the economy. And second, even though other researchers had found industry effects significant enough to warrant estimation of nested models, these sample sizes were small for the purpose of investigating the impact of diversification within each industry.

By using the COMPUSTAT database of over 7,000 companies, we have been able to get around the above two limitations. Estimation of nested models allowed us a more systematic investigation into the relationship between the association of diversification, firm performance, and industry profitability. We found that a statistically significant negative correlation exists between industry profitability and the regression parameter of diversification on
performance.

This is also the first study to empirically investigate the appropriateness of the design of divisional structure of firms. In the past researchers working on the spread of the multidivisional form (Wrigley, 1970; Rumelt, 1974) or on its impact on the profitability of firms (Armour and Teece, 1977; Teece, 1982) merely noted the presence or absence of a divisional structure as if one type of divisional structure was no different from another. We, on the other hand, have shown that firms with divisional structures may differ radically in the way the structure has been designed. While most firms put related businesses together in a division, some firms seem to design their divisional structure by putting unrelated businesses in a division, and others appear to adopt a flat structure in which even related businesses are put in different divisions. Each of these may be a rational design strategy meant to serve a different purpose. For instance, a firm wanting to resolve a succession issue may put unrelated businesses in the charge of one manager so as to get better information on his or her ability. Another firm operating in an industry characterized by rapid innovations may choose a flat structure to promote entrepreneurial vigor.

LIMITATIONS OF THIS STUDY

The multiple point competition based measure of relatedness is a surrogate measure at best for two reasons. First, because even profitable firms in less profitable industries diversify into unrelated areas, this measure can not tell us which industries are related to a less profitable industry. And second, for an industry, such as the electrical machinery industry, which has many more firms operating in it than in any other
industry, this measure could result in a large value of distance. This measure will also be of little use for studying relatedness of new technology industries in which very few firms have been able to enter yet.

Even though we began with specific hypotheses derived from a formal model of diversification, our statistical analysis of diversification and profitability had been based on a measure of firm diversification at one point of time and on firm's segment operating profit figures for one year. Such data can not be used for making any causal assertions.

The limitations of the surrogate measure apply to our results relating to the correspondence between the divisional structure of firms and the structure of multiple point competition as well. The dendograms resulting from cluster analysis were insightful, but there are no good summary statistics available to measure the correspondence between the divisional structure of firms and the clustering solution. In addition, since the SIC code data in COMPSTAT was limited to 4-digits, we could analyze the organizational structure of companies only at the highest level of aggregation, such as the group. Our analysis gives us no information on the correspondence between the structure of competition and the structure of companies at some other level of organization such as the SBU. Though our models indicated that information and incentives could be important predictors of divisional structure, they were not included in our analysis. Such exclusion could result in inflated test statistic for our measure of relatedness.

SUGGESTIONS FOR RESEARCH

Models in economics are based on certain assumptions and can not be falsified (Popper, 1977). Care therefore must be taken in giving causal
interpretation to such models. There is no substitute for a study using time
series data on diversification.

The measure of relatedness based on multiple point competition needs to
be validated with a more direct measure of relatedness based on distance along
cost. The FTC line of business data could perhaps be used for this purpose.
Because data on the relatedness of new technology industries will by
definition not be available, instruments such as O’Meara’s (1963) Product
Screen and Du Cros’ (1985) Industrial Morphology Grid will have to be
developed that would capture relatedness along the relevant dimensions.

Another advantage of such a measure will be that it will not suffer from
the problem of endogeneity that has arisen in our study out of the use of the
same set of companies for the calculation of the index of diversification for
which we study the relationship between profitability and diversification.

For simplicity we limited our analysis to the level of segment and used
only one measure of economic performance. Researchers in the past, however,
have investigated the association between diversification and performance at
the firm level, using a variety of measures of performance such as growth in
sales, earnings per share, and the like. Christensen and Montgomery (1981),
for instance, report statistically significant relationship between related
diversification and growth without controlling for industry and no such
relationship after controlling for industry. There is need to extend our
analysis to the level of the firm using a variety of measures of performance.

Our analysis of the group structure of firms should be extended to the
division or SBU levels which may require data at the level of 5-digit SIC
codes. Because the Arrow and Radner’s (1979) model of divisional structure is
not the only possible model, it appears even more important to us to
investigate the performance impact of the choice of divisional structure, i.e., over-divisionalization or under-divisionalization, under different contexts. For instance, if our model of the flat organization structure is valid then such an organization could exhibit greater effectiveness in industries with higher R&D intensity. A contextual analysis of this kind will require a larger or a carefully chosen homogeneous sample. Such an analysis, however, would be no substitute for the study of the process through which companies arrive at a particular configuration of their businesses.

Finally, in keeping with the tradition of research on strategy and structure, this line of research needs to be extended to other countries. If, for instance, the overall direction of association between diversification and profitability is reversed in the U.K. as reported by Luffman and Reed (1984) then it may corroborate the model of diversification. It may also be interesting to know how do firms in countries known for their entrepreneurial vigor, such as Japan, design their organizational structure.
Table 5.1

HYCORP's businesses

<table>
<thead>
<tr>
<th>SIC</th>
<th>Name of business</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024</td>
<td>Ice creams, frozen desserts</td>
</tr>
<tr>
<td>2065</td>
<td>Candy and other confectionery</td>
</tr>
<tr>
<td>2066</td>
<td>Chocolate, cocoa products</td>
</tr>
<tr>
<td>2098</td>
<td>Macaroni, spaghetti, noodles</td>
</tr>
</tbody>
</table>
Figure 5.1

Cluster analysis of food products businesses
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